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from steam-ploughing. At any rate, what with economical performance, improved work from the absence of trampling, and the three-and-a-half-mile per hour speed of the implement, the expedition and other advantages I have alluded to, it is clear that Mr. Redman has made a move in a safe direction; and time alone can show what the effect will be in empowering him to adopt a higher order of culture and a reformed system of cropping.*

The present Essay can be regarded only as a summary of progress up to the date subjoined; and this must be its apology for not describing still later improvements; nearly every week producing some novelty in steam-tilling machinery, or furnishing yet stronger evidence of its value to the farmer.

Long Sutton, Lincolnshire, February, 1859.

XIV.—*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.

Parts II. and III.

(Continued from Vol. xix., p. 573.)

Part II.—Produce of Constituents per Acre.

In order that the more directly practical conclusions to be drawn from the experiments might be brought out more prominently,

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* In the following letter to Mr. Fowler, Mr. Redman states the total number of acres steam-ploughed by him in the autumn, and again during last spring:—

Overtown, near Swindon, 17th May, 1859.

My dear Sir,—The set of Steam Plough Tackle you sent me, at the end of September last, has done good service: the more I use it the better am I satisfied with steam cultivation. Under no use of animal strength could the land be left in the mild and healthy state it at present presents. I have 60 acres under preparation for roots, which is in a very different condition from what it would have been had it been ploughed by cattle, and altogether different to what my land for roots has been at this time in former years. The quantity of land ploughed by me with steam last autumn was 210 acres—at a cost of 112*l.* 10*s.* 6*d.*, including incidental expenses, and a first start (this was accomplished by the 4th January)—in 50 working days, being 4¼ acres per day, which completed our winter work. In future I hope to finish all autumn cultivation by the end of November. I again brought out the tackle in March, and ploughed above 40 acres for a neighbour; since which I have ploughed 95 acres, and scarified 14 in 21 days, or about 5¼ acres per day. The cost of this I am not able to state accurately, as there are some bills not yet paid, but think I am safe in saying that it will not exceed 7*s.* per acre. The acreage cost I have no doubt will be much reduced when you send me a new set of your standard apparatus (as there will be less liability to casualties); this I shall be glad to have as soon as convenient. . . . . .

I am, &c.,

T. H. Redman.

attention was confined in the former section of our Report almost exclusively to the nature of the manures employed, and to the amounts of the gross produce or increase of hay obtained by their use. A few passing remarks only were made upon the variable character of the herbage, according to the description of manure employed. But there are other aspects of the subject than those hitherto considered, which are well worthy the attention of the intelligent farmer.

The permanent meadow land of a farm stands in a somewhat isolated position in regard to the crops under tillage. In the case of the *rotation* crops, the straw of the corn ones, the larger portion of the most important manurial constituents of the green crops, frequently the manure from the consumption of the hay of the meadow land itself, and perhaps that from imported cattle-food also, will, at least once in the course, find their way to the arable land. But the meadow land does not generally come in for a due share of restoration of constituents by the home manures. Hence it happens, that the amount of constituents actually carried from the land, year by year, in the hay crop, has generally a more direct influence on exhaustion, than that harvested in the rotation produce.

It is important to consider then—what amounts of the several constituents are taken from an acre of land in an ordinary crop of hay?—what is the drain of them, which the stores of the soil, or the supplies of other manures, are called upon to meet, when the produce is increased by means of active portable manures?—and further, what is the proportion of the active manurial constituent *nitrogen* supplied in such manures, that is recovered in the increase of crop obtained by its use?

It is also essential to a right appreciation of the action of different manures upon the grass-crop, carefully to ascertain their influence upon the development of the different plants of which the mixed herbage is made up, and at the same time to take into consideration the recognised comparative qualities of the different plants so developed.

Lastly, with a great variation in the proportion of the different plants developed, and in the degree of their maturity at any given time, according to season and the manure employed, it is obvious, that there must be corresponding variation in the per-centage composition of the complex produce—*hay*. The influence of the different manures upon the *chemical composition of the hay* constitutes, therefore, another important point of inquiry.

It would perhaps, in some points of view, be more in order to give the results of the analyses, and with them to consider the *per-centage* composition of the hay, before treating of the *acreage* yield of the several constituents, calculated by means of those

results; but it will, upon the whole, be more convenient to complete the subject of the *quantity* of produce before commencing upon that of *quality*.

Having, therefore, in Part I., considered the acreage amounts of the *gross produce*, or *hay*, attention will be directed in the present section (Part II.) to the acreage quantities of certain *constituents*, or *classes of constituents*, obtained by the different manures.

Part III. will be devoted to the discussion of one element of quality, namely, that of the description and proportion of the different plants developed.

Lastly, in Part IV., the *per-centage composition* of the complex produce—*hay*, will be considered.

The particulars relating to the amount of the several constituents, per acre, contained in the produce by the different manures, are given in a series of Tables, as follow:—

In Table III.—The produce of hay, per acre, calculated in lbs., as the basis of the succeeding Tables.

In Table IV.—The produce of total *dry substance*, per acre, in lbs.

In Table V.—The *mineral matter* (ash), per acre, in lbs.

In Table VI.—The *nitrogen* in the *total produce*, per acre, in lbs.

In Table VII.—The *nitrogen* in the *increase by manure*, per acre, in lbs.

In Table VIII.—The *proportion* of the *nitrogen recovered in increase, for* 100 *parts supplied in manure.*

1. *The Dry Matter per Acre.*

On the amounts of *dry matter*, per acre (Table IV.), a very few observations will suffice. Taking the average of the three years over which the experiments extended, the annual yield of dry matter was, *without manure*, almost exactly a ton per acre. This is slightly under the amount obtained, without manure, in *wheat* (corn and straw together), taking the average of fourteen years of the consecutive growth on the same land; and it is several hundredweights below that obtained in *barley*, without manure, taking the average of six years' consecutive growth on the same land.

By means of *manures*, the yield of dry matter, per acre, in the hay crop, was in several of the experiments considerably more than doubled. The increased produce of dry matter was thus great—indeed the greatest—where no carbonaceous manure whatever was employed. It may be reckoned that the dry substance of the hay would contain about 40 per cent. of carbon. Adopting this estimate, there would be about 900 lbs. of carbon assimilated per acre,

Table III.—Produce of Hay per Acre: lbs.

Plot, Nos.	MANURES. (Per Acre, per Annum.)	ANNUAL PRODUCE. 1856.	1857.	1858.	Average of 3 Years.	Average Annual Increase by Manure.
	Series 1.—Without Direct Mineral Manure.					
1	Unmanured	2515	2856	2472	2614	..
2	Unmanured (duplicate plot)	2351	2592	3360	2768	..
	Mean, or Standard Unmanured	2433	2724	2916	2691	..
3	2000 lbs. Sawdust	2312	2340	2244	2299	−392
4	200 lbs. each, Sulphate and Muriate Ammonia	4028	3774	3982	3928	1237
5	200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	3953	3710	4166	3943	1252
6	275 lbs. Nitrate of Soda	..	..	2952	..	261
7	550 lbs. Nitrate of Soda	..	..	3564	..	873
	Series 2.—With Direct Mineral Manure.					
8	*"Mixed Mineral Manure"	3429	3666	4082	3726	1035
9	"Mixed Mineral Manure," and 2000 lbs. Sawdust	3711	3994	4376	4027	1336
10	"Mixed Mineral Manure," and 200 lbs. each, Sulphate and Muriate Ammonia	6363	6422	7172	6652	3961
11	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	6369	6428	6892	6563	3872
12	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Cut Wheat-Straw	5412	6050	6752	6071	3380
13	"Mixed Mineral Manure," and 400 lbs. each, Sulphate and Muriate Ammonia	6970	6940	7508	7139	4448
14	"Mixed Mineral Manure," and 275 lbs. Nitrate of Soda	..	..	4236	..	1545
15	"Mixed Mineral Manure," and 550 lbs. Nitrate of Soda	..	..	5646	..	2955
	Series 3.—With Farmyard Manure.					
16	14 Tons Farmyard Manure	4030	5328	4164	4507	1816
17	14 Tons Farmyard Manure, and 100 lbs. each, Sulphate and Muriate Ammonia	5009	6008	5320	5446	2755

* For full description of the "*Mixed Mineral Manure*," see Part I. of this Paper, vol. xix., p. 556, of this Journal.

Experiments with Different Manures on Permanent Meadow Land.

Table IV.—Produce of Total Dry Substance per Acre: lbs.

Plot, Nos.	MANURES. (Per Acre, per Annum.)	ANNUAL PRODUCE. 1856.	1857.	1858.	Average of 3 Years.	Average Annual Increase by Manure.
	Series 1.—Without Direct Mineral Manure.					
1	Unmanured	2061¼	2431¾	2124½	2205½	..
2	Unmanured (duplicate plot)	1885¾	2262¾	2872	2340	..
	Mean, or Standard Unmanured	1973½	2347¼	2498¼	2273	..
3	2000 lbs. Sawdust	1866¼	2052¼	1893½	1937¼	−335¾
4	200 lbs. each, Sulphate and Muriate Ammonia	3222½	3272	3348	3280¾	1007¾
5	200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	3148¼	3251½	3496	3298½	1025½
6	275 lbs. Nitrate of Soda	..	..	2503¼	..	230¼
7	550 lbs. Nitrate of Soda	..	..	3059¼	..	786¼
	Series 2.—With Direct Mineral Manure.					
8	"Mixed Mineral Manure"	2751½	3179¾	3493½	3141½	868½
9	"Mixed Mineral Manure," and 2000 lbs. Sawdust	2987½	3466¾	3679¼	3377⅓	1104½
10	"Mixed Mineral Manure," and 200 lbs. each, Sulphate and Muriate Ammonia	5024¼	5591½	5889½	5501¾	3228¾
11	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	4924½	5606½	5778¼	5436½	3163½
12	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Cut Wheat Straw	4286¾	5249½	5562¾	5033	2760
13	"Mixed Mineral Manure,' and 400 lbs. each, Sulphate and Muriate Ammonia	5445	5967	6057½	5823	3550
14	"Mixed Mineral Manure," and 275 lbs. Nitrate of Soda	..	..	3660¾	..	1387¾
15	"Mixed Mineral Manure," and 550 lbs. Nitrate of Soda	..	..	4811½	..	2538½
	Series 3.—With Farmyard Manure.					
16	14 Tons Farmyard Manure	3068½	4652½	3521	3747¼	1474¼
17	14 Tons Farmyard Manure, and 100 lbs. each, Sulphate and Muriate Ammonia	3985¼	5181¼	4400¾	4522½	2249½

Table V.—Produce of Total Mineral Matter (Ash), per Acre : lbs.

Plot, Nos.	MANURES. (Per Acre, per Annum.)	ANNUAL PRODUCE. 1856.	1857.	1858.	Average of 3 Years.	Average Annual Increase by Manure.
	Series 1.—Without Direct Mineral Manure.					
1	Unmanured	157·4	160·7	141·0	153·1	..
2	Unmanured (duplicate plot)	156·1	148·0	186·8	163·7	..
	Mean, or Standard Unmanured	156·8	154·4	163·9	158·4	..
3	2000 lbs. Sawdust	153·0	132·0	113·8	132·9	−25·4
4	200 lbs. each, Sulphate and Muriate Ammonia	259·4	206·8	204·5	223·6	65·2
5	200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	237·5	206·5	222·1	222·0	63·6
6	275 lbs. Nitrate of Soda	..	..	169·1	..	10·7
7	550 lbs. Nitrate of Soda	..	..	191·7	..	33·3
	Series 2.—With Direct Mineral Manure.					
8	"Mixed Mineral Manure"	237·4	225·8	264·5	242·6	84·2
9	"Mixed Mineral Manure," and 2000 lbs. Sawdust	271·3	263·4	283·2	272·6	114·2
10	"Mixed Mineral Manure," and 200 lbs. each, Sulphate and Muriate Ammonia	431·2	403·3	468·5	434·3	275·9
11	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	447·9	412·4	468·7	443·0	284·6
12	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Cut Wheat Straw	364·1	394·9	451·2	403·4	245·0
13	"Mixed Mineral Manure," and 400 lbs. each, Sulphate and Muriate Ammonia	457·9	445·5	476·6	460·0	301·6
14	"Mixed Mineral Manure," and 275 lbs. Nitrate of Soda	..	..	271·1	..	112·7
15	"Mixed Mineral Manure," and 550 lbs. Nitrate of Soda	..	..	368·1	..	209·7
	Series 3.—With Farmyard Manure.					
16	14 Tons Farmyard Manure	293·9	346·7	279·8	306·8	148·4
17	14 Tons Farmyard Manure, and 100 lbs. each, Sulphate and Muriate Ammonia	376·5	387·6	358·4	374·2	215·8

Experiments with Different Manures on Permanent Meadow Land.

Table VI.—Produce of Nitrogen per Acre: lbs.

Plot, Nos.	MANURES. (Per Acre, per Annum.)	ANNUAL PRODUCE. 1856.	1857.	1858.	Average of 3 Years.	Average Annual Increase by Manure.
	Series 1.—Without Direct Mineral Manure.					
1	Unmanured	42·2	36·8	34·6	37·9	..
2	Unmanured (duplicate plot)	42·1	38·1	45·0	41·7	..
	Mean, or Standard Unmanured	42·2	37·4	39·8	39·8	..
3	2000 lbs. Sawdust	38·6	32·3	31·6	34·2	−5·6
4	200 lbs. each, Sulphate and Muriate Ammonia	63·2	58·5	65·7	62·5	22·7
5	200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	62·8	55·3	65·0	61·0	21·2
6	275 lbs. Nitrate of Soda	..	..	49·6	..	9·8
7	550 lbs. Nitrate of Soda	..	..	60·9	..	21·1
	Series 2.—With Direct Mineral Manure.					
8	"Mixed Mineral Manure"	57·3	55·4	57·1	56·6	16·8
9	"Mixed Mineral Manure," and 2000 lbs. Sawdust	65·7	59·1	60·8	61·9	22·1
10	"Mixed Mineral Manure," and 200 lbs. each, Sulphate and Muriate Ammonia	78·3	75·8	89·6	81·2	41·2
11	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	80·2	71·3	80·6	77·4	37·6
12	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Cut Wheat Straw	79·5	80·8	91·1	83·8	44·0
13	"Mixed Mineral Manure," and 400 lbs. each, Sulphate and Muriate Ammonia	103·8	112·4	128·4	114·9	75·1
14	"Mixed Mineral Manure," and 275 lbs. Nitrate of Soda	..	..	64·4	..	24·6
15	"Mixed Mineral Manure," and 550 lbs. Nitrate of Soda	..	..	74·5	..	34·7
	Series 3.—With Farmyard Manure.					
16	14 Tons Farmyard Manure	54·4	69·8	49·1	57·8	18·0
17	14 Tons Farmyard Manure, and 100 lbs. each, Sulphate and Muriate Ammonia	81·1	64·9	67·6	71·2	31·4

Table VII.—Nitrogen per Acre in Increase where a Known Quantity was supplied in Manure: lbs.

Plot, Nos.	MANURES. (Per Acre, per Annum.)	Increase over the Produce without Manure.				Increase over the Produce by the "Mixed Mineral Manure."			
		1856.	1857.	1858.	Average of 3 Years.	1856.	1857.	1858.	Average of 3 Years.
	Series 1.—Without Direct Mineral Manure.								
4	200 lbs. each, Sulphate and Muriate Ammonia	21·1	21·0	25·9	22·7	..	..	..	..
5	200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	20·7	17·8	25·2	21·2	..	..	..	..
6	275 lbs. Nitrate of Soda	..	..	9·8	..	..	..	..	..
7	550 lbs. Nitrate of Soda	..	..	21·1	..	..	..	..	..
	Series 2.—With Direct Mineral Manure.								
10	"Mixed Mineral Manure," and 200 lbs. each, Sulphate and Muriate Ammonia	36·1	38·3	49·8	41·4	21·0	20·4	32·5	24·6
11	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	38·1	33·9	40·8	37·6	23·0	16·0	23·5	20·8
12	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Cut Wheat Straw ..	37·4	43·4	51·3	44·0	22·3	25·5	34·0	27·2
13	"Mixed Mineral Manure," and 400 lbs. each, Sulphate and Muriate Ammonia	61·7	75·0	88·6	75·1	46·6	57·1	71·2	58·3
14	"Mixed Mineral Manure," and 275 lbs. Nitrate of Soda	..	..	24·6	..	..	..	7·2	..
15	"Mixed Mineral Manure," and 550 lbs. Nitrate of Soda	..	..	34·7	..	..	..	17·4	..
	Series 3.—With Farmyard Manure.*								
17	14 Tons Farmyard Manure, and 100 lbs. each, Sulphate and Muriate Ammonia*	26·7	−4·9	18·4	13·4	..	..	..	..

* The Increase is here taken over the produce by Farmyard Manure alone.

Experiments with Different Manures on Permanent Meadow Land.

Table VIII.—Nitrogen *recovered*, and *not recovered*, in Increase, for 100 supplied in Manure.

Plot, Nos.	MANURES. (Per Acre, per Annum.)	Increase taken over the Produce without Manure.					Increase taken over the Produce by the "Mixed Mineral Manure."				
		Per-cent. of supplied Nitrogen recovered in Increase.				Average Per-cent. of supplied Nitrogen not recovered in Increase.	Per-cent. of supplied Nitrogen recovered in Increase.				Average Per-cent. of supplied Nitrogen not recovered in Increase.
		1856.	1857.	1858.	Average of 3 Years.		1856.	1857.	1858.	Average of 3 Years.	
	Series 1.—Without Direct Mineral Manure.										
4	200 lbs. each, Sulphate and Muriate Ammonia ..	25·7	25·7	31·6	27·7	72·3	..	..	..	..	..
5	200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	23·9	20·6	29·1	24·5	75·5	..	..	..	..	..
6	275 lbs. Nitrate of Soda	..	..	23·8	..	..	..	..	..	..	..
7	550 lbs. Nitrate of Soda	..	..	25·8	..	..	..	..	..	..	..
	Mean	24·8	23·1	..	26·1	73·9	..	..	..	..	..
	Series 2.—With Direct Mineral Manure.										
10	"Mixed Mineral Manure," and 200 lbs. each, Sulphate and Muriate Ammonia	44·0	46·7	60·8	50·5	49·5	25·6	24·9	39·6	30·0	70·0
11	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust ..	44·0	39·2	47·2	43·5	56·5	26·6	18·5	27·2	24·1	75·9
12	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Cut Wheat Straw	39·5	45·8	54·2	46·5	53·5	23·6	26·9	35·9	28·8	71·2
13	"Mixed Mineral Manure," and 400 lbs. each, Sulphate and Muriate Ammonia	37·6	45·7	54·0	45·8	54·2	28·4	34·8	43·4	35·5	64·5
14	"Mixed Mineral Manure," and 275 lbs. Nitrate of Soda	..	..	59·9	..	..	..	..	17·7	..	..
15	"Mixed Mineral Manure," and 550 lbs. Nitrate of Soda	..	..	42·3	..	..	..	..	21·2	..	..
	Mean	41·3	44·4	54·0	46·6	53·4	26·0	26·3	36·5	29·6	70·4
	Series 3.—With Farmyard Manure.										
17	14 Tons Farmyard Manure, and 100 lbs. each, Sulphate and Muriate Ammonia*	65·2	−12·0	44·9	32·7	67·3	..	..	..	..	..

* The Increase is here taken over the produce by Farmyard Manure alone.

acre, in the average annual produce of the unmanured land. Where an enormous amount of organic matter, rich in carbon, was supplied in the form of sawdust, little or no increased assimilation of carbon took place; where a still larger quantity was employed in the form of farm-yard manure (in admixture, therefore, with other active manurial matters), there was a considerable increase in the assimilation of carbon. But, under these circumstances, it is doubtful whether the farm-yard manure itself was the source of the increased amount of carbon fixed, or, at any rate, whether its supply of that substance (in the form of carbonic acid or otherwise) has been at all essential.

Thus, it was by means of mixtures of mineral manures and ammoniacal salts, without the direct supply of any carbon, that the greatest increased assimilation of that substance was obtained. For instance, on plots 10 and 13, there was an average of about $1\frac{1}{2}$ tons of increase of dry substance per acre, per annum, by the use of the mixed mineral manure and ammoniacal salts. This amount of gross dry increase represents an increased assimilation of carbon, by about 12 cwts. per acre per annum, without the supply of any in the manure. To this enormous extent, therefore, have these *non*-carbon-yielding manures enabled the plants, either by their roots or their leaves, to draw that element, so essential for the maintenance of the respiration, and for the fattening of our animals, from the *atmosphere*:—into which, in the course of the ever-constant revolutions of organic nature, it had been emitted by the combustion or decomposition of the products of former vegetation, or by the respiration of animals fed on former crops:—and into which, it is destined to be returned by the same means, as the resource of future vegetable growth.

It was seen, how unavailing were *mineral manures alone* materially to increase the growth of the *Graminaceous* hay-plants. That is to say, by their supply alone, these plants were not enabled to assimilate an increased amount of either nitrogen or carbon from natural sources. Nor did the supply of one of these elements — *carbon* — enable the plants to draw from natural sources an increased amount of the other element—*nitrogen*. On the other hand, provided there were a sufficiency of the necessary mineral constituents, the supply of the element *nitrogen*, in an available form of combination, increased enormously the assimilation of the atmospheric constituent *carbon*. It may be remarked in passing, that a very similar result is observed when nitrogenous manures are employed for the *Graminaceous crops of our rotations*. Not that no other crops are found to assimilate an increased amount of carbon without its supply in manure, when they have a sufficiency of mineral constituents and available nitrogen within the soil. But compared with others, the

Graminaceous crops appear to be the most strikingly independent of any artificial carbonaceous supply.

2. *The Mineral Matter per Acre.*

The average annual yield per acre of *mineral matter* (Table V.) was, in the *unmanured hay-crop*, 158½ lbs. This, it may be observed, is about 1½ times as much as was contained in the annual *unmanured* produce of either *wheat* or *barley*.

By the use of *ammoniacal salts alone*, an average of 223½ lbs., or about 2 cwts. of mineral matter, was annually taken from the land in the hay-crop. This, again, is from 1⅓ to 1½ times as much as was removed in either wheat or barley when similarly manured; that is, by ammoniacal salts alone. By the *addition of mineral manures to the same amount of ammoniacal salts*, the quantity of mineral matter annually taken off the land in the hay-crop was increased to nearly 4 cwts. per acre. Against this amount, *farm-yard manure* gave an average of only 306¾ lbs. of mineral matter in its annual yield of hay, notwithstanding that it itself contained not only a very large amount of mineral constituents, but of nitrogen also, which is so essential to bring them into play. This comparatively defective action of the constituents of farm-yard manure is, doubtless, owing in great measure to the slow liberation of both the nitrogen and the mineral matter supplied in that form. When *ammoniacal salts* were used in *addition to the farm-yard manure*, still only 374¼ lbs. of mineral matter were annually taken from the land; that is to say, still considerably less than when the whole of both the nitrogen and the mineral matter were provided in a more readily available condition.

It is more particularly in *potash*,* that the hay-crop is more exhausting than what might be called a corresponding produce of either wheat or barley. In relation to this point, attention should be called to the fact, that, as practice goes, almost as a matter of course, a notable proportion of the phosphoric acid, and of the magnesia, almost the whole of the silica, and by far the larger proportion of both the lime and the potash, taken from the land in the *wheat* and the *barley* crops, will, at some period of the rotation, be returned to it, in the home-manures to which the straw of these crops has contributed. But, in the case of *meadow-land* associated with land under tillage, it is by no means so probable,

* Independently of the fact that an ordinary hay-crop will contain more mineral matter than the corn and the straw of an ordinary wheat or barley crop, the ash of the *hay* contains about twice as high a per-centage of *potash*, as that of the gross produce (corn and straw) of *wheat* or *barley*. But further particulars will be given regarding the *individual mineral constituents* of the hay-crop, in Part IV. of our Paper.

that the mineral constituents of the hay will, in anything like a corresponding degree, find their way back from whence they came. It will be obvious, therefore, that, according to current practice, the meadow-land will be much more liable than the arable to become deficient in a due provision of the necessary mineral constituents. These considerations show that both the wheat and the barley-crops may, with comparative impunity, be kept up to a high point of productiveness by means of forcing portable manures, provided only that the crops of the course, as a whole, receive their due share of the home manures. It will, at the same time, be equally obvious, that similar means are not applicable for the production of full crops of hay, unless similar conditions be provided; that is to say, unless the meadow, in its turn, receive a due proportion of the home manures.

Where, however, grass is grown for hay by those holding little or no arable land, it is generally for the supply of a neighbouring town; and in such cases a liberal amount of stable and other town-manures is generally brought upon the land. Under these circumstances, the additional use of the more active portable manures, will not, as a rule, be advantageous.

3. *The Nitrogen per Acre.*

Attention must now be directed to the acreage yield in the hay of the important constituent *nitrogen*. In the experiments under consideration, the annual yield of nitrogen per acre, taking the average result of 3 years, was, *without manure*, 39·8 lbs. (see Table VI.). By the side of this amount it may be mentioned, that the average of 14 consecutive years of *unmanured wheat* gave 30·7 lbs.; and that of 6 consecutive years of *unmanured barley*, 26·5 lbs. of nitrogen.

From these figures it appears, that the hay-crop (so far as the experiment has yet extended) has given from one-third to one-half more nitrogen per acre per annum, without manure, than either wheat or barley. Part of this excess of nitrogen in the hay-crop, though probably not the whole of it, is due to the fact, that the *mixed herbage* of the hay comprised a number of *Leguminous* plants, which contain a higher per-centage of nitrogen, and have apparently greater powers of assimilating it from natural sources, than the *Graminaceous* ones. Indeed, where mineral manures alone were employed (Plot 8), under the influence of which the development of *Leguminous* plants was greater than on any of the other plots, there was an average of 56·6 lbs. per acre per annum of nitrogen, without the supply of it in manure, instead of only 39·8 lbs. without manure of any kind. Thus, without the addition of any nitrogenous manure, there was

here an average annual increase of 16·8 lbs. of nitrogen per acre. But this increased yield of nitrogen obtained by the use of mineral manures, it is to be observed, was not due to an increased development of the *Graminaceous*, but to that of the *Leguminous* portion of the herbage. In fact, the annual yield of nitrogen per acre in this case, where the *Leguminous* plants comparatively so much predominated, was nearly double that which has been obtained in the continuously unmanured cereal crops of the arable land.

The next point of consideration in regard to the *nitrogen-statistics* of the *hay-crop*, is one of great interest, both in a practical and scientific point of view; namely, that of the relation of the nitrogen in the *increase*, to that in the *manure* employed to produce it. Tables VII. and VIII. illustrate this part of the subject. Table VII. shows the *actual increase* of nitrogen in the produce (in lbs. per acre), where it was supplied in manure. Table VIII. shows the *proportion* of nitrogen recovered in the increase, for 100 of it supplied in manure. But in both Tables two sets of columns are given. The first of these relates to the increase of nitrogen over that in the *unmanured* produce, and the second to the increase over that in the produce by the "*mixed mineral manure.*" The reader has thus the facts put before him in two aspects. It appears to us, however, from a careful consideration of all the circumstances of the experiments, that the only legitimate mode of estimating the amount, or proportion, of nitrogen recovered in the increase of hay, for a given amount of it supplied in the manure, will be to assume the nitrogen of the *unmanured*, and *not* that of the *mineral manured produce*, as the standard or normal yield, upon which to calculate the increase obtained by the action of nitrogenous manure, whether this be used alone, or in addition to mineral manures.

Thus, it must be remembered, that the increase, both of gross produce and of nitrogen, was, when *mineral manures alone* were employed, due to an increased development of *Leguminous* plants. On the other hand, when nitrogenous manures were used, either alone or in combination with mineral manures, the increase was due to the increased development of the *Graminaceous* herbage only. Under these circumstances, it is obvious, that the whole increase by the combined action of both nitrogenous and mineral manures (it being almost entirely graminaceous), must be supposed to be due, *so far as the resources of nitrogen are concerned*, to that artificially supplied in the manure. That is to say, bearing in mind the difference in the *description* and *composition* of the herbage grown by mineral manures alone, and by mineral manures in admixture with nitrogenous ones, the influence of the

addition of the nitrogen is not represented simply by the difference between the prominently *Leguminous* produce by mineral manures alone, and the almost exclusively *Graminaceous* produce, when nitrogenous as well as mineral manures are employed. It will be obviously much nearer the truth to assume, that the artificially supplied nitrogen—whether employed alone or in conjunction with mineral manures—was engaged in the production of *at least* the whole amount of increase *above* the produce *without manure.*

In fact, it is not impossible that, in even this mode of estimate, the degree in which the artificially-supplied nitrogen has been involved in the amount and composition of the produce, is somewhat understated. For, even the *unmanured* produce contained more of the highly-nitrogenized *Leguminous* herbage, than did that grown by either ammoniacal salts alone, or by ammoniacal salts in conjunction with mineral manure. Hence, it might be concluded, that the point beyond which the artificially-supplied nitrogen became involved in the production of *Graminaceous* increase, would be even *below* that represented by the acreage yield of nitrogen *without manure.* For, that amount depended materially upon the quantity of the highly *Leguminous* herbage in the unmanured produce, which was at once diminished on the addition of nitrogenous manures.

For the above reasons, then, it is assumed that, at least the whole of the nitrogen in the produce by nitrogenous manures *beyond that yielded on the unmanured plot* may be calculated as due, in a certain sense, to that which was artificially supplied—whether or not the nitrogen was so supplied alone, or was aided in its action by conjunction with mineral manures. At the same time, it is freely granted, that the legitimacy of any estimates regarding the proportion of the nitrogen supplied by manure which is involved in the increase obtained by its use, must rest entirely on that of the assumption made as to the amount of the whole nitrogen of the produce, which is to be attributed to natural sources. It is not, indeed, possible, to obtain actual proof, that produce grown by nitrogenous manures has really assimilated *neither more nor less* of nitrogen from other sources, than that grown without them. It might be supposed that, with a ready supply of available nitrogen within a limited range of the soil, the plants would draw less upon the natural or unaided resources. On the other hand, it might be assumed that, with the increased vigour of growth due to nitrogenous manure, the feeders of the plant would be so extended, both above and under ground, as to increase its command over the natural resources of available nitrogen. It is obvious, therefore, that the best estimate to which our judgment can lead, cannot, after all, be looked upon

as representing with certainty, the exact proportions in which the nitrogen of the manured produce has, in point of fact, been obtained from the natural and the artificial sources respectively. These observations will sufficiently indicate the degree of reservation with which the figures in the Tables, and the arguments founded upon them, should be accepted.

In regard to the figures in Table VII., which show in lbs. the *actual increase of nitrogen per acre by its use in manure*, it should be explained, that, where 400 lbs. of ammoniacal salts, or 550 lbs. of nitrate of soda, were employed per acre, it is estimated that 82 lbs. of nitrogen were thereby supplied. The 275 lbs. of nitrate of soda is, of course, assumed to supply half, and the 800 lbs. of ammoniacal salts double that amount. The 2000 lbs. of sawdust, according to direct analysis, would contain only $4\frac{1}{2}$ lbs. of nitrogen. It is, then, to these amounts of nitrogen *supplied*, that those recorded in the Table as *increase*, are to be respectively referred.

But it is in Table VIII., where the *increase* of nitrogen in the produce is, for each experiment, calculated in relation to 100 parts of it supplied in manure, that the *proportion* of the nitrogen assumed to be recovered, to that supplied, is brought to view the most clearly.

Where ammoniacal salts were used alone (see upper Division of Table VIII.), there was, taking the average of the three years, only 27·7 *per cent.* of the supplied nitrogen recovered in the increase. And where the ammoniacal salts and sawdust were used, there was somewhat less still recovered, namely, 24·5 per cent.

The nitrate of soda, which was employed in one season only, and then sown somewhat disadvantageously late, when it was used alone, returned in the increase of produce nearly the same proportion of its nitrogen as the ammoniacal salts (as just quoted)—namely, 23·8 per cent. when the smaller amount, and 25·8 when the larger amount of the salt was used. But in reference to this result, it should be mentioned, that the *percentage* of nitrogen in the hay grown by the nitrate, was notably higher than in that grown by the ammoniacal salts in the same season; in fact, the proportion of nitrogen in the former was somewhat abnormally high.

The result was, then, that where either ammoniacal salts or nitrate of soda were employed without the aid of the mineral manure, there was only about *one-fourth* of the supplied nitrogen recovered in the immediate increase of the hay-crop.

In connexion with the result just stated, attention may be called to the fact, that if, where both mineral and nitrogenous manures are employed (see lower Division of Table VIII.), the

increase of nitrogen in the produce by the use of it in manure is supposed to be represented by *so much only* as was over and above that yielded by the *mineral manures alone*, there would then appear to be only about the same proportion of the supplied nitrogen recovered as when the nitrogenous manures were used alone, and the increase of nitrogen then calculated over that in the *unmanured* crop. Thus, taking, as supposed, the yield of nitrogen by the *mineral manures alone* as the basis of the calculation, the increase obtained by the super-addition of the 400 lbs. of ammoniacal salts will have returned only 30 per cent.; that by the 400 lbs. of ammoniacal salts, and 2000 lbs. of sawdust, only 24·1 per cent.; that by the 400 lbs. of ammoniacal salts and 2000 lbs. of cut wheat-straw, only 28·8 per cent.; and that by the 800 lbs. of ammoniacal salts, 35·5 per cent., of the supplied nitrogen. In regard to the fact, that there appears to be a larger proportion of the supplied nitrogen recovered (35·5 per cent.) when the extravagant amount of 800 lbs. of ammoniacal salts per acre was employed, it may be stated that the result is due to an extremely *high percentage* of nitrogen in the produce, and not to a favourable proportion of increase. The larger return of the supplied nitrogen is, therefore, though an apparent, yet only a questionable advantage. Adopting the same mode of calculation as above, the addition of nitrate of soda to the mineral manures gave a less favourable result than that of ammoniacal salts. When 41 lbs. of nitrogen were employed in the form of nitrate, there were only 17·7 per cent.; and when 82 lbs. of nitrogen were so provided, there were only 21·2 per cent. of the supplied nitrogen recovered in the increase.

But, reckoning, as has been shown it would be more proper to do, that the whole of the nitrogen obtained by the conjoint action of the mineral and nitrogenous manures *beyond that yielded without manure*, has probably been due to that artificially supplied, the proportional return in the immediate increase then appears to be much greater. On this mode of estimation, the 400 lbs. of ammoniacal salts (with mineral manure) have returned in the increase 50·5 per cent.; the 400 lbs. of ammoniacal salts and 2000 lbs. of sawdust (with mineral manure) 43·5 per cent.; the 400 lbs. of ammoniacal salts and 2000 lbs. of cut wheat-straw (with mineral manure) 46·5 per cent.; the 800 lbs. of ammoniacal salts (with mineral manure) 45·8 per cent.; the 275 lbs. of nitrate of soda (with mineral manure) 59·9 per cent.; and the 550 lbs. of nitrate of soda (with mineral manure) 42·3 per cent., of the nitrogen supplied in the manure.

Taking the average of the results just quoted, there were about 48 per cent. of the supplied nitrogen recovered in the immediate increase of the hay-crop, when the nitrogenous manure was asso-

ciated with a liberal provision of the necessary mineral constituents. Such at any rate is the result, on the assumption that as much of the nitrogen of the produce as was *in excess of that obtained without manure*, is to be attributed to that which was *artificially supplied*. When, however, the same nitrogenous manures were employed without the aid of mineral manures, only about half as much of the supplied nitrogen appeared to be recovered in the immediate increase. There was, moreover, little more than half as much of the supplied nitrogen estimated as recovered, if, when mineral and nitrogenous manures were used together, the yield of nitrogen by the *mineral manures alone*, instead of that *without manure*, were assumed to represent the amount obtained from natural sources. But, even though the *larger* amount may more nearly represent the actual proportion of the supplied nitrogen which was recovered in the increase when mineral manures were also used, it will be, at the same time, obvious that, in a certain *practical* sense, the only *gain* of nitrogen in produce by the addition of it to mineral manures, is that amount beyond what would have been obtained by the *mineral manures alone*.

On other occasions it has been shown, that, in the growth of full crops of either *wheat* or *barley* by the direct application of nitrogenous manures, little more than 40 per cent. of the supplied nitrogen could be estimated as recovered in the immediate increase obtained. It might perhaps be anticipated, that the result would be different in the case of the *hay-crop*. Not only are but few of the plants composing it fully ripe at the time of being cut, but their roots have a much more complete possession of the whole area of the superficial layers of soil. So far as the experiments have yet extended, the *hay-crop* does not appear to return in its immediate increase, a larger proportion of the supplied nitrogen compared with *wheat* or *barley*, than might perhaps with reason be attributed to the more extended distribution of the feeders of the crop on a given area of land.

It appears, then, from the evidence as yet at command, that in the case of the *grass-crop*, as in that of the *ripened cereal grains*, a considerable proportion of the expensive constituent—*nitrogen*—which may be supplied in manure, has to be reckoned as *unrecovered* in either the immediate or the closely-succeeding increase of crop.

The possible explanations of this loss of nitrogen—real or apparent as the case may be—are numerous ; but they are more or less within the reach of careful and extended experimental inquiry. It may be supposed—that a portion of the unrecovered amount of nitrogen is, in some form, drained away and lost?—that the supplied nitrogenous compound is transformed in the soil,

and nitrogen in some form evaporated?—that a portion remains in the soil in some fixed and unavailable state of combination?—that ammonia, or some other compound of nitrogen, or free nitrogen itself, is given off during the growth of the plant?—or, it may be, that the range of distribution of the supplied nitrogen, and its state of combination within the soil, are alone sufficient obstacles to its being taken up in larger proportion by the immediate crop? Should the last supposition afford a sufficient explanation of the facts observed, the assumed loss would be one but in appearance merely. The farmer might then still hope to reap the whole benefit of his costly nitrogenous manures, in the course of time, in succeeding crops. Be this as it may, the facts that have been recorded afford additional confirmation of the opinion so frequently insisted upon, that, in the case of the *Graminaceous* plants which we cultivate, a full crop is obtained only when there is a liberal provision of *available nitrogen within the soil;* and, further, that when this provision is made by means of direct nitrogenous manures, a large proportion of the so-supplied nitrogen will remain *unrecovered in the increase of crop*, at least for a considerable period of time.

The main facts elicited on a consideration of the *acreage yield* in the *hay-crop*, of some of its important *constituents*, or *classes of constituents*, according to the condition of manuring, may be summed up as follow:—

1. The average annual produce of *Total Dry Substance*, in the *unmanured meadow-hay-crop*, was about 1 ton per acre, which would contain about 900 lbs. of *carbon*. These amounts are somewhat less than were annually obtained *without manure* in either *wheat* or *barley*.

2. *Purely carbonaceous manures* did not appear to increase the assimilation by the *Graminaceous* herbage of either *carbon* or *nitrogen*.

3. *Purely mineral manures* induced little or no increased assimilation of either *carbon* or *nitrogen* by the *Graminaceous*, but a considerable amount by the *Leguminous* herbage.

4. *Specially nitrogenous manures*, such as ammoniacal salts, even when used alone, notably increased the assimilation of *carbon* and *nitrogen* by the *Graminaceous*, but not by the *Leguminous* herbage.

5. By means of manures supplying *both mineral constituents and nitrogen*, but no carbon, there was an annual increase of *Graminaceous* produce, equal to about $1\frac{1}{2}$ ton of *dry substance* per acre, which would contain about 12 cwts. of *carbon*.

6. The annual yield of *mineral constituents* in the *unmanured*

hay-crop was nearly 1½ cwt. This amount is about one and a-half times as much as was contained in either *wheat* or *barley* when *unmanured*.

7. By means of *mineral manure alone*, or *ammoniacal salts alone*, the annual yield of *mineral matter* in the hay-crop was raised to about 2 cwts. per acre; and by *mineral and nitrogenous manure combined*, to about 4 cwts. per acre.

8. It is particularly in *potash*, that the *hay-crop* is more exhaustive of soil-constituents, than either *wheat* or *barley*.

9. Owing to the comparatively large amount of *mineral constituents* taken from the land in the *hay-crop*—to the less regular return of them by the *home manures*—and to the less exposure of the soil in the case of *meadow-land*—more special attention is required to prevent *its* practical exhaustion of soil-constituents, than in the case of *arable-rotation-land*.

10. The annual yield of *nitrogen* per acre was, in the *unmanured hay-crop*, nearly 40 lbs. This is from one-third to one-half *more* than was annually obtained in *unmanured wheat* or *barley*.

11. The hay grown by *mineral manures alone*, yielded considerably *more nitrogen per acre* than that grown *without manure*. The increased amount was due to an increased growth of the *Leguminous*, and not of the *Graminaceous* herbage.

12. *Nitrogenous manures alone* (ammoniacal salts and nitrate of soda) gave an *increase of nitrogen in the produce* equal to only about *one-fourth of that supplied in the manure*.

13. *Mineral and nitrogenous manures combined* gave an *increased produce of nitrogen* equal to from 45 to 50 per cent. of the *nitrogen supplied in the manure*. *Wheat* and *barley*, under similar circumstances, gave an increased produce of nitrogen equal to rather more than 40 per cent. of that supplied in the manure. The rather more favourable result with the *hay-crop* is not more than is probably attributable to the more complete distribution of the under-ground feeders of the crop.

14. In the case of the *meadow-grasses*, as in that of the *Graminaceous plants grown in rotation*, the growth was much increased by *direct nitrogenous manures;* and, in both cases, from 50 to 60 per cent. of the *supplied nitrogen* remained *unrecovered* in either the immediate, or the closely-succeeding increase of crop.

Part III.—Description of Plants developed by different Manures.

Perhaps the most remarkable and interesting of the effects of the different descriptions of manure, upon the complex herbage of which the experimental meadow was composed, was the very

varying degree in which they respectively developed the different kinds of plants.

Allusion has already frequently been made, in a cursory way, to the greater development of the *Leguminous* herbage by purely *mineral manures*, and to that of the *Graminaceous* plants, or natural grasses commonly so-called, by characteristically *nitrogenous manures*. In fact, the plots had each so distinctive a character in regard to the prevalence of different plants, that the experimental ground looked almost as much as if it were devoted to trials with different seeds as with different manures. So striking and characteristic, indeed, were the effects produced in this respect, that, in 1857 and 1858, the subject was thought of sufficient interest to induce us to request the examination of the plots by Professor Henfrey, to which he kindly assented.

An endeavour was also made in the second year, 1857, to separate, and determine, the proportion of the different plants in carefully averaged and weighed samples, taken from the several plots as soon as the grass was cut. Taking advantage of the experience gained in this first trial, the separations have been carried out more carefully in the case of the produce on some of the most important plots in the third season, 1858. The results of these separations are recorded in detail in Table IX., p. 250, and in a summary form in Table X., p. 252 ; and it is the consideration of those results that will constitute the subject of this Third Part of our Report.

The mode of proceeding in making the separations and estimations may be shortly explained. As soon as the grass on a plot was cut down, samples were taken from many parts of it. These were carefully intermixed in such manner as to shake out as little seed as possible; and then, from the whole, a certain quantity was weighed out to be further operated upon. Characteristic specimens of each of the plants *in flower or seed*, or in other conditions in which they could be recognised, were then selected as types ; and a number of boys were set to pick from the weighed sample, all they could find to correspond with these types. The remainder consisted chiefly of *detached foliage, and undeveloped stems*, which was then separated into four or five different lots, according to types selected to the best of our judgment. Each weighed sample was thus divided into from fifteen to twenty different descriptions of herbage. The weight of each of the selected portions was afterwards taken—all in an equal condition of dryness. The weights so obtained, of the respective grasses, or other plants, or parts of plants, in the original weighed sample from the plot, were then calculated into their percentage relation to the collective weight of the whole of the separated portions in their partially dried state. It is the results

so obtained that are recorded in the Tables. It should be mentioned, that we are indebted to Dr. Evan Pugh, of Pennsylvania, for the superintendence of the Botanical part of the inquiry.

It will be obvious, that absolute exactness in the determination of the proportions in which the different plants really occurred on the respective plots, would be extremely difficult to attain. If the bulk of the sample taken were so large as to exclude all possible doubt of its being a fair average of the whole produce, the labour of the separations would be so great as to be almost impracticable. There is, however, no doubt that the Tables do, in the main, very closely represent the facts. They do so, at any rate, quite sufficiently to bring very strikingly to view the most characteristic and important distinctions that were observed to be developed.

In the respective columns of the Table of detail (IX.) are given:—

1st. The Botanical names of the plants.
2nd. The Common or English names.
3rd. The *percentage proportions* of each plant, &c., on some of the most important of the experimental plots.
4th. Notes taken on a comparative examination of the specimens.

The plots selected for the Botanical analysis of their produce were:—

Plot 1. Unmanured.
Plot 4. With ammoniacal salts alone.
Plot 8. With the "mixed mineral manure"* alone.
Plot 10. With the "mixed mineral manure," and ammoniacal salts.
Plot 13. With the "mixed mineral manure" and the double quantity of ammoniacal salts.
Plot 16. With farmyard manure.
Plot 17. With farmyard manure and ammoniacal salts.

The separated plants are classified into:—

1st. Graminaceous herbage (Grasses commonly so called), in culm, bearing flower or seed.
2nd. Graminaceous herbage, detached leaf and undeveloped stem.
3rd. Leguminous herbage.
4th. Miscellaneous herbage, chiefly weeds.

Within each of these classes, the plants are enumerated in the Table, *in the order in which they respectively occurred in the largest*

* For full description of the "*Mixed Mineral Manure*," see Part I. of this Paper, vol. xix., p. 556 of this Journal.

proportion on the unmanured plot. The comparison of the figures in the column relating to any particular *manured* plot, with those relating to the *unmanured*, thus shows at once, the deviation from the standard result which is induced by the manure in question, both as regards the *order* as to quantity, and the *actual numerical proportion*, in which the different descriptions of herbage were found to be developed.

In addition to the above explanation, it will be an useful further preliminary to the discussion of the effects of the different manures, to make a few remarks on the general character of the herbage of the experimental meadow.

In the third season (1858), to which our Table of separations refers, there was no *Dactylis glomerata* (Rough Cock's-foot), no *Poa pratensis* (Smooth-stalked Meadow-grass), no *Bromus mollis* (Soft Brome-grass), and no *Avena pratensis* (Meadow Oat-grass), detected in the produce of the *unmanured* plot. The Rough Cock's-foot and Smooth-stalked Meadow-grass occurred, however, on some of the manured plots; and each in large proportion under certain conditions of manuring. But the Soft Brome-grass, and Meadow Oat-grass, occurred in very few cases at all, and then in very small quantity. There was, too, a striking absence, on all the plots, of several esteemed permanent meadow-grasses. Thus *Alopecurus pratensis* (Meadow Foxtail), *Festuca pratense* (Meadow Fescue), *F. duriuscula* (Hard Fescue), *Phleum pratense* (Meadow Cat's-tail), and *Poa trivialis* (Rough-stalked Meadow-grass), were not found in our list at all in the third season, 1858. The Meadow Fox-tail, the Meadow Cat's-tail, and a Fescue-grass were, however, each observed on one or more of the plots in 1857.

Attention may now be directed to the comparative development of each of the plants according to the manure employed, taking each *seriatim*, in the order in which it predominated on the unmanured land. A short statement of the reputed characters of each, as to its adaptation to local conditions, and as to its recognised agricultural value, will, at the same time, be given.* The comparative development of the different *Graminaceous* plants will be first considered. The records relating to these are given in the two upper Divisions of the Table (IX.); those in the first refer to the plants *in culm*, and those in the second to the *leafy and indeterminate Graminaceous produce.*

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* See on these points, Lawson's 'Synopsis of Vegetable Products,' &c.; Bravender's 'Prize Report,' Journal of the Royal Agricultural Society of England, vol. v., part ii.; Professor Buckman's Papers, Journal of the Royal Agricultural Society of England, vol. xv., p. 462, vol. xvii., p. 162, and vol. xvii. p. 513; Donaldson 'On Manures and Grasses;' and Morton's 'Cyclopædia of Agriculture.'

EXPERIMENTS with DIFFERENT MANURE

TABLE IX.—Showing the Description and Proportions of the Different kinds c

DESCRIPTION OF THE HERBAGE.		PER-CENTAGE AMOUNTS OF EACH				
			Artificial Manures.			
Botanical Names.	Common Names.	Unmanured. (Plot 1.)	Ammoniacal Salts alone. (Plot 4.)	"Mixed Mineral Manure." (Plot 8.)	"Mixed Mineral Manure" and Ammoniacal Salts. (Plot 10.)	"Mixed Mineral Manure" and double quantity Ammoniacal Salts (Plot 13.)
	1.—Graminaceous Herbage; Stem					
Lolium perenne	Common rye-grass	16·77	14·73	23·39	32·23	12·10
Holcus lanatus	Woolly soft-grass, or Yorkshire Fog.	14·02	14·43	6·94	32·64	26·37
Arrhænatherum avenaceum	Fibrous-rooted, tall oat-like grass	6·04	3·27	9·07	4·84	2·56
Anthoxanthum odoratum	Sweet-scented vernal grass	5·43	0·41	1·01	0·09	..
Agrostis vulgaris	Common or creeping-rooted bent-grass, also black switch, &c.	4·82	0·97	0·03	1·48	2·16
Briza media	Common quaking-grass	2·07	0·41	1·01	..	..
Cynosurus cristatus	Crested dog's-tail grass	1·10	0·05	0·39	..	0·05
Dactylis glomerata	Rough cock's-foot	..	1·64	..	1·38	20·17
Poa pratensis*	Smooth-stalked meadow grass*	..	..	..	..	..
Bromus mollis	Soft or downy brome-grass	..	..	..	..	0·10
Avena pratensis	Meadow oat-grass	..	..	0·34	..	1·57
	Total	50·25	35·91	42·18	72·66	65·08
	2.—Graminaceous Herbage; detache					
Leafy produce—from woolly soft-grass		3·41	12·28	5·46	4·06	15·35
Coarse leaf, &c.—some bent-grass; probably also cock's-foot, soft brome-grass, and others		8·78	11·46	1·79	6·64	3·93
Middling leaf—chiefly bent-grass; some meadow oat-grass, &c.		3·41	8·18	14·33	4·43	..
Fine leaf, &c.—unknown; possibly some Festuca bromoides, or barren fescue-grass		7·81	16·37	5·82	2·58	1·18
Dead leaves and stems		2·44	4·91	2·24	7·01	11·81
	Total	25·85	53·20	29·64	24·72	32·27
	3.—Leguminou					
Lathyrus pratensis	Yellow or meadow vetchling	2·07	2·20	4·53	..	..
Lotus corniculatus	Common bird's-foot trefoil	1·83	..	0·45	..	..
Trifolium pratense perenne†	Perennial red clover†	1·22	..	17·91	..	..
	Total	5·12	2·20	22·89	..	..
	4.—Miscellaneous Herbag					
Plantago lanceolata	Rib-grass or plantain	10·79	0·41	..	0·09	..
Carum carui	Common caraway	1·71	..	0·78	0·28	..
Achillæa millefolium	Common milfoil or yarrow.	1·34	3·58	0·48	0·28	0·59
Rumex acetosa	Sheep's sorrel or dock	0·67	1·02	0·23	0·88	1·08
Silene	Catchfly	0·61	..	..	..	..
Ranunculus‡	Crow-foot	0·49	1·13	..	..	..
Lazula campestris	Field wood-rush	0·12	..	..	..	..
Veronica chamædrys	Germander speedwell	..	..	0·22	..	..
Galium verum	Common yellow-flowered bed-straw, or cheese rennet	..	..	..	0·32	..
	Total	15·73	6.14	1·71	1·85	1·67

* With some *Agrostis*. † With some *T. repens* on Plot

on PERMANENT MEADOW LAND.

Herbage developed, according to the Manure employed. 3rd Season, 1858.

PLANT, &c.		NOTES.		
Farm-yard Manure.				
Alone. (Plot 16.)	With Ammoniacal Salts. (Plot 17.)	Order of Luxuriance.	Order of Ripeness.	General Condition.
bearing Flower or Seed.				
29·00	14·92	Plots 10, 16, 17, 8, 13; 1 and 4	Plots 8 and 4; 1; 13 and 16, nearly ripe; 17, unevenly ripe; 10, rather green	On all plots more or less shedded, remaining seeds not ripe.
10·75	19·87	Plots 10, 13, 17, 16 and 4; 1; and 8	Plots 8; 16 and 17, nearly ripe; 4 and 1, greenish; 10 and 13, green	Rather green, little difference, 10 and 13 affected by bulk and laying.
14·33	17·16	Plots 17, 16, 10, 1, 8 and 4; and 13	Plots 4, ripe; 1 and 8, pretty ripe; 17, part dead ripe; 13, nearly ripe; 10 and 16, part ripe	On every plot two distinct grades of ripeness: some dead ripe, some green.
0·34	0·66	Plots 1, 8, 4, and 10, 16 and 17	Plots 17, dead ripe; 8, 4, and 10, ripe; 1, mostly ripe; 16, nearly ripe	All dead ripe, chiefly shedded.
..	1·25	Plots 1, 10, and 13; 17, 4, and 8	Plots 10, dead ripe; 8 and 4, ripe; 13, unevenly ripe; 17, greenish; 1, green	
..	..	Plots 1, 8, and 4	Plots 8; 1 and 4, ripe	All nearly ripe.
0·45	0·26	Plots 1 and 16; 17, 8, and 4 and 13	Plots 8, 4 and 13, ripe; 16, tolerably ripe; 17, middling; 1, greenish	All in full head.
..	..	Plots 13, 10, and 4	Plot 4; 10, nearly ripe; 13, greenish	Seeds not quite ripe.
14·89	10·10	Plots 16 and 17	Plots 16; 17	Generally dead ripe.
..	..	..	Ripe	Ripe.
..	0·40	..	Plots 17, dead ripe; 8 and 13, ripe	Dead ripe and mostly shedded.
69·76	64·62			
Leaves and indeterminate Stems.				
2·24	5·55			
3·58	1·32			
4·03	..			
4·48	4·22			
3·58	3·96			
17·91	15·05			
Herbage.				
2·02	1·32	Plots 8, 1, 4 and 16; and 17	Plots 1, little seeded; 4, no ripe seed; 16, in flower; 8 and 17, green and in flower	All in flower.
..	..	Plots 1 and 8	Plots 8, in flower; 1, chiefly in flower, green	In flower, plants green.
1·68	0·46	Plots 8, 16, 1, and 17.	Plots 1; 17, scarcely ripe; 8, in full head; 16, some flowers, greenish	Green; chiefly in bloom; turning.
3·70	1·78			
chiefly Weeds.				
1·96	8·25	Plots 17, 1, 16, 4, and 10	Plots 4, pretty ripe; 10 and 17, nearly ripe; 16; 1, full head, not ripe	All in head, but seeds not ripe.
1·62	1·72	Plots 16 and 17, 1, 8 and 10	Plots 17; 1, seed shedding; 8, 10, and 16, ripe	All ripe.
0·22	1·78	Plots 4, 17, 1, 8, 10 and 13, and 16	Plots 13; 1 and 16, not in flower; 8 and 10, greenish; 4 and 17, green	None in flower; all green.
1·12	3·10	Plots 17, 10, 13 and 16, 1 and 4, and 8	Plots 1 and 8; 16, nearly ripe; 4 and 17, some seeded; 10 and 13, green	Some in bloom; some with ripe seeds.
..	..	..	Ripe	Ripe.
2·02	1·58	Plots 16, 17, 4, and 1	Plots 17, seed ripe; 16, in seed; 1, in seed, leaves green; 4, flowers and seed	Stems bearing ripe seed, but having green radical leaves.
..	..	..	Ripe; seeded	Ripe.
0·11	..	Plots 8 and 16	Plots 8 and 16, in flower	In flower.
..	..	..	..	Not yet in flower.
7·05	16·43			

‡ Various species.

TABLE X.—Summary of the facts given in more detail in Table IX.

	PER CENTAGE AMOUNTS OF EACH PLANT, &c.						
		Artificial Manures.				Farm-yard Manure.	
	Unmanured.	Ammoniacal Salts alone.	"Mixed Mineral Manure."	"Mixed Mineral Manure" and Ammoniacal Salts.	"Mixed Mineral Manure" and double quantity Ammoniacal Salts.	Alone.	With Ammoniacal Salts.
	(Plot 1.)	(Plot 4.)	(Plot 8.)	(Plot 10.)	(Plot 13.)	(Plot 16.)	(Plot 17.)
Total Grasses in flower or seed	50·25	35·91	42·18	72·66	65·08	69·76	64·62
Total Grasses in condition of detached leaves and indeterminate stems	25·85	53·20	29·64	24·72	32·27	17·91	15·05
Total Graminaceous herbage	76·10	89·11	71·82	97·38	97·35	87·67	79·67
Total Leguminous herbage	5·12	2·20	22·89	..	..	3·70	1·78
Total Miscellaneous herbage (chiefly weeds)	15·73	6·14	1·71	1·85	1·67	7·05	16·43
	96·95	97·45	96·42	99·23	99·02	98·42	97·88
Shedded seeds, &c., &c.	3·05	2·55	3·58	0·77	0·98	1·58	2·12
Total	100·00	100·00	100·00	100·00	100·00	100·00	100·00

I. GRAMINACEOUS HERBAGE.

1.—*Lolium perenne*—*Common Rye-Grass.*

This grass is reputed to be suitable to a great variety of soils, but to vary very much in character according to external conditions. It is easily propagated, is luxuriant and succulent, and yields an earlier feed than most other grasses. It is relished by stock, yields good hay, and is, in fact, one of the most generally useful of grasses. It flowers in June and July.

The grass having these reputed characters stands at the head of the list as to quantity *in culm*, not only on the unmanured plot, but on several of the others also. What proportion of the *detached leaf and undeveloped stem*, on the different plots, belonged to this grass, we were not able to determine. In the condition of flowering or seeding stem, the produce without manure contained 16·8 per cent. of it, that by purely mineral manures 23·4 per cent., that by ammoniacal salts alone 14·7 per cent., that by the "mixed mineral manure" and 400 lbs. of ammoniacal salts 32·2 per cent., and that by the "mixed mineral manure" and 800 lbs. of ammoniacal salts only 12·1 per cent. of it. Against these proportions of flowering and seeding Lolium, on the unmanured and artificially manured plots, the produce by the farm-yard manure contained 29 per cent. of it, and that by the farm-yard manure and ammoniacal salts only 14·9 per cent.

The general result in regard to the amount of Rye-grass in

flowering and seeding stem, according to manure, is as follows:— The proportion of it in the total produce was considerably increased by the "mixed mineral manures" alone, by the "mixed mineral manures" and the smaller amount of ammoniacal salts, and by the farm-yard manure alone. On the other hand, its proportion was diminished whenever the ammoniacal salts were used in relative excess; that is, when the ammoniacal salts were used alone, when they were used (with the mineral manures) in double quantity, and when they were employed in addition to the farm-yard manure. When the ammoniacal salts were used *alone*, the proportion of *Graminaceous leaf and undeveloped stem* was very high; when those salts were used in *excessive* amount with the mineral manures, the proportion of *two other grasses* (the Woolly soft-grass and the Rough Cock's-foot) predominated over that of the Rye-grass; and when the ammoniacal salts were used in addition to farm-yard manure, *three other plants* (Woolly soft-grass, Tall Oat-like grass, and Smooth-stalked Meadow-grass) seemed to gain upon the Rye-grass in degree of luxuriance.

Before passing to the next plant on the list, a few remarks may be appropriately made, which have a bearing not only on the interpretation of the results just given, but on that of those which have to follow. It must not be supposed, that figures which represent the proportion of *flowering and seeding stem* of a certain plant at one given period of the season, are at the same time accurate indications of the relative development of the *total plant* under the conditions in question. It must be borne in mind, that the numerous plants which constitute the complex herbage of our meadows, have each their natural period of flowering and seeding. This period will, however, be accelerated or postponed, as the case may be, by the external circumstances of soil, season, manure, and the association with other plants. General observation shows, that *nitrogenous* manures have a characteristic tendency to increase the development of *leaves and shoots* in our Graminaceous herbage. *Mineral* manures, on the other hand, induce much more the *seeding tendency*. With full supplies of mineral manures, therefore, we should expect (other conditions being favourable) that there would be a larger proportion of the growing plant in culm, at a given period, than when ammonia was supplied in relative excess. The general result was, indeed, that the proportion of the total Graminaceous plants which was *in culm*, was the greater where the mineral supplies predominated, and the proportion in leaf and undeveloped stem the greater when ammoniacal salts predominated. Hence, the effect of a manure on the development of the *total plant*, cannot be determined unconditionally by the proportion found in flowering and seeding stem.

The evidence is, nevertheless, sufficiently clear, that the bulky, luxuriant, and generally useful *Rye-grass*, was considerably developed by high artificial manuring, when this supplied a sufficiency of mineral constituents, and a pretty full, but not excessive, amount of nitrogen. But when ammoniacal salts were used in addition to farm-yard manure, the proportion of the Rye-grass appeared to be diminished. It will be afterwards seen, that this result was due to the fact, that two other grasses (Tall Oat-like grass, and Smooth-stalked Meadow-grass), which occurred either in comparatively small proportion, or not at all, on the other plots, were very considerably developed by the farm-yard manure.

2.—*Holcus lanatus*—*Woolly Soft-Grass, or Yorkshire Fog.*

This grass is said to be natural to damp and peaty soils; to give a considerable amount of after-math, but not to be liked by cattle either when green or in hay, being too soft, spongy, and insipid. In fact, some consider it as almost a weed. It is further said, to usurp the land in sandy soils, not to be reduced by cultivation, and to have the tendency to banish the artificial grasses. It flowers in July.

Such are the characters of the grass which was found second in amount among those in *culm*, on the unmanured land. It occurred, however, in larger proportion still on some of the manured plots. A considerable proportion of the *leafy* produce was also referred to this plant. The Woolly soft-grass, in the condition of flowering and seeding stem, constituted 14 per cent. of the produce without manure, 6·9 per cent. of that by mineral manures alone, 14·4 per cent. of that by ammoniacal salts alone, 32·6 per cent. of that by the mineral manures and 400 lbs. per acre of ammoniacal salts, and 26·4 per cent. of that by the mineral manures and the 800 lbs. of ammoniacal salts. Lastly, in the produce by farm-yard manure alone, the proportion was only 10·7 per cent., and in that by farm-yard manure and ammoniacal salts 19·9 per cent.

The general result was, that the proportion of the Woolly soft-grass was very much increased by nitrogenous manures. The effect was the more apparent when the leafy portion of the produce attributed to this plant was taken into the calculation. In fact, it is those artificial manures which developed the largest proportions of *total Graminaceous herbage*, that yielded the largest amounts of this grass. It amounted, culm and leaf together, to more than a quarter of the total produce when ammoniacal salts were used alone, to nearly 40 per cent. of it when the mineral manures and the 400 lbs. of ammoniacal salts were employed, and to more than 40 per cent. of the total produce when

the mineral manures and the 800 lbs. of ammoniacal salts were used. The proportion of the whole which was in the condition of leaf and undeveloped stem, was much the greatest where the ammoniacal salts were in relative excess; that is to say, when those salts were either used *alone*, or in the *double quantity with the mineral manures.* Where farm-yard manure was employed the Woolly soft-grass, like the Rye-grass, as mentioned above, appeared to be somewhat displaced in its proportion by the predominance of two other grasses (Oat-like grass, and Smooth-stalked meadow grass), to which further reference will be made presently. Still, by the addition of ammoniacal salts even to farm-yard manure, the proportion of the Woolly soft-grass was considerably increased.

This Woolly soft-grass, and the Rye-grass together, constituted about one-third of the total produce without manure; they together made up more than two-thirds of that by the mineral manures and the smaller amount of ammoniacal salts; and more than half of that by the mineral manures and double amount of ammoniacal salts.* Upon the whole, it appears that, although the Rye-grass is much increased by nitrogenous manures, the Woolly soft-grass is even more characteristically so; the latter, at the same time, seems less dependent on a coincidently liberal supply of mineral constituents. So far, therefore, as the relative development of these two plants is concerned, the character of the herbage would be the better when the supply of nitrogen in the manure was not excessive, and that of mineral constituents liberal.

It is quite consistent with the character given to the Woolly soft-grass—namely, that it tends to usurp the land and is not reduced by cultivation—that the manures which give the greatest increase in the produce of hay should give so large a proportion of this ill-reputed element. If, indeed, this grass be really so objectionable as it has been stated to be; it would appear to be very desirable carefully to exclude it from the seed in laying down grass-land; otherwise—soil and other circumstances being adapted to its growth—the higher the manuring, and the larger the crop, the greater will be the proportion in it of this ill-famed plant.

3.—*Arrhœnatherum avenaceum—Fibrous-rooted, tall Oat-like Grass.*

The reputed characters of this grass are, that it yields a considerable quantity of foliage on the culms, which affords a good

* Under this very excessive manuring, the Rye-grass appeared to be somewhat displaced in its proportion by the rough Cock's-foot, which on that plot, and on that alone, was very luxuriant.

deal of leafy feed in the spring. It is said to reproduce rapidly after cutting. Its taste is rather bitter, but it is not disliked by cattle. It does not grow abundantly except upon poor soils, and is upon the whole of somewhat questionable value; it is, however, much grown in France. Its time of flowering is May.

This grass (in culm, &c.) stood third in amount on the unmanured land; it there constituted, however, only 6 per cent. of the total produce. Purely mineral manures raised its proportion to 9 per cent. Ammoniacal salts, on the other hand, whether alone or in admixture with the mineral manures, seemed adverse to its predominance. Its proportion with such manures (see Plots 4, 10, and 13) was less than on the unmanured land. With farmyard manure, as with mineral manures, the proportion of the Oat-like grass was, as already alluded to, considerably increased. In fact, when the farmyard manure was used alone, the proportion of this grass in the total produce was more than double; and when with the addition of ammoniacal salts, about three times as great as it was on the unmanured plot.

The general conclusion to be drawn regarding the relative development of this grass, when grown in a mixed herbage, would seem to be, that, with high artificial manuring of the kind that meadow-land is most likely to receive, it would not by such means alone be increased, but more probably diminished in its proportion in the total produce. But when farmyard manure is liberally used, or the soil is comparatively rich in mineral constituents, its development would appear to be encouraged. The result may be due, either to the special adaptation of rich mineral manuring to the luxuriant development of this grass, or to the fact that, with highly nitrogenous manures, its growth is somewhat checked by the greater luxuriance of the freer-growing grasses.

4.—*Anthoxanthum odoratum*—*Sweet-scented Vernal Grass.*

It is to the presence of this grass that the peculiar fragrance of newly-made hay is due. Its foliage is broad and coarse, but the plant is a scanty grower, though most luxuriant on wet soils. It is not relished by cattle, but is not objected to in small proportion; it is said to be best adapted for sheep. Upon the whole this grass takes rank somewhat low in the scale of the better grasses for permanent purposes. It flowers early, namely, in April and May.

Our separations showed 5½ per cent. of the Sweet-scented Vernal-grass (in culm), in the produce of the unmanured land. There was only one other instance—namely, that where mineral manures were used alone—in which the proportion amounted to 1 per

cent. The highly nitrogenous artificial manures appeared to be very adverse to its growth, nor did it succeed much better with farm-yard manure. As, however, this grass is a very early one, it is possible that, at the time of cutting, some of it would be past the stage at which it would be recognised in our samples.

The general result was, that the growth of the Sweet-scented Vernal-grass was much discouraged by such manures as greatly increased the amount and proportion of the Graminaceous hay-plants as a whole. Whether this is of consequence in any other point of view than that of fragrance, and whether in this one it is of real practical importance, is, perhaps, a question.

5.—*Agrostis vulgaris—Common, or Creeping-rooted Bent-Grass, or Black-switch, &c.*

This grass is said to flourish most on dry soils, to be a troublesome weed on arable land, to be disliked by cattle, and also by sheep, excepting sometimes in winter. It is, in fact, reputed as useless, and is recommended to be discouraged as much as possible. The time of flowering is May.

This grass amounted, in culm, to nearly 5 per cent. in the produce without manure. The proportion was, however, very much reduced under every one of the manured conditions. This result is certainly not to be regretted, if the characters of the grass are fairly given, as above. However, the *detached leaf and undeveloped stem* set down in the Table as "middling," was supposed to consist chiefly, and that set down as "coarse" more or less, of Bent-grass; and if this estimate be correct, it would appear, that there was a considerable proportion of this grass in this undeveloped condition on most of the plots; though it would be least in amount where either the farm-yard manure or the mixtures of mineral manure and ammoniacal salts were employed. Fortunately, then, a grass having such a bad character as is attributed to the creeping-rooted Bent-grass seems to meet with the desired discouragement in those manures which develop more freely its more valuable congeners.

6.—*Briza media—Common Quaking-Grass.*

This grass is reputed to thrive best on poor soils, to afford a small yield, not to be liked by cattle, and to be discouraged by manuring. It flowers in June.

The Quaking-grass amounted to 2 per cent. in the sample of the produce from the unmanured land. It was only found in two cases in the manured produce, and then in even less proportion than in the unmanured. In the most highly-manured produce none whatever of it was to be found. The reduction or entire exclusion by manuring, is consistent with the character

of this grass as given above. It would seem, therefore, that it is not likely to be troublesome on good land, and that it is easy of expulsion by good manuring.

7.—*Cynosurus cristatus*—*Crested Dog's-tail Grass.*

This grass is said to have a wide range of soils, to grow on dry, damp, and even irrigated lands, and to vary in character accordingly. The opinions given respecting its value are somewhat conflicting. Some authorities consider its root-leaves, which are comparatively abundant, to be a favourable food for sheep, and that it is useful on soils and in seasons when other grasses are deficient. The stems seem, however, not to be eaten at all; and the more recent opinions, especially those of Professor Buckman, are quite against its utility. It is said, however, to be better for pasture than for hay; but as its character is to die out by improvement, its perhaps now established inferiority need not be much regretted. The time of flowering is June and July.

This crested Dog's-tail grass stood lowest of any among the grasses, in the scale of quantity on the unmanured land. It there amounted, in culm, to only 1 per cent. of the total produce. It was found in the manured produce in less proportion still, especially where ammoniacal salts were used. It would appear, therefore, that where such manuring is employed as greatly increases the produce of hay, there will be little or none of this doubtfully useful element.

8.—*Dactylis glomerata*—*Rough Cock's-Foot.*

The Rough Cock's-foot is said to be very abundant and productive on good soils, particularly on those of a clayey nature, and to be much improved by cultivation. It grows well in moist and shady places, has broad foliage, is tufty, and reproduces rapidly after cutting. All stock like it, but particularly sheep, early in the season, before it has become hard and coarse. Its time of flowering is June and July.

Of this grass, in the condition of flowering and seeding stem, none whatever was found in the sample taken from the unmanured plot; none in that from the mineral manured plot; and none in that from either of the plots manured with farm-yard manure. It would appear, however, from the notes made by Professor Henfrey on the growing crop of 1857, as well as from the results of the partial separations made by ourselves when the crop of that year was cut, that the Rough Cock's-foot was far more predominant in the second than in the third year of the experiment. The conditions of growth of the samples in which it was found in the third year, are consistent with its apparent exclusion under

the conditions mentioned above. It was found to the amount of less than 2 per cent. (in flowering and seeding stem) in the sample grown by ammoniacal salts alone, in less than 1½ per cent. in that by the same amount of ammoniacal salts with mineral manures in addition, but to the extent of 20 per cent. when the double or excessive amount of ammoniacal salts, together with the mineral manures, were employed. Where this very large proportion of Rough Cock's-foot was found in the produce of 1858, it was set down by Professor Henfrey in 1857, as "very fine," "abundant," and "ripe," and in the other cases as "backward." Consistently with this order of development of this plant according to manuring, we find a very small proportion of that leafy produce (the coarse) which was estimated to contain Cock's-foot, where the amount in flowering and seeding stem was so large, but more where the amount in flowering and seeding stem was only small. There was the most of it where the ammoniacal salts were used alone; and it was in the sample of "coarse" leafy produce grown by that manure, that Professor Henfrey concluded there was the most of the Cock's-foot.

It appears that characteristically nitrogenous manures are favourable to the predominance of the Rough Cock's-foot. Where the supply of nitrogen is only moderate, it would appear to be outgrown and overpowered by the Rye-grass and Woolly soft-grass. It, in its turn, appears to overpower, particularly the Rye-grass, when the nitrogenous manure is very abundant. And, under the same conditions, it seems to reduce, and almost to exclude, several of the grasses of less value, and of less free growth. Thus, when the Cock's-foot was so abundant, there was less of the Oat-like grass found than on any of the other plots, no Sweet-scented Vernal-grass, very little creeping Bent-grass, no Quaking-grass, and scarcely any crested Dog's-tail. The reputed characters of the Rough Cock's-foot given above, are consistent with this luxuriant growth under high manuring, and with this apparent tendency to push out other plants by its own active vegetation. The Cock's-foot also affords an example of a useful grass much developed by those manures which yield a great bulk of total produce.

9.—*Poa pratensis*—*Smooth-stalked Meadow Grass.*

The Poa pratensis is said to be rather particular in its choice of situation, not to relish damp soils, but to thrive well in good and rather dry ones. It grows tuftily, and is said to have the tendency to banish other grasses. Its character is to yield a good early feed, and a free-growing and hardy after-grass. It flowers in May and June.

This grass was found only in the samples of the produce

grown by farm-yard manure. In these, however, its proportion was very considerable, amounting to about 15 per cent. of the whole where the farm-yard manure was used alone, but to only 10 per cent. where the farm-yard manure and ammoniacal salts were used together. From our records relating to the produce of the second season, it appears that this Smooth-stalked Meadow-grass was detected on more of the plots in that season than in the third. Still, even then, it was found in very much larger proportion in the produce grown by farm-yard manure than in that by any of the other manures. This very marked development almost exclusively by farm-yard manure might lead to the conclusion, that part of the result was due to seed brought upon the land by the dung. But that the character of the manure, as such, had much to do with the effect, would seem from the fact, that the proportion of the Smooth-stalked Meadow-grass was considerably reduced when ammoniacal salts were used in addition to farm-yard manure.

It would appear that the Smooth-stalked Meadow-grass is particular in the choice of manure as well as situation, and that artificial nitrogenous manures are either directly obnoxious to it, or cause it to be pushed out by those grasses whose luxuriance is greatly stimulated by such manures. Nor was this Poa perceptibly favoured in its growth by purely mineral manures. It might be supposed, therefore, that the carbonaceous organic matter of the farm-yard manure had something to do with the greatly increased development of the plant under the influence of that manure. This greatly increased development of the Smooth-stalked Meadow-grass under the influence of farm-yard manure appeared to be chiefly at the cost of the Woolly soft-grass —an exchange not at all to be regretted. The Oat-like grass is another grass much more valuable than the Woolly soft-grass, the proportion of which was much increased by farm-yard manure. This manure was seen, therefore, to develop two better grasses at the expense of a worse one. But it is to be regretted, that so useful a grass as the Smooth-stalked Meadow-grass should appear to be so nearly excluded under the influence of those so-called artificial manures, which are practically the most useful in increasing the produce of Graminaceous hay.

10.—*Bromus mollis*—*Soft or Downy Brome-Grass.*

This grass is described as a common weed in grass-land, the seed of which should be carefully excluded when sowing down. It is said to be innutritious, and even injurious to some animals. It flowers early in the season, but, after cutting, often seeds in the after-grass. It is found most in poor exhausted pastures.

With such characters as are here given to this grass, it is not

to be regretted that it was found in only one of our samples, and there in very small proportion. Professor Henfrey was, however, of opinion that its leaf occurred in a few of the samples of the "coarse" leafy produce.

11.—*Avena pratensis*—*Meadow Oat-Grass.*

This grass is best adapted to dry heathy places. It is of doubtful feeding value, though conflicting opinions are given respecting it. But, as it is said to be soon got rid of by good cultivation, its qualities are perhaps not of much consequence. It is the last on our list of *flowering and seeding Graminaceous plants.* It was found in the samples from three only of the seven plots, and in those in but insignificant amount. The largest quantity was found in the sample grown by the mixture of mineral manure and the excessive amount of ammoniacal salts.

There are two other items to be briefly noticed before closing this *seriatim* account of the different descriptions of *Graminaceous* herbage found in the produce of the respective plots.

The proportion of the *leafy* produce set down in the Table as "*fine*," varied extremely according to the manuring. It was very large where the ammoniacal salts were used *alone;* and moderately so on the other plots where the total produce was not very large; but very small in the samples from the heaviest crops. We were quite unable to determine with any certainty to what plant or plants this "fine" leafy matter was to be referred. Professor Henfrey was, however, of opinion that some at least belonged to *Festuca Bromoides*, or Barren Fescue-grass.

"*Dead leaf and stem*" is the last item in the list of *Graminaceous* produce. Contrary to the fine leaf, this worthless dead matter occurred in very far the largest proportion where the artificial manuring was the highest, and the crops were the heaviest. Where the mineral manure and excessive amount of ammoniacal salts were employed, this damaged portion of the produce amounted to nearly 12 per cent. of the whole; and where the mineral manure and the more moderate amount of ammoniacal salts were supplied, to 7 per cent. Here, then, is experimental evidence showing a practical disadvantage in manuring so highly as to cause the crop to fall and die at the bottom before the bulk is fit for cutting.

II. Leguminous Herbage.

In the second season, 1857, four descriptions of Leguminous plant were distinguished on the experimental plots. These were *Lathyrus pratensis* (Yellow or Meadow Vetchling); *Lotus cornicu-*

latus (Common Bird's-foot Trefoil) ; *Trifolium pratense perenne* (Perennial Red Clover) ; and *Trifolium repens* (White or Dutch Clover). In the third season, 1858, very little of the last mentioned plant (Dutch clover) was observed on any of the plots ; and the three other Leguminous plants seemed to be confined to fewer plots than formerly. Their limitation, or extension, according to manuring, is very striking ; and it is to the degree and conditions of their distribution, that attention is now to be directed. The results relating to these points are given in the third Division of Table IX.

1.—*Lathyrus pratensis—Yellow or Meadow Vetchling.*

This plant is described to grow naturally on either moist or dry soils, but generally on such as are of good quality. Cattle generally eat it with avidity ; and hence it is recommended to be grown on very dry soils. The creeping nature of its roots unfits it for growth in rotation, but not so much for permanent meadow. It flowers in July.

The Meadow Vetchling occurred in rather larger proportion than either of the other Leguminous plants on the unmanured land. It there amounted, however, to only 2 per cent. of the total produce. On the *mineral manured plot* its proportion was raised to $4\frac{1}{2}$ per cent. ; and on the plot with ammoniacal salts alone, there were about $2\frac{1}{4}$ per cent. In the produce by the mineral manure and ammoniacal salts together, none of this plant was observed. The produce by farm-yard manure gave about 2 per cent., and that by farm-yard manure and ammoniacal salts little more than 1 per cent. of the Meadow Vetchling.

2.—*Lotus corniculatus—Common Bird's-foot Trefoil.*

This plant is said to grow abundantly on dry elevated pastures, and heathy soils ; and to be well deserving of cultivation on light, dry, elevated inferior soils, on which it will yield a greater bulk of herbage than any of the cultivated clovers. It is supposed to be highly nutritious, and is eaten with avidity by cattle. From the great depths to which its roots penetrate, it is not liable to be injured by drought, and is hence enabled to retain its verdure after the grasses and other plants are burnt up. It flowers from June to August.

The Bird's-foot Trefoil was found in the produce of only two of the experimental plots, namely, the *unmanured,* and the *mineral-manured* ones.

3.—*Trifolium pratense perenne—Perennial Red Clover.*

There are several varieties of this plant, of which the most important are the Native perennial Red Clover, and the Common

perennial Red Clover or Cow-grass. They are too well known to every farmer to require description here.

Perennial Red Clover amounted to little more than 1 per cent. of the total produce on the *unmanured* land, but to nearly 18 per cent. of that grown by *mineral manures alone*. Not any of it was found in the produce by either ammoniacal salts alone, or ammoniacal salts in conjunction with mineral manures. There was little more than $1\frac{1}{2}$ per cent. of it in the produce by farm-yard manure alone, and less than $\frac{1}{2}$ per cent. in that by farm-yard manure and ammoniacal salts.

The proportion of *total Leguminous Herbage* found in the produce of the *unmanured* plot, was about 5 per cent. This was made up of two parts Meadow Vetchling, rather less than two parts Bird's-foot Trefoil, and rather more than one part Perennial Red Clover. The produce by *mineral manures alone* was estimated to contain about 23 per cent. of Leguminous herbage, or about $4\frac{1}{2}$ times as high a proportion as that grown without manure. These 23 parts comprised about $4\frac{1}{2}$ parts Meadow Vetchling, about $\frac{1}{2}$ a part of Bird's-foot Trefoil, and about 18 parts of Perennial Red Clover = 15 times as much as was found of it in the unmanured produce. The *ammoniacal salts alone, reduced* the proportion of total Leguminous plant to little more than 2 per cent. in the produce, and then it consisted entirely of Meadow Vetchling: the Bird's-foot Trefoil and the Perennial Red Clover being apparently extirpated. And, in the produce by *mineral manures and ammoniacal salts together, not any* Leguminous plant was to be found. The *farm-yard manure produce* contained less than 4 per cent. of Leguminous plant, which consisted of nearly equal parts Meadow Vetchling and Perennial Red Clover, to the exclusion of the Bird's-foot Trefoil. The *addition of ammoniacal salts* to farm-yard manure, *reduced* the proportion of Leguminous herbage to about one-half. There was still no Bird's-foot Trefoil; and the Perennial Red Clover, as before, gave way more than the Meadow Vetchling under the influence of the ammoniacal salts.

III. Miscellaneous Herbage, chiefly Weeds.

The fourth Division of the Table shows, that there were nine descriptions of these questionably useful, or even objectionable plants, detected in the samples from the experimental plots. Only seven of them were found together on the unmanured land, and a smaller number still on each of the manured plots. A few remarks will be made upon the characters, and conditions of occurrence, of these several plants, taking them in the order in which they occurred in the largest proportion on the unmanured land.

1.—*Plantago lanceolata—Rib-grass or Plantain.*

This plant is reputed to yield an herbage which, early in the season, is eaten by cattle, horses, and sheep; but which is disliked by them as the season advances. It is also objectionable on account of its spreading leaves, which tend to exclude other plants. It is natural to dry pastures. It flowers in June and July.

Nearly 16 per cent. of the produce *without manure* consisted of *Miscellaneous Weedy herbage.* This comprised seven descriptions of plant, yet nearly 11 out of the 16 parts consisted of the Rib-grass. None of it was found in the produce grown by mineral manures alone; scarcely any in that by ammoniacal salts alone; less still in that by the same amount of ammoniacal salts and the mineral manures; and none at all in that by the double amount of ammoniacal salts and the mineral manures. On the farm-yard manure plot less than 2 per cent. of the total produce, or only about one-sixth as much as on the unmanured land, consisted of the Rib-grass. The addition of ammoniacal salts to the farm-yard manure, however, greatly increased the proportion of Rib-grass in the produce—namely, to 8¼ per cent.

It appears, then, that the Rib-grass, which was so prominent an item on the unmanured land, was greatly reduced in its proportion by farm-yard manure and ammoniacal salts; still more by farm-yard manure alone; and nearly or entirely excluded by those artificial manures which increase the most the total produce of hay, and especially that of the Graminaceous herbage.

2.—*Carum carui—Common Caraway.*

This plant, though second in amount among the Miscellaneous Weedy herbage on the unmanured land, amounted there to less than 2 per cent. of the total produce, and to about the same proportion in the produce of the two farm-yard manure plots. It was much diminished in its proportion, or excluded altogether, by the purely-artificial manures, especially when ammoniacal salts were in relative excess.

3.—*Achillæa millefolium—Common Yarrow or Milfoil.*

The Milfoil is stated to be a grateful element in small admixture with other herbage for sheep; and it is recommended, therefore, to be sown with other seed for permanent sheep-pasture.

The Milfoil was found to the amount of somewhat more than 1 per cent. in the produce without manure. Its proportion was much diminished by farm-yard manure alone, mineral manure alone, and the mixtures of the mineral manure and ammoniacal salts. Where the larger amount of ammoniacal salts was used (with mineral manure) both the proportion and the actual

amount of this plant were considerably greater than where the smaller amount was employed with the mineral manures. Consistently with this effect of ammoniacal salts, the proportion of the Milfoil was very much increased by the addition of these salts to farm-yard manure ; and it was the greatest—in fact, then nearly three times as great as without manure—where the ammoniacal salts were used alone.

If the characters of the Milfoil as sheep-food be such as above-described, it need not perhaps be much regretted that its growth seems to be favoured by nitrogenous manures.

4.—*Rumex acetosa—Sheep's-sorrel or Dock.*

This plant is undoubtedly objectionable. Unfortunately, however, it, as well as the Milfoil or Yarrow, was found in the produce of every plot ; and, like the latter, it was increased in its growth by the use of ammoniacal salts. It was more or less increased by these salts in whatever combination they were employed. Farm-yard manure alone also notably increased the proportion of the Dock in the produce ; but farm-yard manure and ammoniacal salts together increased it still more. With the latter combination the Dock amounted to more than 3 per cent. of the produce. As this obnoxious plant seems to be favoured in its growth by manuring, its expulsion must be attained by other means.

The remaining five plants that were detected in the samples are, without doubt, useless, if not obnoxious. They were each found, however, only on a few of the plots, and generally in but insignificant proportion.

5.—*Silene, or Catch-fly,*

was found in the unmanured produce only, and there to the extent of little more than ½ per cent.

6.—*Ranunculus—Crow-foot* (various species).

These plants were found in small quantity in the produce from the unmanured plot ; in larger proportion in that grown by ammoniacal salts alone ; and in larger proportion still on the two plots with farm-yard manure. Their growth was, however, very much discouraged by the most productive artificial manures.

7.—*Lazula Campestris—Field Wood-rush.*

This rush was found only in the sample from the unmanured land, and there in very insignificant amount.

8.—*Veronica chamædrys*—*Germander Speedwell*—

was found only in the produce by mineral manures alone, and by farm-yard manure alone; and in both cases in very small amount.

9.—*Galium verum*—*Common Yellow-flowered Bed-straw, or Cheese-rennet.*

This plant was only found in the sample grown by the mixed mineral manure in conjunction with the lesser quantity of ammoniacal salts.

It is possible that there were some other plants that either did not come within the reach of the scythe, or were otherwise excluded from our samples or determinations. Nor are the exact numerical proportions set down in the Table, to be considered, either within this or the other classes of plants, as anything more than approximations. Such, however, they undoubtedly are; and the facts brought out regarding the distribution, and development, of Miscellaneous Weedy herbage, according to manure, are very clear and striking.

From this examination the very satisfactory result appears, that by far the larger *number* of the obnoxious or comparatively-useless plants occurred in the produce of the *unmanured* land. Taken collectively, too, their *proportion* was there very much larger than under any of the other conditions, excepting the one where the farm-yard manure and ammoniacal salts were used together. It was chiefly the Rib-grass, and the Sheep's-sorrel or Dock, that were encouraged by this latter manuring. The *farm-yard manure alone* gave a larger proportion of Weedy herbage than any of the *artificial manures;* but not half as much as either the *unmanured* land, or that manured by *farm-yard manure and ammoniacal salts.* On all the artificially-manured plots the *number* of species found was reduced to about half that occurring on the unmanured land. In fact, those artificial manures which were the *most productive*, not only reduced the number of species of weeds considerably, but reduced the proportion of the total of such produce to about *one-tenth as much* as was developed *without manure.* It is certainly very satisfactory to find, that the most active artificial manures had the effect of very greatly *reducing* the proportion of the useless and obnoxious plants in the mixed herbage of the meadow. It is, on the other hand, somewhat discouraging to find, that the influence of *farm-yard manure*, which must be relied upon for the hay-crop to a certain extent, was not so favourable. It is to be hoped, that the facts which have been adduced regarding the conditions of development, and the amounts, of the Miscellaneous Weedy herbage on the meadow

land, may fix on the mind of the farmer, the clear idea which the discussion of actual figures conveys, of the real amount of objectionable produce which he may frequently grow, unless proper means of reduction or eradication be had recourse to.

Attention may now be turned from the detailed consideration of the circumstances of development of the *individual plants*, to a statement of the more general character of the herbage under the different manurial conditions. In the Summary Table X. (p. 252) are recorded the main facts necessary to such a review; and the most prominent results already noticed in their place in more detail, will supply the remainder.

1.—*Total Graminaceous Herbage.*

At the time of cutting, 76 per cent. of the produce without manure consisted of Graminaceous herbage. At the same period of time, the proportion of such herbage in the total produce was increased to about 87¾ parts by farm-yard manure alone, and to 79¾ parts by farm-yard manure together with ammoniacal salts. The produce by mineral manures alone contained scarcely 72 per cent. of Graminaceous herbage; 4 per cent. less, therefore, than the produce without manure. On the other hand, the produce by 400lbs. of ammoniacal salts per acre, contained 89 per cent.; that by the same amount of ammoniacal salts and mineral manures, 97⅓ per cent.; and that by the double amount of ammoniacal salts and the mineral manures, also, 97⅓ per cent. of Graminaceous herbage.

But the *Graminaceous produce itself* varied extremely in character according to the manure employed. At a given period of the season, the Graminaceous herbage grown without manure, consisted of 66 per cent. of flowering or seeding stem, and 34 per cent. of leaf and undeveloped stem. At the same period, the Graminaceous produce by farm-yard manure, comprised nearly 80, and that by farm-yard manure and ammoniacal salts, rather more than 80 per cent., of culm, in flower or seed. Against these amounts without manure, or by farm-yard manure, the Graminaceous produce grown by the artificial manures alone was composed as follows:—That by the mineral manures alone contained 59 per cent. of flowering and seeding stem; that by ammoniacal salts alone, only 40 per cent.; that by the same amount of ammoniacal salts and mineral manure, 75 per cent.; and that by the double amount of ammoniacal salts and mineral manure, 67 per cent., in flowering and seeding culm.

The general result is, *that those manures which much increased the produce of hay, at the same time very much increased*

its proportion of Graminaceous herbage. In fact, where the largest crops were obtained, namely, where the mixed mineral manure and ammoniacal salts were used together, the proportion of the whole produce that was Graminaceous, was more than 97 per cent., whilst that without manure was only 76 per cent. The characteristic effects of nitrogenous manures to increase the proportion of leaves and shoots, and of mineral manures to determine more to flowering and seeding, are also strikingly illustrated. It will be obvious, therefore, that not only must the character of the gross produce be very different according to the description of manure employed, but that the proper time of cutting must vary very considerably to secure the majority of the herbage at any given point of ripeness.

But it has been seen, that the Graminaceous herbage varied much in character according to the manure, not only in regard to its proportion in the total produce, and to the proportion of the whole that was leafy and stemmy respectively, but also in the description or species of plants developed.

Under the particular conditions of soil, season, original distribution of plants, and other circumstances of these experiments, common Rye-grass was the most predominant of the grasses in the unmanured produce. The inferior Woolly soft-grass occurred in nearly an equal quantity; and then succeeded in lesser quantities, in the order here given, the tall Oat-like grass, the Sweet-scented Vernal-grass, the Creeping-rooted Bent-grass, the common Quaking-grass, and the Crested Dog's-tail—the last in very small amount. Farm-yard manure, which increased the actual amount and proportion of total Graminaceous herbage, gave a considerably increased proportion of Rye-grass and of tall Oat-like grass; a somewhat diminished proportion of the Woolly soft-grass; scarcely any of the other grasses found on the unmanured plot; but a very large amount of the valuable Smooth-stalked Meadow-grass, which was not found at all in the produce without manure. The addition of ammoniacal salts to the farm-yard manure diminished the proportion of the more valuable Rye-grass, and Smooth-stalked Meadow-grass, but increased that of the tall Oat-like grass, and that of the inferior Woolly soft-grass.

Leaving out of consideration here, those artificial manures which did not much increase the total produce of hay, namely, the mixed mineral manure used alone, and the ammoniacal salts alone, the general result with the more active artificial combinations was as follows:—The mixed mineral manure with the more moderate amount of ammoniacal salts gave about 2½ times as much produce as the unmanured land, and the proportion of it that was Graminaceous was more than 97 per cent., instead of only 76 per cent. without manure. This enormously-increased Grami-

naceous produce contained twice as high a proportion of both the valuable Rye-grass, and the inferior Woolly soft-grass, as that without manure. The proportion of the Oat-like grass was, on the other hand, diminished; and, under the same conditions, all the other grasses were either very much reduced, or entirely excluded.

When the double and excessive amount of ammoniacal salts was employed (with the mineral manure), the produce was about $2\frac{3}{4}$ times as much as on the unmanured land, and the proportion of it that was Graminaceous was, as in the last case mentioned, more than 97 per cent. This greatly-increased Graminaceous produce, under the influence of an excess of ammoniacal salts, contained a smaller proportion of the common Rye-grass than the unmanured hay. On the other hand, the proportion of the inferior Woolly soft-grass was very much increased. There was, moreover, with this manure a very large proportion of Rough Cock's-foot—a grass which was found on very few of the other plots, and then in very small proportion. All the other grasses were either excluded, or much reduced in amount, under the influence of this excessive manuring.

2.—*Total Leguminous Herbage.*

The proportion of Leguminous herbage in the total produce without manure was about 5 per cent. Farm-yard manure reduced the proportion, but not the acreage amount, of such produce; and the combination of farm-yard manure and ammoniacal salts, very considerably reduced both the actual amount, and proportion, of this kind of herbage. In the produce by those artificial combinations (mineral manure and ammoniacal salts), which more than doubled or nearly trebled the amount of hay, and which increased the amount and proportion of the Graminaceous herbage so strikingly, not a trace of Leguminous herbage was found. Again, ammoniacal salts alone, which notably increased the Graminaceous herbage, almost excluded the Leguminous. In the produce with this manure, neither Bird's-foot Trefoil nor Perennial Red Clover was found; but the Meadow Vetchling occurred in about the same proportion as in the unmanured produce. On the other hand, mineral manures alone, which gave little or no increase of Graminaceous produce, increased very strikingly both the actual amount, and the proportion, of the Leguminous herbage. The proportion of total Leguminous herbage in the produce by mineral manures alone was 23 per cent., instead of only 5 per cent. in that without manure. The proportion of the Bird's-foot Trefoil was diminished by the mineral manures; that of the Meadow Vetchling was notably increased; and that of the Perennial Red Clover very considerably so.

The effect of *mineral* manures in developing a large proportion

of *Leguminous* herbage, and particularly of Clover, was therefore very striking. Artificial *nitrogenous* manures, on the other hand, seemed almost to extirpate such plants from the mixed herbage of the Meadow-land. These results are perfectly consistent with those observed in the manuring of Leguminous crops (beans, clover, &c.) when grown in *rotation*. Mineral manures have been found greatly to increase such crops, whenever a good plant could be once obtained and the season was not unfavourable. These crops, on the other hand—so highly nitrogenous both in their per-centage composition, and in their acreage yield—have not been found to be specially benefited by the direct use of ammoniacal salts; though nitrate of soda appears somewhat more favourable to their growth.

The general coincidence in the results obtained in regard to the action of characteristic descriptions of manure, on the agricultural plants included within each of these two great families (the Graminaceæ and the Leguminosæ), whether they be grown *separately and in alternation*, or *side by side in a mixed herbage*, is very striking. Such a coincidence, under such very varied conditions, must show, that the result is really due to the plants of the respective families requiring for their luxuriant growth a widely different relation of the mineral and nitrogenous supplies, respectively, *within the soil*. It cannot, under such circumstances, be attributed to mere local peculiarities, or to the mere accidental conditions of exhaustion induced by this or that agricultural practice. We have, then, in the facts observed in regard to the action of characteristic descriptions of manure in developing the different plants of which the *mixed herbage of a meadow* is made up, an unexpected, and very interesting confirmation, of those which have been established in regard to the development of the widely different plants which are grown *in rotation*. Such a coincidence must tend to inspire confidence in the conclusions arrived at in each of the widely different, and separately interesting, paths of inquiry.

3.—*Total Miscellaneous Herbage* (*chiefly Weeds*).

These plants were the most numerous in kind, and nearly in the greatest proportion, on the *unmanured* land. The produce without manure contained nearly 16, that grown by farm-yard manure and ammoniacal salts more than 16, and that by farm-yard manure alone 7 per cent., of Miscellaneous or Weedy herbage. In the produce without manure, about two-thirds of the amount of such herbage was Plantain or Rib-grass; and in that by the farm-yard manure and ammoniacal salts about the same proportion of the whole consisted of Rib-grass in the larger, and Sheep's Sorrel or Dock in the smaller quantity. On the other hand, the produce grown by those artificial manures which gave the largest

crops of hay, contained less than 2 per cent., and a very few species, of Miscellaneous Weedy herbage.

So much then for the results of this enquiry into the comparative development of the *different plants* of which the complex herbage of a Meadow is made up, according to the *manure* employed. The subject has been treated of with much more of system and detail than would otherwise have been necessary, inasmuch as, so far as we are aware, this is the first attempt that has been made, to trace the influence of special manures upon the individual plants of a complex herbage.

It must not be concluded, however, that the degree in which a particular description of manure develops any particular plant, when it is thus grown side by side with many others, is necessarily the same, either actually or relatively to those beside it, that it would be, were each plant grown separately, with such manure. The natural habit of a plant, its relative stage of progress at the different periods of the season, and its range of distribution both above and under ground accordingly, must indirectly affect the degree of luxuriance of the other plants associated with it. But, as it is in this *collective* way, that the various plants are grown in our permanent meadows, it is the action of different manures upon their development under these complex conditions, that is of the most interest to the farmer.

Again, the conditions of soil, situation, season, and of the original distribution and predominance of the respective plants, must, to a great extent, affect their relative development by different manures, when they are thus grown side by side. There is, moreover, evidence in the general observations made, or notes recorded, on the produce of the first two years in the experiments now in question, that there has been a *progression* from year to year, in the greater development of some plants, and in the reduction, or even exclusion, of others, the conditions of manuring remaining the same. It would appear, indeed, that great caution should be exercised in the application of artificial manures to *good feeding pastures*, lest the effect should be, to increase the growth of certain grasses of inferior quality, and to diminish or exclude those to which the high feeding value is attributable.

It is obviously very important, not only that the progressive action of the different manures should be carefully investigated for years to come, in the case of the experiments on the Rothamsted Meadow-land, but that experiments of a similar kind should be conducted by others, in different localities, and on different descriptions of soil. So far as our own part in the matter is concerned, we hope to follow up a subject which seems fraught with so much interest both in a practical and scientific point of view.

And we trust, that others will be found to lend their aid, in extending information in this important and hitherto untrodden field of inquiry.

From a review of the whole of the facts adduced in this Third Part of our Report, it would appear:—

1. That, whether the produce of hay be considerably increased by means of farm-yard manure alone, farm-yard manure and ammoniacal salts, or artificial mixtures of suitable mineral manure and ammoniacal salts, the proportion of the whole which will be *Graminaceous*, will be very much increased.

2. That the produce will be by far the *most Graminaceous* when the "*artificial mixtures*" are employed. In fact, when the increase of hay is obtained by artificial manures containing *both the necessary mineral constituents and ammoniacal salts*—and it is then greater than under any of the other conditions—both the *Leguminous* and the *Weedy* herbage are nearly excluded, and the produce is then, therefore, *almost wholly Graminaceous.*

3. That the *Graminaceous produce itself*, when grown by *farm-yard manure*, is less complex in character than that grown *without manure;* whilst that grown by the *most active artificial manures*, is *less complex still.*

4. That, up to an equal period of the season, the *Graminaceous* produce grown by the *active artificial manures*, will be in larger proportion in *flowering and seeding stem*, than that grown *without manure;* and that the produce grown by *farm-yard manure* will be in still larger proportion in that condition.

5. That the *description* of the produce grown by *farm-yard manure alone* was, upon the whole, superior to that grown *without manure.*

6. That when the crop was further increased, by the *addition of ammoniacal salts to the farm-yard manure*, the character of the produce was somewhat deteriorated, both in regard to the *description* of the *useful plants* grown, and on account of the large proportion of *Miscellaneous* or *Weedy herbage* then developed.

7. That, when in a *mixed mineral and ammoniacal manure* the ammoniacal salts were *not used in excessive amount*, the herbage, which was then almost exclusively *Graminaceous*, and comprised also but *very few species*, nevertheless, included a considerable proportion of grasses of recognised good quality. But, *when excessive amounts of ammoniacal salts were employed*, the character of the produce was deteriorated, both in regard to its *condition*, and to the *description of the grasses* that were developed.

[To be continued.]