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a dressing with nitrate of soda and salt. By this means Mr. Coleman, who manages the Royal Agricultural College farm, has been able to grow good crops of wheat on thin brashy and exposed fields, which usually without such a dressing yielded but a scanty produce.

Nitrate of soda and guano often contain hard lumps, which ought to be carefully broken down before application: this is generally neglected, to the great disadvantage of the farmer. It is true there is some difficulty in reducing guano to a fine powder, and there is trouble connected with passing through a fine sieve nitrate of soda or guano; but no trouble or additional expense for labour should deter any one from reducing artificial manures, intended to be used as top-dressings, into a fine powdery condition: for the difference in the efficacy of manures in such a condition, and the same manures applied in a rough state, is much greater than most people believe who have not tried the experiment.

Whilst speaking of the application of top-dressings, I cannot refrain from observing that all artificial manures—such as nitrate of soda, guano, or a mixture of nitrate of soda and salt—should not only be first passed through a fine sieve, but they should also be mixed with three to five times their own weight of fine red ashes, dry soil, or sand, before sowing them broadcast by hand, or, what is much more convenient and better, by the broadcast manure distributor. Chambers' or Reeves' dry manure distributor cannot be too highly recommended for sowing, in a most uniform and expeditious manner, top-dressings of every description.

In conclusion, I beg publicly to thank Mr. Coleman for the obliging manner in which he has assisted me in carrying out the preceding experiments.

Royal Agricultural College, December, 1859.

XXII.—*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.

(Continued from p. 272.)

Part IV.—Chemical Composition of the Hay.

Thus far it has been shown, that the produce of hay on permanent meadow land was more than doubled by means of manure alone. It has also been shown, that the description of the produce grown on the manured land was very different from that on the unmanured; and again, that it was widely different according to

the kind of manure employed. The proportions respectively of the Graminaceous, the Leguminous, and the other herbage, varied very considerably; so also did the kind and amount of the several plants comprised within each of these main divisions; and so also did the proportions of leaf, stem, and seed, and the condition of maturity.

Now the Leguminous herbage generally contains about twice as high a percentage of nitrogen as the Graminaceous. It also varies in composition in other respects. Leaves, stems, and seeds, differ much in composition from one another. And again, the degree of maturity of vegetable produce very much affects its percentage amount of certain important constituents. It will be obvious, therefore, that the composition of the complex produce —*hay*—must vary very considerably when grown by different manures.

The object of this Fourth and last Part of our Paper is to show the variation according to season, and manuring, in the composition of the hay grown on the different experimental plots, the particulars of the manuring and produce of which have already been so fully considered in other points of view.

In each of the three seasons over which the experiments have extended, the percentage amounts of *total dry substance*, of *mineral matter*, and of *nitrogen*, have been determined in the produce from each of the separate plots. The *woody fibre* has been determined in the produce of each of the three years of those plots, which, in 1858, were selected for the botanical separations described in Part III. The *fatty matter* has been estimated in the produce of the same plots, but in that of the third season (1858) only. Lastly, complete analyses of the ashes of the produce of five out of the seven plots selected for the botanical separations, and also of the mixed ash of the produce from all the plots, for each of the three years separately, have been made. The various analytical results will now be considered under separate heads.

Dry Matter.

From each of the experimental plots, at the time the hay was carted, a sackful was taken, the samples being gathered from many parts of it. The whole of each of the specimens so taken was then cut into chaff and well mixed. From the mixed sample in this condition two quantities of 25 ounces each were weighed, and in both of these the *dry matter* and the *mineral matter* were determined. Other samples were at the same time taken for the determinations of nitrogen, woody fibre, &c.

The *dry matter*, which alone is at present under consideration, was determined by submitting the duplicate 25-ounce samples,

TABLE XI.—PERCENTAGES of DRY SUBSTANCE in the HAY (Means of duplicate Determinations).

Plot, Nos.	MANURES. (Per Acre, per Annum.)	1856.	1857.	1858.	Average of 3 Years.
	SERIES 1.—Without Direct Mineral Manure.				
1	Unmanured	82·0	85·1	85.9	84·3
2	Unmanured (duplicate plot)	81·9	87·3	85·5	84·9
	Mean, or Standard Unmanured	81·9	86·2	85·7	84·6
3	2000 lbs. Sawdust	80·7	87·7	84·4	84·3
4	200 lbs. each, Sulphate and Muriate Ammonia	80·0	86·7	84·1	83·6
5	200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	79·6	87·6	83·9	83·7
6	275 lbs. Nitrate of Soda	..	..	84·8	..
7	550 lbs. Nitrate of Soda	..	..	85·8	..
	Mean	80·5	87·0	84·8	84·0
	SERIES 2.—With Direct Mineral Manure.				
8	"Mixed Mineral Manure"*	80·2	86·7	85·6	84·2
9	"Mixed Mineral Manure," and 2000 lbs. Sawdust	80·5	86·8	84·1	83·8
10	"Mixed Mineral Manure," and 200 lbs. each, Sulphate and Muriate Ammonia	79·0	87·0	82·1	82·7
11	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	77·3	87·2	83·8	82·8
12	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Cut Wheat-Straw	79·2	86·8	82·4	82·8
13	"Mixed Mineral Manure," and 400 lbs. each, Sulphate and Muriate Ammonia	78·1	85·9	80·7	81·6
14	"Mixed Mineral Manure," and 275 lbs. Nitrate of Soda	..	..	86·4	..
15	"Mixed Mineral Manure," and 550 lbs. Nitrate of Soda	..	..	85·2	..
	Mean	79·0	86·7	83·1	83·0
	SERIES 3.—With Farmyard Manure.				
16	14 Tons Farmyard Manure	76·1	87·3	84·6	82·6
17	14 Tons Farmyard Manure, and 100 lbs. each, Sulphate and Muriate Ammonia	79·6	86·2	82·7	82·8
	SUMMARY.				
	General Means for the Experimental Specimens	79·3	86·8	84·1	83·4
	Mixed Hay from the same Meadow; taken out of the rick December 1858	..	87·2	83·8	..

from the rick of that year (also sampled Dec. 1858) was 83·8. The general characteristics of the produce of the *different seasons*, in regard to its percentage of *Dry matter*, are, therefore, correctly represented in the results given in the Table in reference to the experimental specimens.

The differences in the percentages of Dry matter in the hay, due to different *manuring*, are by no means so great as those due to variation of season or climatic circumstance. Still the general tendency of the influence of characteristic descriptions of manure is clearly discernible. The indications of the coincident comparative conditions of the produce, according to the manure employed, are also consistent.

Up to the period at which the crops were cut, the use of *ammoniacal salts* had the almost invariable effect of giving a produce which contained a somewhat lower proportion of Dry matter, than that grown under otherwise exactly comparable conditions. Such is seen to be pretty uniformly the result, whether we compare the produce by ammoniacal salts alone with that without manure; that with ammoniacal salts and sawdust, with that with sawdust alone; that with ammoniacal salts and mineral manure, with that by mineral manure alone; that with ammoniacal salts sawdust and mineral manure, with that by sawdust and mineral manure alone; or that with the larger amount of ammoniacal salts and mineral manure, with that by the smaller amount of ammoniacal salts and the same mineral manure. A similar result is observed too, in two years out of the three, where ammoniacal salts were used in addition to farmyard manure. The results in the Table, which appear to be exceptional to this generalisation in regard to the influence of ammoniacal manures upon the percentage of Dry matter of the hay taken at a given period of the season, occur in some of the cases with the artificial manures in 1857; and in 1856, in the case where the ammoniacal salts were used in addition to farmyard manure.

Ammoniacal salts which have thus been seen, other things being equal, to give a produce which contains a comparatively low percentage of Dry matter, gave, it should be remembered, also a much increased bulk and weight of hay over a given area; hence, even supposing that the description of the herbage, and the condition of maturity of the plants, were the same where the larger crops were grown with ammoniacal salts, and the smaller ones without them, we should still expect that the larger produce would dry somewhat less, exposed to equal circumstances during the making. But the description of the herbage, and its degree of forwardness, have been seen to vary very much according to the manure employed. The produce grown by ammoniacal salts gave a much larger proportion of Graminaceous plants than that

grown without them. The mere flowering and seeding stems of this Graminaceous herbage, would contain a higher percentage of Dry matter than the leaves and younger shoots. But besides the detached leafy matter, the larger culms grown by the ammoniacal salts, were themselves more luxuriant and succulent, and carried more green leaves and shoots than the smaller ones grown under otherwise comparable conditions, but without the ammoniacal salts.

It is obvious, then, that the percentage of the *Dry matter* in such complex and heterogeneous produce as hay, is dependent on too many coincident causes, to be of itself any unconditional indication of the character, or degree of maturity, of such produce.

The percentages of *mineral matter* and of *nitrogen* in the dry substance of the hay grown by the different manures, will be some further guide as to the comparative degrees of succulence, or maturity, of the produce developed under the different conditions.

Mineral Matter (Ash).

The *mineral matter* was determined by burning to ash the portions of hay which had been dried at 212° F., and reweighed for the determination of the dry matter. The burning was conducted on sheets of platinum placed in cast-iron muffles, heated by coke. Duplicate determinations were always made. The *mean* percentages, only of the two determinations, are given in Table XII.; and the *individual results* are recorded for reference in Tables II., III., and IV., in the Appendix.

In *ripened* produce, such as our crops of corn, the relations of the percentages of *mineral matter* in the dry substance in a series of comparable specimens, are pretty clear indications of the relative degrees of elaboration and ripeness of such produce. Other things being equal, the smaller the percentage of Mineral matter in the dry substance, the more highly elaborated, or the riper, is the specimen. The percentage of *nitrogen* in our ripened corn-crops is affected in a somewhat similar manner. Other things being equal, the lower the percentage of nitrogen in the dry substance, the higher, taking the average of seasons, will be the condition of maturation of the produce.

The like generalisation appears to be more applicable to the composition of the complex and but partially ripened produce, *hay*, than would perhaps have been anticipated.

The hay-season of 1856 was wet and cold, and the produce it yielded contained a very low percentage of dry substance. The hay-seasons of 1857 and 1858 were, upon the whole, much drier and warmer, and, accordingly, the percentages of dry substance in

Experiments with Different Manures on Permanent Meadow Land.

Table XII.—Percentages of Mineral Matter (Ash) in the Hay (Means of Duplicate Determinations).

Plot, Nos.	MANURES. (Per Acre, per Annum.)	Percentages in the Hay as taken from the Land.				Percentages in the Dry Substance of the Hay.			
		1856.	1857.	1858.	Average of 3 years.	1856.	1857.	1858.	Average of 3 years.
	Series 1.—Without Direct Mineral Manure.								
1	Unmanured	6·26	5·63	5·70	5·86	7·64	6·61	6·64	6·96
2	Unmanured (duplicate plot)	6·64	5·71	5·56	5·97	8·10	6·54	6·50	7·05
	Mean, or Standard Unmanured	6·45	5·67	5·63	5·91	7·87	6·57	6·57	7·00
3	2000 lbs. Sawdust	6·62	5·64	5·61	5·96	8·20	6·43	6·65	7·09
4	200 lbs. each, Sulphate and Muriate Ammonia	6·44	5·48	5·14	5·69	8·06	6·32	6·11	6·83
5	200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	6·01	5·51	5·33	5·62	7·54	6·29	6·35	6·73
6	275 lbs. Nitrate of Soda	..	..	5·73	..	..	..	6·75	..
7	550 lbs. Nitrate of Soda	..	..	5·38	..	..	..	6·26	..
	Mean	6·38	5·59	5·67	5·79	7·92	6·40	6·45	6·91
	Series 2.—With Direct Mineral Manure.								
8	"Mixed Mineral Manure"*	6·92	6·16	6·48	6·52	8·63	7·10	7·57	7·77
9	"Mixed Mineral Manure," and 2000 lbs. Sawdust	7·31	6·60	6·47	6·79	9·08	7·60	7·70	8·13
10	"Mixed Mineral Manure," and 200 lbs. each, Sulphate and Muriate Ammonia	6·77	6·28	6·53	6·53	8·58	7·21	7·95	7·91
11	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	7·03	6·42	6·80	6·75	9·09	7·36	8·11	8·19
12	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Cut Wheat-Straw	6·72	6·72	6·68	6·71	8·49	8·49	8·11	8·36
13	"Mixed Mineral Manure," and 400 lbs. each, Sulphate and Muriate Ammonia	6·57	6·42	6·35	6·45	8·41	7·47	7·87	7·92
14	"Mixed Mineral Manure," and 275 lbs. Nitrate of Soda	..	..	6·40	..	..	..	7·40	..
15	"Mixed Mineral Manure," and 550 lbs. Nitrate of Soda	..	..	6·52	..	..	..	7·65	..
	Mean	6·89	6·43	6·53	6·62	8·71	7·54	7·79	8·01
	Series 3.—With Farmyard Manure.								
16	14 tons Farmyard Manure	7·29	6·51	6·72	6·84	9·58	7·45	7·95	8·33
17	14 tons Farmyard Manure, and 100 lbs. each, Sulphate and Muriate Ammonia	7·52	6·45	6·74	6·90	9·45	7·48	8·14	8·36
	Summary.								
	General Means for the Experimental Specimens	6·80	6·15	6·16	6·37	8·58	7·15	7·73	7·82
	Mixed Hay from the same Meadow; taken out of the rick, December, 1858	..	5·58	5·73	..	..	6·40	6·84	..

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

their produce were much higher. Coincidently with the much lower percentage of dry matter in the produce of 1856, there was a considerably higher percentage of Mineral matter in the dry substance of that produce than in that of either 1857 or 1858. Again, the average percentage of dry substance in the hay was lower in the produce of 1858 than in that of 1857 ; and in accordance with this, the average percentage of Mineral matter in the dry substance of the produce of 1858, was higher than in that of 1857. It appears then, that, *comparing season with season*, the general result on this point in regard to hay, is in conformity with that generally observed in the case of more equably ripened produce. That is to say, the lower the condition of elaboration of the constituents of the produce, the lower is the percentage of the Dry substance, and the higher the percentage of the Mineral matter in that dry substance.

So much for the results in regard to the percentage of *Mineral matter* in the hay, as affected by *season*. We turn now, to the influence of *manuring* on the composition of the hay in regard to Mineral matter.

When it is borne in mind—that the proportion of the produce which will consist of Graminaceous, Leguminous, or other herbage, —that the proportion of the respective plants comprised within each of these main classes—that the proportion of each that will be in leaf and culm respectively—and that the condition of maturity at any given time—will vary very considerably according to the manure employed, it will be obvious that the variations in the percentages of Mineral matter, due to manuring, will be the resultants of many coincidently operating causes. On these points it may be observed—that the dry substance of Leguminous herbage contains on the average about $1\frac{1}{3}$rd time as high a percentage of Mineral matter as that of Graminaceous herbage; that the dry substance of the leafy portion of the produce contains a higher percentage than that of the stemmy portion; and lastly, that the riper the produce the lower will be the percentage of Mineral matter in the dry substance. But again, in green and unripened produce more especially, the *percentage* of Mineral constituents, as well as the actual amounts assimilated over a given area of land, are very much affected by the deficiency or liberality of their supply, in available form, within the range of collection of the growing crop.

The Table (XII.) shows that where no mineral manure was employed—and especially where nitrogenous manures were used alone, and the production thus pushed to the extreme limit of the available supplies of the mineral constituents of the soil itself—the percentage of Mineral matter, in the dry substance of the hay, was comparatively low. A somewhat similar result has been

observed in the case of corn-crops grown under similar circumstances. In illustration of the point in regard to the hay, it is seen that, whilst the average percentage of Mineral matter in the dry substance of the specimens grown without mineral manure was 6·91, that, taking the average of the cases where artificial mineral manure was employed, was 8·01. It is true that, in those cases where mineral manure was employed with ammoniacal salts, the *stemmy* produce was somewhat less ripe, and hence, so far, the percentage of Mineral matter in the dry substance would be expected to be comparatively high. On the other hand, the produce in these cases was almost entirely Graminaceous, and the Graminaceous produce itself contained a large proportion of stem to leaf, and both of these circumstances would, other things being equal, tend to a low percentage of Mineral matter in the dry substance. In fact, upon the whole, the evidence is pretty clear, that the lower percentage of Mineral matter in the dry substance of the produce grown without mineral manure, was due to a relalative deficiency of available mineral constituents in the soil. The direct influence of the supply of mineral constituents by manure, upon the assimilation of them by this voracious crop, will be further illustrated presently, when speaking of the *composition of the ash* of the produce grown by the different manures.

Where the mineral manures were used alone, more than one-fifth of the produce consisted of Leguminous herbage. Hence, it might be supposed, that the percentage of Mineral matter in the gross produce, or hay, would be higher than where nitrogenous manures were also employed, and the produce was almost entirely Graminaceous. Again, where the mineral was used without the nitrogenous manure, the proportion of the Graminaceous produce that was leafy was much greater than where nitrogenous manures were also used. This circumstance, again, would tend to a high percentage of Mineral matter in the produce grown by the mineral manures alone. But the fact was, that the percentage of Mineral matter in that produce was comparatively low. The result was, doubtless, due to the fact, that a large proportion of this produce by mineral manure alone, was much riper than that grown by the mineral and nitrogenous manures combined.

It appears then, that in the case of the complex and unripened produce—*hay*, the description of the herbage, the character of development, the stage of progress at which the plants are cut, and the supplies within the reach of the growing crop, all have a marked influence upon the percentage of *Mineral matter* in the produce. The effects of different manure, in one and the same season, upon this percentage are, therefore, at least complicated, if not indirect. Nor do the relative percentages among a series of

specimens so clearly indicate the comparative conditions of elaboration and maturation merely, as they generally do in the case of professedly ripened produce.

Constituents of the Ash.

The influence of the artificial supply of mineral constituents upon the total amount of them assimilated by the crop over a given area of land, has been illustrated in Part II. of our Report. The influence of such supply upon their percentage in the dry substance of the produce has now been shown. By the aid of complete analyses of the ashes of the produce of some of the experimental plots, further light will be thrown on the effects of a liberal provision of mineral constituents in the soil on the mineral composition of the crop.

In the first Division of Table XIII. is given the *percentage composition* of the ashes from the produce of five of the experimental plots; in the second Division of the Table the amounts of each of the several mineral constituents in the average annual *total produce* per acre on each of the plots; and in the third Division the *increase* in the amounts of the several mineral constituents obtained, per acre, in the crop, under the influence of the different manures.

The plots selected were—the unmanured; the one with ammoniacal salts alone; the one with mixed mineral manure alone; that with the mixed mineral manure and the smaller amount of ammoniacal salts; and that with the mixed mineral manure and the larger, or double amount of ammoniacal salts. In the case of each of the 5 plots an equal mixture of the ash of its produce in each of the three years was operated upon. In this way the average effect of each condition of manuring upon the mineral composition of the crop is taken over a three-years' continuance of that condition.

The ash-analyses were made in the Rothamsted laboratory, by Mr. Robert Warington, jun.; and we are glad to take this opportunity of expressing our full confidence in the accuracy of his results.

The facts which the figures in the Table disclose are very interesting. But our comments on them must be very brief, and be confined to their practical bearings.

It has been shown in Parts I. and III. of our Paper, that ammoniacal salts alone gave an almost entirely Graminaceous produce, but that that produce was stunted, very dark green, leafy, and not very much more in weight per acre than that without manure. Mineral manures alone, on the other hand, increased the weight of produce somewhat more than the ammoniacal salts alone; but the increase in this case was chiefly Leguminous herbage—the Graminaceous herbage benefiting but little by this

Effects of Different Manures on the Mixed Herbage of Grass-Land.

Table XIII.—Percentage Composition of the Ash; and Quantities of the several Mineral Constituents in the Total Produce, and in the Increase by Manure, per Acre.

	Percentage Composition of the Ash.					Mineral Constituents in Total Produce (lbs.).					Mineral Constituents in Increase (lbs.).			
	No Manure.	Ammonia Salts. (82 lbs. N.)	Mineral Manure.	Mineral Manure and Ammonia Salts. (82 lbs. N.)	Mineral Manure and Ammonia Salts. (164lbs.N.)	No Manure.	Ammonia Salts. (82 lbs. N.)	Mineral Manure.	Mineral Manure and Ammonia Salts. (82 lbs. N.)	Mineral Manure and Ammonia Salts. (164 lbs.N.)	Ammonia Salts. (82 lbs. N.)	Mineral Manure.	Mineral Manure and Ammonia Salts. (82 lbs. N.)	Mineral Manure and Ammonia Salts. (164lbs.N.)
Peroxide of Iron	0·13	0·12	0·31	0·45	0·52	0·2	0·3	0·7	1·9	2·4	0·1	0·5	1·7	2·2
Lime	14·98	13·85	13·38	9·60	8·65	23·7	31·0	32·4	41·7	39·8	7·3	8·7	18·0	16·1
Magnesia	4·14	4·70	3·70	3·41	3·98	6·6	10·5	9·0	14·8	18·3	3·9	2·4	8·2	11·7
Potash	20·40	17·09	29·77	28·08	28·89	32·3	38·2	72·2	121·9	132·9	5·9	39·9	89·6	100·6
Soda	8·43	10·31	4·58	7·05	8·49	13·3	23·0	11·1	30·6	39·0	9·7	−2·2	17·3	25·7
Phosphoric Acid	4·86	4·64	6·67	6·30	5·97	7·7	10·4	16·2	27·4	27·5	2·7	8·5	19·7	19·8
Sulphuric Acid	6·09	7·56	7·78	6·27	5·71	9·6	16·9	18·9	27·2	26·3	7·3	9·3	17·6	16·7
Chlorine	6·22	14·66	6·52	16·49	19·93	9·8	32·8	15·8	71·6	91·7	23·0	6·0	61·8	81·9
Carbonic Acid ..	5·62	3·21	6·63	1·87	1·73	8·9	7·2	16·1	8·1	7·9	−1·7	7·2	−0·8	−1·0
Silica	25·91	21·17	18·82	18·57	15·89	41·0	47·3	45·6	80·6	73·1	6·3	4·6	39·6	32·1
Sand	1·41	1·95	0·82	2·84	2·98									
Charcoal	3·19	4·08	2·54	3·04	2·13									
	101·38	103·34	101·52	103·97	104·87									
Deduct O = Cl. *	1·40	3·31	1·47	3·72	4·50									
Totals	99·98	100·03	100·05	100·25	100·37	153·1	217·6	238·0	425·8	458·9	64·5	84·9	272·7	305·8

* In the absence of knowledge which chemistry does not supply, as to the state of combination, either in the plant itself or in the ash, of the several constituents determined in a plant-ash, it is considered far better to make no assumptions on the point. It is, moreover, far more convenient, both for the comparison of the composition of one ash with that of another, and for the purposes of any calculations with a practical view, to represent the whole of the sodium and potassium as soda and potash; instead of part as such and part as chlorides, as is frequently done when chlorine is present. This method, of course, requires the deduction from the sum of the constituents, of an amount of oxygen equivalent (chemically) to the total chlorine.

manure, excepting in forwardness and seeding tendency. But the mixture of the two manures—ammoniacal and mineral—gave an enormous increase of crop, and the amount of mineral constituents taken off an acre of land, under the influence of the combination, was nearly twice as great as that in the crop by either of the manures used separately. It was quite obvious, that where the *ammoniacal salts* were used alone, the available supply of some of the necessary *mineral* constituents fell short of the amount required for a more abundant crop. It was equally clear, that where the *mineral manures* were used alone, there was a deficiency of *nitrogen* available for the increased growth of the Graminaceous herbage. The results in the Table show that it was chiefly for its supply of *potash*, and next for that of *phosphoric acid*, that the mixed mineral manure was so efficacious in increasing the growth of the *grasses*, when there was a sufficiency of available *nitrogen* within the soil. They also point to a probable deficiency of soluble *silica* in the case of the heavier crops.

To turn to the figures in the Table: the most striking point of contrast afforded by the view of the results of the five analyses given side by side, is the very great increase in the percentage of *potash*, wherever the mineral manure containing it was employed. There is at the same time always a diminution either in the actual percentage of soda, or in its proportion to that of the potash, or in both these points of view. This was the case, notwithstanding that soda as well as potash was liberally supplied in the mineral manure. The preference of the growing plants for potash rather than soda is sufficiently manifest. And judging from the analogy of other crops it may almost certainly be concluded that, if all the plants of the hay had been allowed to fully ripen, the ash would then have contained but very little soda, if any at all. The increase in the percentage of *potash* in the ash, where it was supplied in manure, is at the expense of the lime and magnesia, though these constituents were also supplied in the mixed mineral manure. In fact the ash both of the produce without manure, and of that by ammoniacal salts alone, gave a somewhat higher percentage of both lime and magnesia than even where the mineral manures alone were used, and the produce contained so much Leguminous herbage, the ash of which is richer in lime and magnesia than is that of the Grasses proper. The percentage of lime more particularly, was still further reduced, when the ammoniacal salts were mixed with the mineral manure, by which the growth of the Grasses, demanding so much potash, was so much increased.*

* It is seen that wherever the ammoniacal salts were employed, which consisted of a mixture of the sulphate and hydrochlorate, the amount of *chlorine* in the

The percentage of *phosphoric acid*, as well as that of potash, increases notably, though not in so great a degree, where the mineral manure containing it was used.

The percentage of *sulphuric acid* in the ash is pretty uniform throughout, though it was supplied largely both in the ammoniacal salts and in the mixed mineral manure. Whether or not, the whole of the sulphuric acid found, existed *as such* in the plant, in combination with bases, or whether, on the other hand, there has been any loss of it, or of sulphur in some form, during the incineration, may be a question. It is, at any rate, worthy of remark how very much larger is the proportion of *chlorine* found in the ash of this succulent produce wherever it was used in manure, notwithstanding that this substance (chlorine) may be supposed to be in a far less degree than sulphur or sulphuric acid, if at all, essential to the elaboration of the final products of the plants.*

Carbonic acid is seen to be in the largest proportion in the produce grown without manure, and in that by mineral manures alone. The Carbonic acid is the product of the incineration of some other organic acid. Its comparatively large amount in the ash of the produce of the two plots mentioned is due to the Leguminous and other non-Graminaceous herbage, occurring in large proportion on those plots. The ash of such herbage (the non-Graminaceous) contains, indeed, little or no silica, and frequently a great deal of Carbonic acid due to salts of organic acids.

The percentage of *silica* is, nevertheless, much higher in the ash of the produce grown without manure than in that grown by any of the artificial manures now in question. The percentage of *silica* in the ash is the less where the produce of the Graminaceous herbage—which so peculiarly requires it—is the greater. And where the total Graminaceous herbage was thus the greater, it was also in the larger proportion in flowering and seeding stem; and as the stem increases, so, when not in defect, does the proportion of *silica*. It is true that where the Graminaceous produce was so large, and the proportion of it that was in flowering and seeding stem was also large, those stems were not so

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ash is very much increased. This constituent, like soda, is found only seldom, or in small quantity, in the ash of perfectly-ripened vegetable produce. It probably serves more as a vehicle of bases, than as an essential constituent of any of the final products of the organism. Were we to exclude it in all cases from these ash analyses, the percentage of potash would be higher where the ammoniacal salts were used with the mineral manure, and the grasses were so much developed, than where the mineral manure was used alone.

* The fact, that in such highly siliceous ashes the amounts of chlorine should not only in some cases be very large, but that the variations in amount should have such very obvious connection with the manurial conditions supplied, is quite in accordance with the experiments of Mr. Way, showing that a loss of chlorine need seldom be feared when the process of incineration is carefully conducted.

ripe as were those of the smaller Graminaceous crops; and it is as the Graminaceous plants progress to ripeness, that their ashes increase so much in percentage of *silica*. It would appear from these considerations, that there was a deficient supply of *available silica* for the greatly-increased growth. But a better view of the probable mineral requirements, or deficiencies, of the crop, will be gained by attention to the actual or increased amounts of the several constituents in the *acreage produce* under the different manuring conditions, as shown in the second and third Divisions of the Table (XIII.).

By the use of *ammoniacal salts alone*, the amount of total mineral constituents taken off in the crop is about 1½ time as much as without any manure at all. From the obvious limit that there was to the Graminaceous increase by ammoniacal salts alone, it is assumed that, in the case of some of the mineral constituents of the soil, its supplies were drained to the utmost that the range of distribution of the underground feeders of the plant would permit. Supposing this to be the case, it is seen that the gain in both *potash* and *silica* was proportionally less than that of any other important constituent. But, as soon as potash is added in manure, even though without ammoniacal salts, the acreage amount of it in the crop is increased in larger proportion than that of any other important mineral constituent, except phosphoric acid. The *silica*, which was not supplied in the manure, was comparatively but little increased in the produce. When the ammoniacal salts as well as mineral manure were employed, the amount of *potash* in the acreage produce was nearly twice as much as when the mineral manures were used alone; and it was from 3 to 4 times as much as when no manure at all, or ammoniacal salts alone, were employed. Under the same circumstances, the acreage amount of *phosphoric acid* increased in almost an equal degree. So also did that of the *sulphuric acid*. The *silica* even, was about doubled; though there was no supply of it in manure. And, lastly, the *magnesia*, but especially the *lime* (though both were supplied in the manure) increased in very much less acreage amount than the potash.

From the whole it appears, that the much less acreage produce of hay, when the ammoniacal salts were used alone, than when they were used in conjunction with the mixed mineral manure, was due to a deficiency of available *potash* and *phosphoric acid* within the range of the roots of the crop. It also appears probable, that there was a relative deficiency of available *silica*, notwithstanding that the range of collection of the roots of the crop would be considerably increased where the ammoniacal salts and the non-siliceous mineral constituents were employed. It is true that the *acreage* yield of Silica was considerably increased where the

larger crops were grown; though it was so not at all commensurately with either the potash or the phosphoric acid. How far the increased amount of Silica, such as it was, was due to its being liberated in available form by the chemical action of the constituents of the manures employed, or how far only to the increased distribution and range of collection of the roots of the more actively growing crop, we are not able to decide.

To call to mind even more clearly than by the above statements how great is the drain upon the soil, more particularly of potash, phosphoric acid, and of silica, by a heavy hay-crop, it will be useful to quote here a few figures from the Table.

Whilst the unmanured produce contained only $32\frac{1}{3}$ lbs., and that by ammoniacal salts alone only $38\frac{1}{4}$ lbs. of *potash*, that grown by the mineral manure alone (supplying potash) contained $72\frac{1}{4}$ lbs., that by the mineral manure and smaller amount of ammoniacal salts nearly 122 lbs., and that by the mineral manure and the larger amount of ammoniacal salts nearly 133 lbs. of potash, per acre annually.

The *phosphoric acid* was increased from about $7\frac{3}{4}$ lbs. per acre per annum without manure, to scarcely $10\frac{1}{2}$ lbs. with ammoniacal salts alone, to $16\frac{1}{4}$ lbs. with mineral manure alone, and to about $27\frac{1}{2}$ lbs. by the mineral manure and ammoniacal salts together.

The *silica* amounted to 41 lbs. per acre per annum in the produce without manure, to $47\frac{1}{3}$ lbs. in that by ammoniacal salts alone, to nearly $45\frac{2}{3}$ lbs. in that by mineral manure alone, to $80\frac{2}{3}$ lbs. in that by the mineral manure and the smaller amount of ammoniacal salts, and to a little more than 73 lbs. in that by the mineral manure and the larger amount of ammoniacal salts.

We have already prominently called attention to the fact that the hay-crop, both from the large amount of mineral constituents it generally carries from the land, and from the generally more inadequate return of them by the home or other manures, is liable to be much more exhausting to the soil than the rotation crops of a farm. It has been stated, too, that *potash* was perhaps the constituent most likely first to show a deficiency. These ash-analyses, and the discussion to which they have led, cannot fail to impress upon the mind of the farmer still more forcibly the necessity of a due return to the land, at least of *potash* and *phosphoric acid*, if not even of available *silica* (which would be accomplished by farmyard-manure), if he would hope to obtain anything like maximum crops of hay, year by year, by the aid of artificial nitrogenous manures.

It has just been seen how very variable is the composition of the *ash* of the mixed herbage of meadow-land according to the *manure* employed. It has before been shown that the composi-

tion of the total mixed produce, or *hay*, varied very much according to *season*—both in regard to the percentage of Dry substance, and to that of the Mineral matter in that Dry substance. It will also presently be seen that the percentages of total Nitrogenous compounds likewise varied very much according to *season*. The *composition of the ash* does not, however, appear to be so much affected by variation in *season* as from the influence of the latter on the composition of the hay in other points of view might have been anticipated.

The much less effect of variation in *season*, than in *manuring*, on the composition of the ash of the experimentally-grown hay, is illustrated by the results given in Table XIV., which now follows :—

TABLE XIV.—Showing the COMPOSITION of the ASHES of MEADOW-HAY grown Experimentally in different Seasons.

	Mixed Ashes of the Produce by 16 different Manures in each Year.			
	1856.	1857.	1858.	Calculated Mean (1856-7-8).
Peroxide of Iron	0·14	0·33	0·25	0·24
Lime	13·02	12·13	11·92	12·36
Magnesia	3·59	3·93	3·97	3·83
Potash	26·83	26·43	25·26	26·17
Soda	6·40	7·45	9·58	7·81
Phosphoric Acid	5·59	5·68	5·52	5·60
Sulphuric Acid	6·02	7·14	7·18	6·78
Chlorine	11·37	12·15	12·25	11·92
Carbonic Acid	3·37	2·74	2·73	2·95
Silica	22·28	19·93	20·23	20·81
Sand	2·15	2·89	2·29	2·44
Charcoal	2·22	2·22	2·17	2·20
	102·98	103·02	103·35	103·11
Deduct O = Cl *	2·56	2·74	2·76	2·69
Totals	100·42	100·28	100·59	100·42

* See note at foot of Table XIII.

In the first column of the Table is given the composition of an equal mixture of the ashes of the produce from all the experimental plots in 1856 ; in the second column, the composition of a similarly mixed ash from the produce of all the plots in 1857 ; and in the third column, the composition of the mixed ash from all the plots in 1858. The fourth column gives the calculated mean of the three analyses.

The uniformity in the composition of the three mixed ashes,

representing as they do the percentage mineral composition of the produce of three very different seasons—the characters of which differed so widely in several other respects—is somewhat remarkable. The differences are indeed too slight to justify the deduction from them of any very defined conclusions. Still, it may be observed, that the tendency of the variations is to show a scarcely maintained, and in some cases an even diminished proportion, of those constituents which may be considered the most characteristic of the hay crop, when it is supplied liberally with all the necessary mineral constituents. Thus, the proportion of phosphoric acid is about equal in the three seasons, whilst that of the lime, the potash, and the silica, show a tendency to decrease from year to year. The carbonic acid too, which is characteristic of the ash of the non-graminaceous part of the herbage, also diminishes somewhat from the first to the third year. On the other hand, the soda and the chlorine—constituents the most of all characteristic of crude and succulent growth—increase very obviously in their proportion in the ash from year to year.

Upon the whole then, these results, comparatively slight as the differences are, still indicate, as did those which have gone before, that there was a probable relative deficiency of *lime*, *potash*, and *silica*;—especially of the latter two.

With regard to the results given in the fourth column attention may be called to the fact, that the figures represent the mean composition of the ash of specimens of hay grown under sixteen different manuring conditions, in each of the three widely differing seasons. The results may therefore be taken as showing the average mineral composition of the mixed herbage grown under a great variety of circumstances.

Nitrogen.

For the information of the chemical reader it may be mentioned, that the *nitrogen* in the hay, as given in the Table, was determined by burning with soda-lime, and estimating by the volumetric method. Duplicate determinations were always made. The individual results are given for reference in Tables V., VI., and VII., in the Appendix. The *mean* results only, are given in Table XV. on the next page; and these will be in sufficient detail for the purpose of our illustrations. The *nitrogen* was thus determined, in the hay from every one of the experimental plots, in each of the three years of the experiments. The figures in the first set of four columns (Table XV.) represent the percentages of Nitrogen in the *fresh hay*—that is, in the condition in which it was carted from the land. The figures in the second Division represent the percentages in the *Dry substance* of the hay.

Table XV.—Percentages of Nitrogen in the Hay (Means of Duplicate Determinations).

Plot, Nos.	MANURES (Per Acre, per Annum).	Percentages in the Hay as taken from the Land.				Percentages in the Dry Substance of the Hay.			
		1856.	1857.	1858.	Average of 3 years.	1856.	1857.	1858.	Average of 3 years.
	Series 1.—Without Direct Mineral Manure.								
1	Unmanured	1·68	1·29	1·40	1·46	2·05	1·52	1·63	1·73
2	Unmanured (duplicate plot)	1·79	1·43	1·34	1·52	2·18	1·64	1·57	1·80
	Mean, or Standard Unmanured	1·73	1·36	1·37	1·49	2·11	1·58	1·60	1·76
3	2000 lbs. Sawdust	1·67	1·38	1·41	1·49	2·07	1·57	1·67	1·77
4	200 lbs. each, Sulphate and Muriate Ammonia	1·57	1·55	1·65	1·59	1·96	1·78	1·96	1·90
5	200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	1·59	1·49	1·56	1·55	1·99	1·71	1·86	1·85
6	275 lbs. Nitrate of Soda	..	..	1·68	..	..	..	1·98	..
7	550 lbs. Nitrate of Soda	..	..	1·71	..	..	..	1·99	..
	Mean	1·64	1·44	1·56	1·55	2·03	1·66	1·84	1·84
	Series 2.—With Direct Mineral Manure.								
8	"Mixed Mineral Manure"*	1·67	1·51	1·40	1·53	2·09	1·74	1·64	1·82
9	"Mixed Mineral Manure," and 2000 lbs. Sawdust	1·77	1·48	1·39	1·55	2·21	1·71	1·65	1·86
10	"Mixed Mineral Manure," and 200 lbs. each, Sulphate and Muriate Ammonia	1·23	1·18	1·25	1·22	1·55	1·36	1·52	1·48
11	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	1·26	1·11	1·17	1·18	1·64	1·27	1·40	1·44
12	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Cut Wheat-Straw	1·47	1·33	1·35	1·38	1·85	1·55	1·64	1·68
13	"Mixed Mineral Manure," and 400 lbs. each, Sulphate and Muriate Ammonia	1·49	1·62	1·71	1·61	1·88	1·88	2·12	1·96
14	"Mixed Mineral Manure," and 275 lbs. Nitrate of Soda	..	..	1·52	..	..	..	1·76	..
15	"Mixed Mineral Manure," and 550 lbs. Nitrate of Soda	..	..	1·32	..	..	..	1·55	..
	Mean	1·48	1·37	1·39	1·41	1·86	1·58	1·66	1·70
	Series 3.—With Farmyard Manure.								
16	14 Tons Farmyard Manure	1·35	1·31	1·18	1·28	1·77	1·50	1·40	1·58
17	14 Tons Farmyard Manure, and 100 lbs. each, Sulphate and Muriate Ammonia	1·62	1·08	1·27	1·32	2·04	1·26	1·53	1·61
	Summary.								
	General Means for the Experimental Specimens	1·53	1·37	1·43	1·44	1·93	1·58	1·70	1·74
	Mixed Hay from the same Meadow, taken out of the rick December, 1858	..	1·33	1·16	..	..	1·53	1·38	..

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

It will be found that the percentage of *nitrogen* in the Dry substance, of such heterogeneous and irregularly ripened produce as hay, is, like that of the mineral matter, contingent upon many coincident circumstances. Still, the results will show, as already alluded to, that, other things being equal, the lower the condition of maturation of the produce the higher will be the percentage of Nitrogen, and *vice versâ*.

In accordance with this general observation, the Table shows that the season which gave the produce yielding the lowest average percentage of Dry substance, and the highest average percentage of Mineral matter in that dry substance (1856), gave also a produce containing a higher percentage of *nitrogen* in its dry substance than that of either of the years of higher condition of the hay. Conversely, the second season (1857), the produce of which showed the highest average percentage of dry matter, and the lowest average percentage of mineral matter in that dry substance, gave, at the time of cutting, a hay which contained the lowest average percentage of Nitrogen in that dry substance. As between the produce of one season with that of another, then, the general result was, that the more matured the condition of the hay, the lower was the percentage of Nitrogen in its dry substance. This is in general accordance with what we have elsewhere shown to obtain in the case of ripened crops—wheat and barley. It is true, that in the case of the hay-crop, the object is not a fully ripened produce. There is, therefore, of course, a limit below which a depreciation in the percentage of Nitrogen, the result of over-ripening, will be a disadvantage. At the same time we believe that, comparing the produce of hay of one season with that of another, each cut at its proper stage of progress, that which has the lower percentage of Nitrogen in its dry substance will, taking the average of seasons, have its constituents in the better condition of elaboration, and be, therefore, a better food for animals.

The variations in the percentage of Nitrogen in the hay within one and the same season, according to the *manuring*, are very marked and interesting.

Taking the average result of the three seasons, the produce grown on the plot manured with ammoniacal salts alone, contained a much higher percentage of Nitrogen in its dry substance than did that grown without manure. Again, the produce grown by ammoniacal salts and sawdust gave a higher percentage of Nitrogen than that grown by sawdust alone. When the ammoniacal salts were thus supplemented to the unmanured, or to the merely sawdusted conditions, the supply of Nitrogen was in considerable relative excess; as was shown by the greatly increased produce when the mixed mineral manure was superadded.

Under these circumstances, the percentage of the deficiently-provided Mineral constituents was comparatively low, whilst that of the relatively excessively supplied Nitrogen was considerably increased. The percentage of Nitrogen was thus increased, notwithstanding that the produce was almost entirely Graminaceous where the ammoniacal salts were used; whilst, where they were not employed, it contained a notable proportion of Leguminous herbage, the percentage of Nitrogen in which is generally about twice as high as in purely Graminaceous produce. The high percentage of Nitrogen in the produce grown by ammoniacal salts without mineral manure was, therefore, due to an increased percentage of it in the Graminaceous herbage. This highly nitrogenised Graminaceous produce consisted, it will be remembered, in very large proportion of *leaf;* it was stunted in growth; and was of a very dark green colour compared with the produce where there were larger crops.

The mixed mineral manure used alone, or in conjunction only with sawdust, gave a produce which contained a higher percentage of Nitrogen than either that grown without manure or with sawdust alone. The percentage of Nitrogen under these conditions was nearly as high as where the ammoniacal salts, or the ammoniacal salts and sawdust (without mineral manure), were used, which gave the stunted, dark green produce, above referred to. But the high percentage of Nitrogen in the produce now under consideration, namely, that grown by mineral without nitrogenous manure, was not due to a high percentage in the Graminaceous part of it. It was due to the fact, that the produce grown under these conditions contained a large proportion of Leguminous herbage, the percentage of Nitrogen in which is, as above stated, generally about twice as high as that in purely Graminaceous hay.

It has been seen, then, that the mineral manure alone gave a produce containing a high percentage of Nitrogen by increasing the proportion in it of the highly nitrogenous Leguminous herbage. It has also been seen, that the use of ammoniacal salts alone, mineral constituents being in defect, gave a stunted Graminaceous produce, also with a considerably increased percentage of Nitrogen. The addition of ammoniacal salts, when there was at the same time a liberal provision of mineral constituents, gave a very different result both as to the character and amount of the crop, and as to the percentage of its Nitrogen.

If we compare the composition of the produce manured with both ammoniacal salts and the mineral manure, with that grown by the mineral manure alone, or again, if we compare the produce by ammoniacal salts, sawdust, and mineral manure, with that by the sawdust and mineral manure without the ammoniacal

salts, the Table shows that, in both cases, the percentage of Nitrogen in the produce was considerably lower where the ammoniacal salts were employed than in the comparable instances without them. This lower percentage of Nitrogen in the hay, by the addition of ammoniacal salts to mineral manure, was partly due to the fact, that the produce grown by the mineral manure without the ammoniacal salts, contained so large an amount of the highly Nitrogenous Leguminous herbage, whilst that grown with ammoniacal salts in addition, was almost entirely Graminaceous. But the percentage of Nitrogen in this Graminaceous produce grown by ammoniacal salts together with a liberal supply of mineral constituents, was also very much lower than that in the equally Graminaceous produce where the nitrogenous supply was in excess; that is to say, where the ammoniacal salts were used without the mineral manure. Thus, taking the average of the three years, the percentage of Nitrogen in the dry substance of the hay grown by ammoniacal salts alone, was 1·9; whilst that in the dry substance of the produce grown by the same amount of ammoniacal salts, but in conjunction with the mineral manure, was only 1·48. This produce grown by the nitrogenous and mineral manure combined, was about $1\frac{2}{3}$ time as great as that grown by the use of ammoniacal salts alone; it was of a far lighter, and more lively green colour whilst growing; it was far more luxuriant; and it gave a much larger proportion of flowering and seeding stem. Such were the comparative characters of the produce, which contained much the lower percentage of Nitrogen. The higher percentage of Nitrogen in the produce grown by the ammoniacal salts without the mineral manure was, therefore, coincident with a much smaller yield of hay, with a much less luxuriance of growth, and with a much larger proportion of leafy produce. In fact, in the case of hay, as in that of the ripened cereal grains, a relatively low percentage of Nitrogen (within certain limits) is, in cases comparable on the point, more likely to be associated with a relatively high, than with a relatively low condition, and degree of elaboration, of the constituents; and it is also more likely to be the result of moderately luxuriant, than of either stunted or over-luxuriant growth.

The points last referred to, are aptly illustrated by a comparison of the characters and nitrogenous percentage of the hay grown by the double amount of ammoniacal salts with the mineral manure, with those of the produce grown by the smaller amount of ammoniacal salts and the same mineral manure. The average percentage of Nitrogen in the dry substance of the scarcely too heavy or luxuriant produce grown by the mineral manure and the smaller amount of ammoniacal salts, was only 1·48; whilst,

that in the dry substance of the over-luxuriant, unevenly-ripened, and laid and damaged produce, grown by the same mineral manure and the double or excessive amount of ammoniacal salts, was 1·96. It will not be doubted, that the higher percentage of Nitrogen was, under these circumstances, coincident with a more crude and less favourable condition of the constituents of the hay. It has been shown experimentally by Professor Voelcker, that succulent plants may contain a part of their nitrogen in the condition of ammoniacal salts; and Professor Sullivan has more recently called attention to the apparently frequent occurrence of both ammonia and nitric acid in the sap of plants. We had too, ourselves, long since pointed out, that turnips in which the percentage of Nitrogen was raised beyond a comparatively low amount by means of highly nitrogenous manures were, weight for weight, of less feeding value—indeed they were sometimes even purgative and injurious—than those having a far lower percentage of Nitrogen, but which were in a less crude and succulent, and a more highly elaborated condition.*

Attention should be called to the fact, that the produce grown by *nitrate of soda* alone, like that grown by ammoniacal salts alone, contained a much higher percentage of Nitrogen, than that grown without manure.† Again, the addition of mineral manure to the nitrate of soda, by which the crop was considerably increased, gave a produce containing a lower percentage of Nitrogen than that grown by nitrate of soda alone.

Before leaving the results of Table XV., it may be observed that, *taking the average of the three seasons*, the addition of ammoniacal salts to *farmyard manure*, gave a produce containing a slightly higher percentage of Nitrogen. In the second season, however, which was the one of the highest dryness and maturation of the hay, at the time of cutting, a contrary result was obtained.

From the whole of the results in regard to *nitrogen*, it would appear, that a *high percentage* is by no means a safe indication of relatively high feeding quality. In fact, in succulent and unripened produce more particularly, it is an uncertain indication even of high amount of elaborated nitrogenous vegetable compound.

Woody Fibre.

The constituent of vegetable food-stuffs, to which the term "*woody fibre*" is frequently given, is that portion which remains

* 'Jour. Roy. Agr. Soc. Eng.,' vol. x. (1849), pp. 306–315 inclusive.

† As the amount of nitrogen in the hay grown by the *nitrate of soda*, was determined by combustion with soda lime, and estimation as ammonia by the volumetric method, the high amount recorded in the Table could not be due to undecomposed nitric acid or nitrate.

undissolved after the application of such solvents as are supposed to remove all the other vegetable compounds—namely, the nitrogenous substance, the fatty matter, the starch, the sugar, the gum, the extractive matters, &c. The substance so remaining generally retains, however, a certain amount of mineral matter, the quantity of which is determined by the incineration of the fibre. The attainment of certain results in regard to the amount of this so-called "woody-fibre" is, however, in practice, not a very easy matter. It is seldom that two experimenters have adopted the same methods for its quantitative estimation. And, although it is comparatively easy to determine whether or not the product of the process still retains some of the other matters enumerated above, it is by no means so easy to settle whether or not any portion of the substance which it is intended to include under the term Woody-fibre, has itself been rendered soluble and removed. For the results we have to lay before the reader under this head, as well as for those relating to the Fatty matter, to which we shall refer further on, we are indebted to Mr. Thomas Segelcke, of Copenhagen, who kindly undertook this part of the investigation whilst staying in the Rothamsted laboratory.

It would be out of place to go elaborately into the question of method here; and it is the less necessary as Mr. Segelcke will probably publish in detail on this point elsewhere. It may be mentioned, however, that he in vain tried to get results which corresponded with one another when using the different methods that have been recommended. In fact, constancy of result seemed to be only attainable, when solvents of a constant strength were employed, for a fixed period of time, and at a given temperature. The necessity for observing fixed time and temperature, has been insisted upon by Millon; and the strength of solvents which Mr. Segelcke adopted in the analysis of the hays, as giving pretty uniform results, was very much the same as recommended by M. Peligot.

The method by which the results given in the Table were obtained, was briefly as follows. About 10 grammes of the finely ground hay were first fully dried at a temperature of 212° F. The substance was next digested for three-quarters of an hour at a temperature, as nearly as it could be maintained, of 180° F., in 150 septems* of sulphuric acid, composed of one part, by volume, oil of vitriol, and two parts, by volume, water.†

* A septem measure is that of $\frac{1}{1000}$th of a pound avoirdupois, or 7 grains, of water.

† The above is the strength of acid recommended by M. Peligot. In subsequent investigation Mr. Segelcke has found, that results of which the duplicates were much more closely agreeing, and which still ranged very close to those recorded in the Table and obtained by the method described in the text, could be insured by using a weaker acid, but at a higher temperature. So far as his experiments have yet proceeded, the strength of acid which he has found to be the

After this digestion, the whole was diluted with hot water, filtered, and the insoluble matter well washed with hot water. At this stage the product retained several per cent. of nitrogenous substance, and a considerable amount of other matters which were dissolved in the next step of the process. The substance was removed from the filter, and then boiled for half an hour with 600 septems of very dilute caustic soda. The whole was again thrown on a filter and well washed with hot water. A drop of sulphuric acid was, however, added to the wash-water after the main portion of the washings had passed off; and the washing was continued until the water no longer came through acid. The matter was then washed from the filter, dried, and weighed as *woody fibre*. After this treatment, the product still retained 0·1 per cent., or less, of its weight of nitrogenous substance, and some mineral matter; both of which were determined and deducted by calculation.

The individual determinations of this Woody-fibre are given for reference in Table VIII. in the Appendix; and an examination of them will show within what limits the duplicate or triplicate results agree with one another. It is believed that the figures are probably very trustworthy as a comparative series, comparing specimen with specimen as to the respective amounts of Woody-fibre of a given degree of insolubility or induration; but they are pretty certainly too low considered as including the whole of the *cellulose*. At least Mr. Segelcke found that even Swedish filtering paper was somewhat reduced in amount by the second part of the process, namely, the treatment with alkali, though it was not so by the digestion with the sulphuric acid. On the other hand, with any less treatment with the alkali, not only higher results, but inconstant duplicates or triplicates, were obtained; and the product at the same time retained a considerably higher amount of nitrogenous substance.

As already intimated, the *woody fibre* was only determined in the hay of certain plots, namely, those selected for the botanical separations referred to in Part III. It was, however, determined in the produce of those plots, in each of the three years of the experiments. We are enabled, therefore, to trace the effects of both *season* and *manuring* on the percentage of the

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best is, 1 volume of oil of vitriol to 16 volumes of water; the temperature that of the boiling point; and the time of action a quarter of an hour. A great practical advantage of substituting the use of a stronger acid, and a temperature below the boiling point, by a weaker acid and the boiling point, is the ease by which constancy in the latter temperature can be secured. Indeed, the discrepancies, such as they are, between the duplicate and triplicate determinations recorded in the Appendix, Table VIII., Mr. Segelcke attributes mainly to the accidental fluctuations in practice, somewhat above or below his then adopted temperature of 180° F.

more insoluble *woody fibre*—so far as it can be indicated by the results of the method above described. The *means* only, of the two or more determinations made on each specimen, are given in Table XVI. which now follows; and it is these to which we shall confine attention.

The professed object of determining the amount of *woody-fibre* in our food-stuffs, is to acquire some means of judging of their amount of probably indigestible and effete material. Now, it is sufficiently established by the researches of many able investigators, among whom we may mention Mulder, Harting, Boussingault, Millon, Peligot, Mitcherlich, Chevreul, Fremy, Cramer, and Payen, that the substance to which is given the somewhat generic term *woody-fibre*, comprises many modifications, which vary from each other, in physical characters, and in behaviour to solvents, according to age, and other circumstances of their deposition, and to the character and amount of the incrusting matters, and of the injected, or foreign matters, with which they are associated. In fact, some of the modifications which yield most easily to certain chemical solvents, seem to be separated by almost imperceptible lines of demarcation, from the admittedly more digestible starchy bodies. The two series of bodies appear, indeed, to be mutually transformable, not only in the laboratory of vegetable existence, but more or less in that of the chemist also. How then, are we by the chemical analysis of a food, to determine exactly at what point of aggregation, induration, or protection by foreign substances, its Cellular or Woody matter is to be accounted as indigestible, innutritious, and effete? So long as the Cellular substance is in such a condition as to be easily acted upon by chemical solvents, or to be transformable within the plant, we may perhaps venture to assume, that it would not be wholly refractory to the digestive agencies of animals. If, therefore, it be admitted, that the amounts of matter recorded as *woody fibre* in our Table, do not include the more delicate and changeable Cellulose of the vegetable substance examined, they may nevertheless, on that account, the more nearly represent the proportions of the respective hays, that will be necessarily indigestible and effete. In fact, although we do not at all claim that the results do indicate the *total cellulose* of the specimens examined, we still believe, that so far as present experience goes, results so obtained are the best means at command for the purpose of comparing the specimens one with another, in regard to the relative proportion in each of the more refractory Cellular matter. And, so far as the substance which resists the action of solvents employed in the degree above described, may be found to be really indigestible and effete, a large relative proportion would in this point of view be objectionable. At the same time, it must be

Experiments with Different Manures on Permanent Meadow Land.

Table XVI.—Percentages of Woody Fibre in the Hay (Means of Duplicate Determinations).

Plot, Nos.	MANURES. (Per Acre, per Annum.)	1856.[1]	1857.	1858.	Average of 3 Years.
	Percentages in the Hay as taken from the Land.				
1	Unmanured	24·5	22·9	22·9	23·4
4	200 lbs. each, Sulphate and Muriate Ammonia	24·8	23·1	22·9	23·6
8	"Mixed Mineral Manure" *	24·0	23·0	25·0	24·0
10	"Mixed Mineral Manure," and 200 lbs. each, Sulphate and Muriate Ammonia	25·5	25·3	24·1	25·0
13	"Mixed Mineral Manure," and 400 lbs. each, Sulphate and Muriate Ammonia	25·6	24·2	23·6	24·5
16	14 tons Farm-yard Manure	23·7	25·8	24·5	24·7
17	14 tons Farm-yard Manure, and 100 lbs. each, Sulphate and Muriate Ammonia	23·6	25·0	24·3	24·3
	Means	24·5	24·2	23·9	24·2
	Percentages in the Dry Substance of the Hay.				
1	Unmanured	29·9	26·9	26·6	27·8
4	200 lbs. each, Sulphate and Muriate Ammonia	31·0	26·6	27·2	28·3
8	"Mixed Mineral Manure"	30·0	26·5	29·2	28·6
10	"Mixed Mineral Manure," and 200 lbs. each, Sulphate and Muriate Ammonia	32·3	29·0	29·4	30·2
13	"Mixed Mineral Manure," and 400 lbs. each, Sulphate and Muriate Ammonia	32·8	28·2	29·3	30·1
16	14 tons Farm-yard Manure	31·2	29·6	29·0	29·9
17	14 tons Farm-yard Manure, and 100 lbs. each, Sulphate and Muriate Ammonia	29·7	29·0	29·4	29·4
	Means	31·0	28·0	28·7	29·2

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

borne in mind, that a certain proportion of this otherwise useless and effete matter, is absolutely essential to give bulk, and to aid the digestion of the other constituents of the food, especially of our ruminant animals.

With these brief observations on the character and relationships of the substance, the amounts of which, in the respective hays, are recorded in the Table, attention may now be directed to the results there given.

In the upper portion of Table XVI., the percentages of *woody-fibre*, or more properly of comparatively indurated Cellular matter, in the *fresh hay* are given; and in the lower Division, the percentages in the *Dry substance* of the hay. The latter indicate the most clearly the differences in the composition of the vegetable substance of the hay. Comparing the produce of one season with that of another, the percentage of this comparatively insoluble Woody-fibre is, on the average, considerably the highest in that of the wet, cold, and ungenial season 1856, and the lowest in that of 1857. It will be remembered that the produce of 1856, which shows the largest proportion of comparatively refractory Woody matter in its Dry substance, gave a very low percentage of Dry substance; but high percentages of both Mineral matter and Nitrogen (in a questionable degree of elaboration), in that Dry substance. And conversely, the produce of 1857, which now gives the lowest proportion of such Woody fibre in its Dry substance, gave the highest proportion of Dry substance and the lowest proportion of Mineral matter and Nitrogen, in that Dry substance.

It might perhaps not have been anticipated, that the season which gave the most crude, succulent, and ill-conditioned produce, would at the same time give a vegetable substance containing a high proportion of comparatively indurated cellular or woody matter. In all cases, the specimens were so far dried soon after they were collected, as to leave in them only about 5 per cent., or less, of moisture; and in this condition they were ground and preserved. And, as the Woody-fibre determinations have only recently been made, the produce of 1856 has had some considerable time for change, were it liable to it. Under the circumstances of the preparation and preservation of the specimens, however, it would be difficult to conceive of any changes that would raise the percentage of indurated cellular matter in the remaining substance, to the extent indicated in the Table above that in the produce of the other years. Against the probability of such change, may be noted the fact, that the produce of 1857 which had been preserved for nearly 2 years when examined, gave a *lower* percentage of this Woody-fibre in its Dry substance, than that of 1858 which, of course, had not been preserved so long. On the

other hand, neither do any of our records as to the character of the produce in the several years, or as to the characters of the seasons themselves, lead to the belief that the produce of 1856 was either in such large proportion *stemmy*, or so *forward*, at the time of cutting, as that of the other seasons. Should then, future researches confirm the indications of these results, we should have to adopt the important conclusion, that a crude and succulent produce—a large proportion of whose more soluble constituents exists in a low condition of elaboration—may at the same time have a large proportion of its more fixed constituents in the condition of comparatively indurated and innutritious cellular matter. Or, may it be, that, when there is a low condition of elaboration of some of the more soluble constituents, so large a proportion of these undergo change, as to leave the more fixed Woody matter in larger proportion in the remaining total dry substance?

When the observed variations in the character of the produce are borne in mind, the effects of *manures* upon the relative percentages of the more fixed Woody-fibre in its Dry substance, are more clearly in accordance with what would be expected than are those of *season*. Taking the average result of the 3 years, the Dry substance of the *unmanured* produce, contained a comparatively low percentage of such Woody-fibre. This produce contained a large proportion of non-Graminaceous herbage; a fair proportion was stemmy, but it was backward, and with these characters there is a low percentage of Woody-fibre in the Dry substance. The Dry substance of the produce by *ammoniacal salts alone*, whose Graminaceous stems were comparatively ripe, but which contained a very large proportion of leaf, contained at the same time a comparatively small proportion of the "woody fibre." The produce by *Mineral manures alone* consisted of a good deal of non-Graminaceous herbage, and the Graminaceous herbage comprised a considerable proportion of leaf, though its stems were comparatively ripe. With these characters, the percentage of the "woody fibre" in the Dry substance was comparatively low. Where the *mixed mineral manure and ammoniacal salts were used together*, the produce was, comparatively, somewhat unripe; but it was almost entirely Graminaceous, and in very large proportion stemmy, and coincidently there is a comparatively large proportion of the "woody fibre" in the Dry substance. The produce by *farm-yard manure* was in a still larger proportion stemmy; but it contained also a considerable proportion of non-Graminaceous herbage. The result was, that its Dry substance contained a comparatively high percentage of the "woody fibre," but not quite so high as that where the mineral manure and ammoniacal salts were used, and the produce was more exclusively Graminaceous.

Adopting the experimental indications which have been recorded, as the most trustworthy which in the existing condition of our knowledge on the points in question could be supplied, the result upon the whole would appear to be, that, on the one hand, a generally low condition of elaboration of succulent produce may still be associated with a high proportion of comparatively indurated, and therefore probably innutritious Cellular matter, in its dry substance. On the other hand, comparing the produce by different *manures*, in one and the same season, the more Graminaceous, the riper, and the more stemmy, the higher will be the proportion of the comparatively indurated Woody or Cellular matter.

Fatty Matter.

In the analysis of animal and vegetable food-stuffs, it is usual to estimate as "*Fatty Matter*," that portion which is dissolved out from the dried substance by means of ether. In the case of animal substances, or of ripened vegetable ones, such as grain, the substance so determined does generally represent a fatty matter of high respiratory and fat-forming capacity. Not so, however, in the case of crude, unripened, vegetable produce. In fact, in such produce, the so-called *fatty matter* separated merely by extraction with ether, is largely contaminated with waxy and green colouring matter, a considerable proportion of which passes from the animal in its solid excrements. A relatively large proportion of such impure fatty substance can hardly be regarded, therefore, as an advantage. Still, it is useful to ascertain the amount of such matter, if it be only that, by a careful consideration of the conditions of growth, and other admitted qualities of the hay yielding the larger or the smaller proportions of it, we may be the better able to form a valid decision, whether or not the substance in question is likely really to indicate the high condition of elaboration of the constituents, which a large proportion of *pure fatty matter* might be supposed to do. A further reason for determining the amount of this substance, notwithstanding that we consider it of such doubtful value, is the fact, that this mode of analysis has been adopted with apparent confidence by most of our predecessors; whilst an accurate separation of the several bodies which compose this Ether-extract, would have increased the labour of analysis beyond that which our time enables us to devote to it. Nor, is the quantity of this impure fatty matter in hay so large, as to render the differences in its amount of much importance in any other point of view, than as indicating the general character and condition of the produce.

The method adopted by Mr. Segelcke, in his determinations

of the *crude fatty matter*, was to pass ether through a dried and weighed portion of the finely ground hay, until it came through colourless. For this purpose, he devised an apparatus, by means of which the ether was continuously distilled from the extract, and repassed through the substance. At the end of the first treatment in this way, that is, when the ether passed through colourless, the substance was re-dried in the water bath, and then submitted to a second extraction in the ether-apparatus. The ether was finally distilled from the total ether-extract; and the remaining *green fatty matter* dried in a water bath, until it no longer lost weight.

From what has already been said of the character of the "Fatty matter," the quantity of which in the respective hays, was determined by the methods just described, it would be useless to go into much detail as to the amounts found in the different specimens. It is the less desirable, too, to do so, as the circumstances and extent of its occurrence will be sufficiently brought to light, in taking the summary view of the composition of the different hays, with which we now propose to conclude our Report. The individual determinations of the Fatty matter will be found in Table IX. in the Appendix; and the mean percentages of it are embodied with those of the other constituents in Table XVII., to which attention is next, and lastly, to be directed.

Summary of the Composition of the Hay.

In Table XVII. is given a summary view of the collective composition of the specimens of hay grown in the Third Season (1858), on those plots the produce of which was selected for the botanical separations. In the upper Division of the Table, the percentages of the several constituents *in the fresh hay as carted from the land*, are given. In the middle Division, the percentages in the *Dry substance* of the hay are given. And in the lowest Division, is a summary statement of the general description of the herbage on the respective plots. The means are thus afforded, of considering the chemical composition of the respective hays, in connection with the other known characters of the herbage. The constituents given are—

1st. Nitrogenous substance.
2nd. Fatty matter.
3rd. Woody-fibre.
4th. Other non-nitrogenous vegetable compounds.
5th. Mineral matter.
6th. Total Dry substance.
7th. Water.

A few brief remarks should first be made, as to the character of the several substances represented in the above enumeration.

Nitrogenous substance.—The most practicable and usual mode of getting at an approximate estimate of the total amount of Nitrogenous compounds, in vegetable or animal food-stuffs, is to determine the amount of *nitrogen*, and calculate from it the amount of Nitrogenous substances, on the assumption that they consist of the so-called *proteine compounds*. Adopting this assumption, the amount of Nitrogen has only to be multiplied by 6·3, to give, very nearly, the amount of Nitrogenous proximates that it would represent. This is the method which, from convenience, we have adopted. From what has been said under the head of Nitrogen, however, it will be obvious, that this mode of estimation affords, more particularly in the case of succulent and unripened produce, at best but an uncertain indication of the amount of elaborated and nutritive Nitrogenous compound. The so-calculated Nitrogenous substance may, in fact, not only include a quantity of matter in a low condition of elaboration, but even ammoniacal salts. It will be understood, therefore, with what degree of reservation the recorded amounts of "*nitrogenous substance*" must be taken, as indicating the probable amounts of nutritive proteine compounds.

Fatty matter.—The substance given under the head of Fatty matter, includes, as has been already explained, a quantity of waxy and green colouring matter, and must not be taken therefore as representing pure fatty matter of high respiratory and fat-forming capacity.

Woody-fibre.—It will be borne in mind, that the substance recorded as Woody-fibre, is not supposed to include the whole of the Cellular matter in its various modifications; but only that amount of it which seems to possess a certain fixed degree of persistence, on the application of such solvents as are required to remove the other compounds. It is possible, however, that at any rate the easily changeable, and easily dissolved portions of the Cellular substance, may be amenable to the digestive organs of animals.

Other non-nitrogenous matters.—The substances put down as *other non-nitrogenous matters*, are all those which remain after deducting the "Nitrogenous substance," the "Fatty matter," and the "Woody-fibre," as above defined, and also the "Mineral matter." They comprise probably starch, dextrine, gum, sugar, and certain extractive matters. They will also include so much of the more easily changeable Cellulose, or Cellular matter, as may have been dissolved by the re-agents required to remove all the other matters, in the process adopted for separating and estimating the so-called "Woody-fibre." The characters, and

TABLE XVII.—COLLECTIVE VIEW of the COMPOSITION, and DESCRIPTION, of the MIXED HERBAGE.

CONSTITUENTS.	HAY FROM SELECTED EXPERIMENTAL PLOTS.								Mixed Hay from same Meadow; cut out of rick December, 1858.
		Artificial Manures.				Farmyard Manure.		Mean.	
	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.)	Alone. (Plot 16.)	With Ammoniacal Salts. (Plot 17.)		
1.—Composition per Cent. in the Fresh Hay.									
Nitrogenous Substance (N. × 6·3, reckoning 15·875 N. in Nit. Sub.)	8·82	10·39	8·82	7·87	10·77	7·43	8·00	8·87	..
Fatty Matter (Ether Extract)	2·87	3·00	2·55	1·99	2·36	2·48	2·80	2·58	..
Woody Fibre	22·88	22·87	24·97	24·11	23·64	24·51	24·31	23·90	..
Other non-Nitrogenous Vegetable Compounds (Starch, Sugar, Gum, &c.)	45·63	42·70	42·78	41·60	37·58	43·46	40·85	42·08	..
Mineral Matter (Ash)	5·70	5·14	6·48	6·53	6·35	6·72	6·74	6·24	5·73
Total Dry Substance	85·90	84·10	85·60	82·10	80·70	84·60	82·70	83·67	83·80
Water	14·10	15·90	14·40	17·90	19·30	15·40	17·30	16·33	..
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	..
2.—Composition per Cent. in the Dry Substance of the Hay.									
Nitrogenous Substance (N. × 6·3, reckoning 15·875 N. in Nit. Sub.)	10·27	12·35	10·33	9·58	13·36	8·82	9·64	10·62	..
Fatty Matter (Ether Extract)	3·34	3·57	2·98	2·42	2·93	2·93	3·39	3·08	..
Woody Fibre	26·63	27·20	29·17	29·37	29·30	28·97	29·40	28·58	..
Other non-Nitrogenous Vegetable Compounds (Starch, Sugar, Gum, &c.)	53·12	50·77	49·95	50·68	46·54	51·33	49·43	50·27	..
Mineral Matter (Ash)	6·64	6·11	7·57	7·95	7·87	7·95	8·14	7·45	6·84
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	..
3.—Summary Statement of the Description of the Herbage.									
Graminaceous Stems bearing Flower or Seed	50·25	35·91	42·18	72·66	65·08	69·76	64·62	57·21	..
Graminaceous Leafy Produce	25·85	53·20	29·64	24·72	32·27	17·91	15·05	28·38	..
Leguminous Herbage	5·12	2·20	22·89	..	..	3·70	1·78	5·10	..
Miscellaneous Herbage (chiefly weeds)	15·73	6·14	1·71	1·85	1·67	7·05	16·43	7·23	..
Shedded Seeds, and Indeterminate Vegetable Matter	3·05	2·55	3·58	0·77	0·98	1·58	2·12	2·08	..
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	..

the feeding capacity, of the matters grouped together under this head, will probably depend much upon the *condition* of the hay. The worse the condition of the hay, the greater probably will be the proportion of them, which will consist of the ill-defined "extractive matters."

Mineral matter.—The so-designated Mineral matter, is that which remains as *ash*, on the incineration of the hay. It is needless to say that Mineral constituents are essential in the food of animals. In most vegetable foods, however, they generally exist in a larger proportion to the other constituents than they are probably required; and hence their large amount in any food is no criterion of high feeding value. On the contrary, as, in comparable cases, a high percentage of Mineral matter is generally coincident with a low degree of elaboration of the collateral vegetable substances, the smaller percentage among a series of specimens of produce of like description, will most probably be associated with a higher relative feeding capacity.

The proportions of these several constituents, in the hay grown by the different manures, may now be briefly noticed.

The *unmanured* hay contained a notable proportion of Leguminous, and other non-Graminaceous herbage; and the Grasses themselves were stunted. Under these circumstances, the Dry substance of the hay contained a medium percentage of the calculated Nitrogenous compounds, and comparatively a very small proportion of the estimated Woody-fibre. Comparing the produce of one manuring condition with that of another, in one and the same season, a low percentage of indurated Woody-fibre indicates greenness and immaturity. Coincidently with this, the unmanured hay shows a relatively high amount of the impure Fatty matter.

The produce grown by *ammoniacal salts alone*, contained a very high percentage of Nitrogenous compounds, or at least of Nitrogen in some form. This was due, it will be remembered, not to a large amount of Leguminous herbage, but to the condition of the almost exclusively Graminaceous hay, which was stunted, dark green, leafy, and backward. The Dry substance of the hay having these characters, at the same time contained but a small proportion of the comparatively stable Cellular or Woody matter, but the highest amount of any in the series of the green impure Fatty matter. The fact, that the highest percentage of this merely ether-extracted substance, was found in this stunted, dark-green, leafy, and backward produce, may perhaps be taken as some indication, that a relatively high amount of Fatty matter as so determined in succulent produce, does not really represent a high amount of *pure fat* of the high feeding capacity which that substance is assumed to possess.

The produce by *mineral manure alone*, which contained the highest proportion of any, of Leguminous herbage, nevertheless

contained but a moderate percentage of Nitrogenous compounds. This arose from the fact, that the *grasses*, which still constituted by far the largest proportion of the produce, though meagre and stunted in growth, were still comparatively forward. With these characters, the percentage of the so-called Woody-fibre is comparatively high, and that of the impure Fatty matter is comparatively low.

The produce of the plot manured with the *mineral manure and the smaller amount of ammoniacal salts* was bulky, almost wholly Graminaceous, and very stemmy. Consistently, the dry substance of this hay contained a very low proportion of Nitrogenous compounds, the lowest amount of any in the series of the green Fatty matter, and a high percentage of the more fixed Woody-fibre.

The *mineral manure*, together with the *double and excessive amount of ammoniacal salts*, gave an over-luxuriant, succulent, and unevenly ripened, but stemmy and almost exclusively Graminaceous produce. To the former characters may be attributed a very high percentage of the calculated Nitrogenous compounds; and to the latter a somewhat low percentage of the impure Fatty matter, and a high one of the Woody-fibre. The percentage of the green Fatty matter is, however, as would be expected, higher than in the produce grown by the mineral manure and the smaller amount of ammoniacal salts. The remainder, designated as "other non-nitrogenous matters," is less in this over-luxuriant produce than in any of the other cases.

The produce by *farm-yard manure alone*, comprised a moderate proportion of Leguminous and other non-Graminaceous herbage; but, on the other hand, its Graminaceous herbage was in very large proportion in the condition of flowering and seeding stem. Consequently, the Dry substance of the hay contained a low percentage of the Nitrogenous compounds, a low percentage of the impure Fatty matter, and a high percentage of the Woody-fibre.

The hay grown by *farm-yard manure and ammoniacal salts together*, comprised a larger proportion of non-Graminaceous herbage, than that grown by farm-yard manure alone; but, the Graminaceous herbage itself was in as great a proportion stemmy. The result was a hay containing in its dry substance, a considerably higher proportion both of the calculated Nitrogenous compounds and of the impure Fatty matter, and at the same time a high percentage of the Woody-fibre.

The general result, comparing the produce by the different manures in one and the same season, seems to be, that the more the produce is Graminaceous, the more it goes to flower and seed, and the more it is ripened, the higher will be the percentage of *dry substance* in the hay. Under the same circumstances, the higher will be the percentage of the *comparatively indurated*, and therefore *probably effete*, *Woody-fibre*; and the lower will be

that of the *calculated nitrogenous compounds*, of the *impure green fatty matter*, and of the *mineral matter* in the Dry substance. On the other hand, in a large proportion of the non-Graminaceous herbage, over-luxuriance, succulence, a large proportion of leaf, and unripeness, are likely to be associated with a small proportion of the *more refractory or effete Woody-fibre*, but with a large one of *nitrogenous substance in a questionable degree of elaboration*, a large one of *impure fatty matter* of doubtful nutritive capacity, and a large one of the *mineral matter* also, in the Dry substance of the hay.

This subject obviously throws open a wide field for future investigation. And, if we consider, not only the very complex character, in so many points of view, of the substance included under the term—*hay*, but also the inadequacy of the data, although so voluminous, which we have collected and recorded in the course of our long Paper, it will be at once apparent, that it would be inconsistent with a proper spirit of inquiry, to attempt to do more than draw attention to the prominent indications, and leading directions, of the experimental evidence that has been adduced. There will, nevertheless, be much really gained, if a clear idea be conveyed of the multiplicity of circumstances, upon which must depend the proportion, and relative feeding value, of the various chemical compounds of which the complex produce is made up. It will, then, be understood—and it is very important that it should be—that even supposing there were no question as to the proper relationship to one another, of the different constituents of our stock-foods, it would still be impracticable to get a true and unconditional estimate of comparative feeding value of *crude vegetable substances*, by the simple determination of the percentage amount of one or two important constituents, as is frequently assumed to be sufficient for that purpose. The next step in advance in these inquiries can only be attained, when our knowledge of the proximate compounds, of lower or of higher condition of elaboration, into which the ultimate constituents of our food-stuffs are grouped, has been much extended, and when the digestibility, and applicability to the purposes of the system, of these various proximate compounds, have been experimentally determined.

For the general conclusions in regard to the other separate Sections of the subject into which our Report has been divided, the reader is referred to the concluding portions of Parts I., II., and III. respectively, as follows: Part I.—vol. XIX., pp. 571-3; Part II.—vol. XX., pp. 245-6; and Part III.—vol. XX., p. 272, of this Journal.

APPENDIX.—TABLE I.—Duplicate Determinations of DRY MATTER (at 212° F.) in the HAY of the Seasons 1856, 1857, and 1858.

Plot, Nos.	MANURES. (Per Acre, per Annum.)	Season 1856.		Season 1857.		Season 1858.	
		Experiment 1.	Experiment 2.	Experiment 1.	Experiment 2.	Experiment 1.	Experiment 2.
	SERIES 1.—Without Direct Mineral Manure.						
1	Unmanured	82·1	81·8	85·0	85·3	86·0	85·9
2	Unmanured (duplicate plot)	81·6	82·2	87·3	87·3	85·8	85·1
	Calculated Means of Unmanured	81·8	82·0	86·1	86·3	85·9	85·5
3	2000 lbs. Sawdust	80·6	80·8	87·9	87·5	84·2	84·6
4	200 lbs. each, Sulphate and Muriate Ammonia	79·0	81·0	87·2	86·1	84·0	84·2
5	200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	79·8	79·5	87·7	87·6	84·0	83·8
6	275 lbs. Nitrate of Soda	..	..	..	..	84·6	85·0
7	550 lbs. Nitrate of Soda	..	..	..	..	85·7	86·0
	SERIES 2.—With Direct Mineral Manure.						
8	"Mixed Mineral Manure"*	80·5	80·0	86·8	86·7	85·6	85·6
9	"Mixed Mineral Manure," and 2000 lbs. Sawdust	80·6	80·4	86·8	86·8	84·0	84·2
10	"Mixed Mineral Manure," and 200 lbs. each, Sulphate and Muriate Ammonia	78·9	79·0	87·1	87·0	82·0	82·2
11	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	77·8	76·8	87·6	86·8	83·9	83·8
12	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Cut Wheat-Straw	79·4	79·0	86·5	87·1	82·4	82·4
13	"Mixed Mineral Manure," and 400 lbs. each, Sulphate and Muriate Ammonia	77·8	78·4	86·1	85·8	80·2	81·1
14	"Mixed Mineral Manure," and 275 lbs. Nitrate of Soda	..	..	..	..	86·1	86·7
15	"Mixed Mineral Manure," and 550 lbs. Nitrate of Soda	..	..	..	..	85·4	85·0
	SERIES 3.—With Farmyard Manure.						
16	14 Tons Farmyard Manure	76·0	76·2	87·4	87·3	85·0	84·2
17	14 Tons Farmyard Manure, and 100 lbs. each, Sulphate and Muriate Ammonia	79·5	79·6	86·4	86·1	82·4	83·0

* 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.

APPENDIX.—Table II.—Duplicate Determinations of Mineral Matter (Ash), in the Hay of the Season 1856.

Plot, Nos.	MANURES. (Per Acre, per Annum.)	Percentages in the Hay as taken from the Land.		Percentages in the Dry Substance of the Hay.	
		Experiment 1.	Experiment 2.	Experiment 1.	Experiment 2.
	Series 1.—Without Direct Mineral Manure.				
1	Unmanured	6·25	6·27	7·61	7·66
2	Unmanured (duplicate plot)	6·60	6·68	8·09	8·12
	Calculated Means of Unmanured	6·42	6·48	7·85	7·89
3	2000 lbs. Sawdust	6·60	6·64	8·19	8·21
4	200 lbs. each, Sulphate and Muriate Ammonia	6·75	6·13	8·55	7·56
5	200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	5·95	6·06	7·47	7·62
	Series 2.—With Direct Mineral Manure.				
8	"Mixed Mineral Manure"*	6·94	6·91	8·62	8·64
9	"Mixed Mineral Manure," and 2000 lbs. Sawdust	7·39	7·23	9·18	8·99
10	"Mixed Mineral Manure," and 200 lbs. each, Sulphate and Muriate Ammonia	6·64	6·91	8·42	8·74
11	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	7·23	6·83	9·29	8·90
12	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Cut Wheat-Straw	6·78	6·67	8·54	8·44
13	"Mixed Mineral Manure," and 400 lbs. each, Sulphate and Muriate Ammonia	6·74	6·40	8·66	8·16
	Series 3.—With Farmyard Manure.				
16	14 Tons Farmyard Manure	7·30	7·29	9·59	9·56
17	14 Tons Farmyard Manure, and 100 lbs. each, Sulphate and Muriate Ammonia	8·66†	6·38†	10·88†	8·01†

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

† There is obviously some error in these determinations; whether due to the accidental mixture with one another of a portion of the duplicate quantities, or to adventitious matter in the case of the higher number, is doubtful. It will be easily understood that in such complex and uneven produce as hay, the determinations of both Dry matter, and Mineral matter, will be more liable to uncertainty than in that of grain and the like

Experiments with Different Manures on Permanent Meadow Land.

APPENDIX.—Table III.—Duplicate Determinations of Mineral Matter (Ash), in the Hay of the Season 1857.

APPENDIX.—TABLE III.—Duplicate Determinations of MINERAL MATTER (Ash), in the Hay of the Season 1857.

Plot, Nos.	MANURES. (Per Acre, per Annum.)	Percentages in the Hay as taken from the Land.		Percentages in the Dry Substance of the Hay.	
		Experiment 1.	Experiment 2.	Experiment 1.	Experiment 2.
	SERIES 1.—Without Direct Mineral Manure.				
1	Unmanured	5·58	5·68	6·56	6·66
2	Unmanured (duplicate plot)	5·71	5·71	6·54	6·54
	Calculated Means of Unmanured	5·65	5·69	6·55	6·60
3	2000 lbs. Sawdust	5·60	5·68	6·37	6·49
4	200 lbs. each, Sulphate and Muriate Ammonia	5·52	5·44	6·33	6·31
5	200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	5·55	5·47	6·33	6·25
	SERIES 2.—With Direct Mineral Manure.				
8	"Mixed Mineral Manure"*	6·00	6·32	6·91	7·29
9	"Mixed Mineral Manure," and 2000 lbs. Sawdust	6·83	6·36	7·87	7·33
10	"Mixed Mineral Manure," and 200 lbs. each, Sulphate and Muriate Ammonia	6·32	6·24	7·26	7·17
11	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	6·43	6·40	7·34	7·37
12	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Cut Wheat-Straw	6·78	6·67	8·54	8·44
13	"Mixed Mineral Manure," and 400 lbs. each, Sulphate and Muriate Ammonia	6·49	6·35	7·53	7·40
	SERIES 3.—With Farmyard Manure.				
16	14 Tons Farmyard Manure	6·46	6·56	7·39	7·52
17	14 Tons Farmyard Manure, and 100 lbs. each, Sulphate and Muriate Ammonia	6·48	6·42	7·50	7·46

* 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.

APPENDIX.—TABLE IV.—Duplicate Determinations of MINERAL MATTER (Ash), in the Hay of the Season 1858.

Plot, Nos.	MANURES. (Per Acre, per Annum.)	Percentages in the Hay as taken from the Land.		Percentages in the Dry Substance of the Hay.	
		Experiment 1.	Experiment 2.	Experiment 1.	Experiment 2.
	SERIES 1.—Without Direct Mineral Manure.				
1	Unmanured	5·73	5·68	6·66	6·61
2	Unmanured (duplicate plot)	5·56	5·56	6·48	6·53
	Calculated Means of Unmanured	5·64	5·62	6·57	6·57
3	2000 lbs. Sawdust	5·60	5·62	6·65	6·64
4	200 lbs. each, Sulphate and Muriate Ammonia	5·39	4·88	6·42	5·80
5	200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	5·34	5·32	6·36	6·34
6	275 lbs. Nitrate of Soda	5·80	5·66	6·85	6·66
7	550 lbs. Nitrate of Soda	5·37	5·39	6·26	6·27
	SERIES 2.—With Direct Mineral Manure.				
8	"Mixed Mineral Manure"*	6·48	6·48	7·57	7·57
9	"Mixed Mineral Manure," and 2000 lbs. Sawdust	6·48	6·46	7·71	7·68
10	"Mixed Mineral Manure," and 200 lbs. each, Sulphate and Muriate Ammonia	6·53	6·54	7·96	7·95
11	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	6·96	6·64	8·30	7·92
12	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Cut Wheat-Straw	6·69	6·67	8·12	8·10
13	"Mixed Mineral Manure," and 400 lbs. each, Sulphate and Muriate Ammonia	6·32	6·38	7·88	7·86
14	"Mixed Mineral Manure," and 275 lbs. Nitrate of Soda	6·37	6·43	7·39	7·42
15	"Mixed Mineral Manure," and 550 lbs. Nitrate of Soda	6·38	6·66	7·47	7·83
	SERIES 3.—With Farmyard Manure.				
16	14 Tons Farmyard Manure	6·73	6·71	7·92	7·97
17	14 Tons Farmyard Manure, and 100 lbs. each, Sulphate and Muriate Ammonia	6·72	6·75	8·15	8·13

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

APPENDIX.—Table V.—Duplicate Determinations of Nitrogen, in the Hay of the Season 1856.

Plot, Nos.	MANURES. (Per Acre, per Annum.)	Percentages in the Hay as taken from the Land.		Percentages in the Dry Substance of the Hay.	
		Experiment 1.	Experiment 2.	Experiment 1.	Experiment 2.
	Series 1.—Without Direct Mineral Manure.				
1	Unmanured	1·70	1·66	2·07	2·03
2	Unmanured (duplicate plot)	1·79	1·79	2·19	2·18
	Calculated Means of Unmanured	1·74	1·72	2·13	2·10
3	2000 lbs. Sawdust	1·69	1·66	2·09	2·06
4	200 lbs. each, Sulphate and Muriate Ammonia	1·57	1·57	1·96	1·96
5	200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	1·56	1·62	1·96	2·03
	Series 2.—With Direct Mineral Manure.				
8	"Mixed Mineral Manure" *	1·67	1·68	2·08	2·10
9	"Mixed Mineral Manure," and 2000 lbs. Sawdust	1·80	1·75	2·24	2·18
10	"Mixed Mineral Manure," and 200 lbs. each, Sulphate and Muriate Ammonia	1·22	1·24	1·54	1·57
11	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	1·28	1·25	1·66	1·62
12	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Cut Wheat-Straw	1·48	1·46	1·86	1·85
13	"Mixed Mineral Manure," and 400 lbs. each, Sulphate and Muriate Ammonia	1·49	1·49	1·88	1·88
	Series 3.—With Farmyard Manure.				
16	14 Tons Farmyard Manure	1·35	1·35	1·77	1·78
17	14 Tons Farmyard Manure, and 100 lbs. each, Sulphate and Muriate Ammonia	1·65	1·60	2·07	2·01

* 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.

APPENDIX.—Table VI.—Duplicate Determinations of Nitrogen, in the Hay of the Season 1857.

Plot, Nos.	MANURES, (Per Acre, per Annum.)	Percentages in the Hay as taken from the Land.		Percentages in the Dry Substance of the Hay.	
		Experiment 1.	Experiment 2.	Experiment 1.	Experiment 2.
	Series 1.—Without Direct Mineral Manure.				
1	Unmanured	1·29	1·29	1·52	1·52
2	Unmanured (duplicate plot)	1·42	1·45	1·63	1·66
	Calculated Means of Unmanured	1·35	1·37	1·57	1·59
3	2000 lbs. Sawdust	1·38	1·38	1·57	1·57
4	200 lbs. each, Sulphate and Muriate Ammonia	1·59	1·51	1·83	1·74
5	200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	1·54	1·45	1·76	1·66
	Series 2.—With Direct Mineral Manure.				
8	"Mixed Mineral Manure"*	1·51	1·51	1·74	1·74
9	"Mixed Mineral Manure," and 2000 lbs. Sawdust	1·49	1·48	1·72	1·71
10	"Mixed Mineral Manure," and 200 lbs. each, Sulphate and Muriate Ammonia	1·19	1·18	1·37	1·36
11	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	1·12	1·10	1·29	1·26
12	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Cut Wheat-Straw	1·38	1·29	1·60	1·51
13	"Mixed Mineral Manure," and 400 lbs. each, Sulphate and Muriate Ammonia	1·62	1·62	1·89	1·88
	Series 3.—With Farmyard Manure.				
16	14 Tons Farmyard Manure	1·29	1·33	1·48	1·52
17	14 Tons Farmyard Manure, and 100 lbs. each, Sulphate and Muriate Ammonia	1·07	1·10	1·24	1·28

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

APPENDIX.—Table VII.—Duplicate Determinations of Nitrogen, in the Hay of the Season 1858.

Plot, Nos.	MANURES. (Per Acre, per Annum.)	Percentages in the Hay as taken from the Land.		Percentages in the Dry Substance of the Hay.	
		Experiment 1.	Experiment 2.	Experiment 1.	Experiment 2.
	Series 1.—Without Direct Mineral Manure.				
1	Unmanured	1·39	1·42	1·62	1·65
2	Unmanured (duplicate plot)	1·35	1·34	1·58	1·57
	Calculated Means of Unmanured	1·37	1·38	1·60	1·61
3	2000 lbs. Sawdust	1·41	1·42	1·67	1·68
4	200 lbs. each, Sulphate and Muriate Ammonia	1·69	1·61	2·01	1·92
5	200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	1·56	1·56	1·86	1·86
6	275 lbs. Nitrate of Soda	1·67	1·69	1·97	1·99
7	550 lbs. Nitrate of Soda	1·71	1·71	1·99	1·99
	Series 2.—With Direct Mineral Manure.				
8	"Mixed Mineral Manure" *	1·39	1·42	1·63	1·66
9	"Mixed Mineral Manure," and 2000 lbs. Sawdust	1·39	1·39	1·65	1·65
10	"Mixed Mineral Manure," and 200 lbs. each, Sulphate and Muriate Ammonia	1·25	1·26	1·52	1·53
11	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	1·18	1·17	1·41	1·40
12	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Cut Wheat-Straw	1·34	1·36	1·63	1·65
13	"Mixed Mineral Manure," and 400 lbs. each, Sulphate and Muriate Ammonia	1·70	1·72	2·11	2·13
14	"Mixed Mineral Manure," and 275 lbs. Nitrate of Soda	1·52	1·52	1·76	1·76
15	"Mixed Mineral Manure," and 550 lbs. Nitrate of Soda	1·31	1·34	1·54	1·57
	Series 3.—With Farmyard Manure.				
16	14 Tons Farmyard Manure	1·18	1·18	1·40	1·40
17	14 Tons Farmyard Manure, and 100 lbs. each, Sulphate and Muriate Ammonia	1·29	1·25	1·56	1·51

* 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.

APPENDIX.—Table VIII.—Duplicate Determinations of Woody Fibre, in the Hay from Selected Plots; Seasons 1856, 1857, and 1858.

Plot, Nos.	MANURES. (Per Acre, per Annum.)	Percentages in the Hay as taken from the Land.			Percentages in the Dry Substance of the Hay.		
		Experiment 1.	Experiment 2.	Experiment 3.	Experiment 1.	Experiment 2.	Experiment 3.
	Season 1856.						
1	Unmanured	24·76	24·27	..	30·2	29·6	..
4	200 lbs. each, Sulphate and Muriate Ammonia	24·96	24·72	..	31·2	30·9	..
8	"Mixed Mineral Manure"*	23·98	24·14	..	29·9	30·1	..
10	"Mixed Mineral Manure," and 200 lbs. each, Sulphate and Muriate Ammonia	25·52	25·52	..	32·3	32·3	..
13	"Mixed Mineral Manure," and 400 lbs. each Sulphate and Muriate Ammonia	25·85	25·38	..	33·1	32·5	..
16	14 Tons Farmyard Manure	24·12	23·44	..	31·7	30·8	..
17	14 Tons Farmyard Manure, and 100 lbs. each, Sulphate and Muriate Ammonia	23·56	23·72	..	29·6	29·8	..
	Season 1857.						
1	Unmanured	23·32	23·15	22·11	27·4	27·2	26·1
4	200 lbs. each, Sulphate and Muriate Ammonia	22·89	23·41	22·89	26·4	27·0	26·4
8	"Mixed Mineral Manure"	23·06	23·06	22·89	26·6	26·6	26·4
10	"Mixed Mineral Manure," and 200 lbs. each, Sulphate and Muriate Ammonia	25·40	24·97	25·40	29·2	28·7	29·2
13	"Mixed Mineral Manure," and 400 lbs. each, Sulphate and Muriate Ammonia	24·14	24·57	23·79	28·1	28·6	27·7
16	14 Tons Farmyard Manure	26·19	26·19	25·14	30·0	30·0	28·8
17	14 Tons Farmyard Manure, and 100 lbs. each, Sulphate and Muriate Ammonia	24·57	24·91	25·43	28·5	28·9	29·5
	Season 1858.						
1	Unmanured	22·68	22·68	23·28	26·4	26·4	27·1
4	200 lbs. each, Sulphate and Muriate Ammonia	22·54	22·96	23·13	26·8	27·3	27·5
8	"Mixed Mineral Manure"	25·08	24·65	25·17	29·3	28·8	29·4
10	"Mixed Mineral Manure," and 200 lbs. each, Sulphate and Muriate Ammonia	24·05	24·55	23·73	29·3	29·9	28·9
13	"Mixed Mineral Manure," and 400 lbs. each, Sulphate and Muriate Ammonia	23·24	23·32	24·37	28·8	28·9	30·2
16	14 Tons Farmyard Manure	24·19	24·11	25·21	28·6	28·5	29·8
17	14 Tons Farmyard Manure, and 100 lbs. each, Sulphate and Muriate Ammonia	24·15	24·15	24·64	29·2	29·2	29·8

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

APPENDIX.—Table IX.—Duplicate Determinations of Fatty Matter (by Ether), in the Hay from Selected Plots (Season 1858).

Plot, Nos.	MANURES. (Per Acre, per Annum.)	Experiment 1.	Experiment 2.	Mean.
	Percentages in the Hay as taken from the Land.			
1	Unmanured	2·87	2·86	2·86
4	200 lbs. each, Sulphate and Muriate Ammonia	3·04	2·96	3·00
8	"Mixed Mineral Manure" *	2·58	2·52	2·55
10	"Mixed Mineral Manure," and 200 lbs. each, Sulphate and Muriate Ammonia	2·04	1·93	1·99
13	"Mixed Mineral Manure," and 400 lbs. each, Sulphate and Muriate Ammonia	2·43	2·29	2·36
16	14 Tons Farmyard Manure	2·49	2·46	2·47
17	14 Tons Farmyard Manure, and 100 lbs. each, Sulphate and Muriate Ammonia	2·81	2·79	2·80
	Percentages in the Dry Substance of the Hay.			
1	Unmanured	3·34	3·33	3·34
4	200 lbs. each, Sulphate and Muriate Ammonia	3·61	3·52	3·57
8	"Mixed Mineral Manure"	3·01	2·94	2·98
10	"Mixed Mineral Manure," and 200 lbs. each, Sulphate and Muriate Ammonia	2·49	2·35	2·42
13	"Mixed Mineral Manure," and 400 lbs. each, Sulphate and Muriate Ammonia	3·01	2·84	2·93
16	14 Tons Farmyard Manure	2·94	2·91	2·93
17	14 Tons Farmyard Manure, and 100 lbs. each, Sulphate and Muriate Ammonia	3·40	3·38	3·39

* For full description of the "Mixed Mineral Manure," see Part I. of this Paper, vol. xix., p. 55©, of this Journal.