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THE INFLUENCE OF NITROGEN FERTILIZATION ON THE BOTANICAL COMPOSITION OF PERMANENT GRASSLAND

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the influence of nitrogen fertilization on the botanical composition of permanent grassland

IT IS COMMON KNOWLEDGE that the productivity of grassland may be increased considerably at short term by applying nitrogen fertilizers. In many cases the larger produce is almost in proportion to the amount of nitrogen supplied. As the effect of nitrogen applications is hardly ever doubtful these fertilizers are used in many forms and on a large scale.

In other words, the nitrogen applied as fertilizer (the farmyard-manure and liquid-manure applied from time immemorial may be considered to belong mainly to the normal treatment) produces considerably more grass to be utilized in either fresh or preserved condition by the farmer.

The expressive term "higher produce", however, may not prevent that due attention is given to the quality of the harvested product. Generally fertilization causes a shifting of the relative proportion by weight of the grassland species being often favourable, but sometimes unfavourable. Such a change usually does not only concern the increase of the yield, but the total yield of the fertilized field. Even if an immediate decrease in quality is not at issue, it is possible that the herbage will grow more susceptible to severe frost, drought or other extreme conditions, retaliating at a later moment.

It is necessary to analyse a vegetation on its composing species to gain an accurate insight into the characteristics of a herbage, which characteristics are determined by those of each separate species in their relative connection. This may be reached by means of a botanical analysis. The procentual proportion by dry weight determined in this way and the knowledge of the specific characteristics of each composing species will give a clear conception of characteristics at the time of sampling and the possible qualities of the herbage in future.

Numerous experimental fields have been necessary to get some information on the complex problems resulting from fertilization, nitrogen fertilization included. The results of this experimental field work have been published in many articles in the course of years.

For a general view of the subject, such as this article is meant to be, however, summarizing adaptations of the results obtained by dry weight analyses are more important. An adaptation of the results of the State mines experimental fields (7) and a summary of the results of 47 nitrogen experimental fields of agricultural advisers and institutes (8, 10) were therefore used in the first place. The yield of both groups was determined by haying and in both cases moderate nitrogen applications were given. Furthermore use was made of 25

farm fields moderately to heavily fertilized with nitrogen and used alternately for grazing and haying (1). Finally the results of the nitrogen experimental farms with a high application of nitrogen and intensive use (5) were consulted as well.

Nitrogen fertilization and the abundance of species

With continued, intensive fertilization it may be established repeatedly that the number of species on the field concerned will decrease somewhat. This phenomenon amongst others also occurred on the nitrogen experimental farms, where rather heavy nitrogen applications had been given during a number of years in addition to intensive grazing, alternated by mowing for the production of hay and silage.

The analyses of 19 fields of six of these farms were at our disposal. Those carried out at the beginning of the experiment (spring 1949, 1950 or 1951) could be compared to the analyses of the same fields carried out in spring 1957 after the vegetation had been able to adapt itself to the nitrogen fertilization. A comparison showed that the average number of species per field amounting to 16.8 at the beginning of the experiment, had decreased to 14.8 after 6–8 years. In addition it could be established that Perennial Rye-grass, already having rather a high percentage at the beginning of the experiment, now dominated completely several times.

If these 19 fields were regarded as a whole, it appeared that the total number of 40 species at the beginning of the experiment had decreased to 36 after 6–8 years, consequently a decrease of 4 species, being effected by the appearance of 3 new species and the complete disappearance of 7 species among which the 3 sedges present.

A closer inspection of the analyses showed that the following species often disappeared: Crested Dogstail, Yorkshire Fog, Red Fescue, Sweet Vernalgrass as well as the dicotyledons Meadow Buttercup, Autumnal Hawkbit, Creeping Buttercup and Daisy. The following new species often appeared: Meadow Fescue, Cocksfoot, Floating Foxtail and especially Annual Meadow-grass. A slight decrease in White Clover and in few cases only a complete disappearance of it could be established on these fields.

In case of fields used for hay production this list of species would undoubtedly read different.

Nitrogen fertilization and the grade of quality

The conception 'grade of quality' can be seen as a measure for the agricultural quality of the herbage. This quality is dependent on the

agricultural quality of each species as well as on their quantitative ratio. The first is expressed in the valuation number of each species; the latter is indicated by the weight percentage of each species in the air-dry product (hay). The grade of quality of the herbage is expressed in a scale from 0–10 and in one decimal place it is indicated sufficiently accurate for practical application. BOSCH and TE VELDE (1), giving a summary on 25 farm fields in 1958, said about the grade of quality that it had increased generally on the fields with heavier nitrogen fertilizations. This concerned fields being used alternately for grazing and haying.

Already in 1952 'T HART (4) had compared the grade of quality from fields with low and with high nitrogen from almost the same group of fields. He too found an increase after heavy nitrogen fertilization *(table 1)*.

A similar effect is to be observed on the fields of the nitrogen experimental farms. These are farm fields with heavy nitrogen applications as well. The observations were taken after 5–7 years by means of estimating the botanical composition. As these estimations naturally are not quite reliable, they have been summarized to one average figure per farm. To obviate the seasonal fluctuations only spring figures should be compared to spring figures and autumn figures to autumn figures *(table 2)*.

Table 3, taken from a summary of 47 experimental fields used for mowing (8) also gives an instructive illustration. The difference in the number of increases and decreases in the grade of quality has been expressed here in

TABEL 1 — *Comparison of the average grade of quality and the average percentage by dry-weight of plant groups on farm fields with low and with high nitrogen*

	Low N	*High N*
Grade of quality	7.1	7.5
Good grasses	50	60
Legumes	6	2
Medium-value grasses	25	23
Inferior grasses	12	10
Forbs	7	5

TABEL 2 — *Change in the grade of quality of herbage on farm fields after a nitrogen fertilization of 5–7 years*

	Beginning of the experiment						*After 5–7 years*	
	1949		*1950*		*1951*		*1956*	
	spring	*autumn*	*spring*	*autumn*	*spring*	*autumn*	*spring*	*autumn*
Farm 1 (8 fields)	—	—	6.8	6.5	—	—	7.3	7.3
„ 2 (4 „)	—	—	—	—	—	7.6	—	7.7
„ 3 (13 „)	—	—	—	—	6.6	6.8	7.2	7.2
„ 4 (14 „)	7.4	—	—	7.6	—	—	8.0	7.9
„ 5 (23 „)	—	7.4	—	—	7.2	—	7.8	7.8
„ 6 (8 „)	—	—	6.0	6.2	—	—	6.7	6.7

percentages of the number of observations. If from 25 observations an increase was observed in 15 cases and a decrease in 10, + 15 − 10 = +5 was recorded as +20(%) (+5/25). Here, too, an increase in the grade of quality was observed more often than a decrease.

TABLE 3 – *Difference in the number of times an increase and the number of times a decrease was observed after nitrogen fertilization, expressed in percentages of the total number of observations*

Grade of quality	+57
Good grasses	+70
Legumes	−84
Medium-value grasses	+26
Inferior grasses	+ 6
Forbs	−47

At the nitrogen experimental farms an extensive soil analysis was carried out in addition to a botanical judgement of the herbage. A high grade of quality of the herbage could be determined on nearly all fields, while the potassium status of the soil was often moderate to sufficient and in some cases even poor. At the farms on sandy soil, even with a slight decrease in the potassium status of the soil, still an increase in the grade of quality from 6.8 to 7.2 was found in the course of years. This is not in accordance with the facts observed earlier.

According to an interim report dealing with the relation of the potassium status in the upper layer of the soil and the grade of quality of the herbage, DE VRIES and KOOPMANS (9) found that good grassland (grade of quality over 7.0) could occur only with a potassium value of over 20. This concerns sandy soils. The above mentioned nitrogen experimental farms comprise several fields with a potassium figure below 20 and a grade of quality over 7.5.

According to the opinion of Prof. Ir. M. L. 'T HART, which we endorse, one thing and another are closely related to the nitrogen supply. In former times, when organic manure was mainly applied, an ample nitrogen supply on grazed land meant an ample potassium supply as well, resulting in a high potassium status of the soil. Since nowadays fertilizers are used in the first place this correlation exists to a much lesser extent and an ample nitrogen supply may be coupled with a low potassium supply. This will be the more so, as with a more intensive exploitation one or more cuts of young grass wil be mown yearly. Accordingly even with a sufficient potassium fertilization the potassium status of the soil in many cases will remain moderate to poor. With an ample nitrogen supply this does not seem to be an objection for a favourable development of good grasses.

Nitrogen fertilization and good grasses

An increase in the grade of quality of herbage after nitrogen fertilization is usually caused by an increase in the share of good grasses. This finds clear expression in the tables 1 and 3.

The following may be said about the most important good grasses. Perennial Rye-grass, our highest valued species is clearly 'nitrogen-loving'. After nitrogen fertilization it will often take the lead and not seldom half the herbage will consist of it. The botanical analyses of the nitrogen experimental farms showed that Perennial Rye-grass absolutely dominated only once at the beginning of the experiment, but five times after 6–8 years. This may be observed particularly on intensively grazed fields, as the species is stimulated especially by grazing. BOSCH and TE VELDE (1) also found an increase in Perennial Rye-grass when summarizing nitrogen experiments of more years standing. By the sharp increase in Perennial Rye-grass the herbage will become more one-sided, however, and owing to the poor hardiness of this species which is otherwise quite in demand this will harbour a risk. In fact the best grasslands, used for grazing only, suffer the most from severe frost.

Another good grass species is Rough-stalked Meadow-grass which, although being wider

distributed than the former one, on an average has a smaller share in the harvested product. This species likes an ample nitrogen supply too, and if water supply and fertility are not lacking, it may spread widely. This will be especially the case on fields where the competition of Perennial Rye-grass is not so heavy, e.g. those which are more often used for haying. There is a risk, however, that after heavy nitrogen fertilization this 'humidity-loving' species will decrease rapidly in dry summers, influencing the productivity of the field in an unfavourable way. Especially so, if in consequence of the nitrogen fertilization too little White Clover has remained to replace Rough-stalked Meadow-grass (6).

On modernly grazed fields the risk of this species becoming too dense is somewhat smaller. Although an increase of it after 6–8 years of nitrogen fertilization could be established on some of the afore-cited nitrogen experimental farms, the average percentage from all the farms remained almost constant at about 19 % during this period. The sharp increase in Perennial Rye-grass (from 27 % at the beginning of the experiment to 46 % after 6–8 years) will certainly have had some influence.

Dispersion of this species had also been observed by Bosch and Te Velde (1) with experiments in which different types of use had been combined with light and moderately heavy nitrogen applications.

Ennik (3) established that Rough-stalked Meadow-grass growing on intensively grazed fields of a grazing experiment on soil with a good degree of humidity, reacted clearly positive to a high nitrogen application compared to a low one.

From the other good grasses also Timothy and Smooth-stalked Meadow-grass may be called clearly 'nitrogen-loving'. From all good grasses the former, hardly ever appearing as one of the leading species, may be indicated as the one being most grateful for a nitrogen application. After nitrogen fertilization its share in the harvested product is often doubled. De Vries (7) established on the State mines experimental fields which were mown that, if the production figures of the hay were brought into account, the total production of Timothy was even fourfold.

Smooth-stalked Meadow-grass too may increase considerably in quantity. On an experimental field on sandy soil where it was the leading species, Bosch and Te Velde (2) established a rather pronounced positive effect on this grass of a moderately heavy nitrogen application, compared to a low one.

With all good grasses mentioned, however, the type of use, the degree of humidity and the fertility will determine to a great extent which species will profit the most in an incidental case.

Meadow Fescue finally, does not make high demands on the nitrogen supply. In many cases the percentage by dry weight hardly increases at all after nitrogen fertilization, even though with any general increase in the production it would still mean an increase of this species.

Nitrogen fertilization and legumes

It is known by general experience that the group of legumes (consisting principally of White Clover) will decrease after nitrogen fertilization. De Vries (7) already found this, among others, while adapting the results of the State mines experimental fields. On an average the percentage appeared to have decreased from 13 to 3 after nitrogen fertilization. The tables 1 (alternately used farm grasslands) and 3 (experimental fields) showed this as well as the examination of the intensively grazed nitrogen experimental farms, where the percentage of White Clover diminished on an average from 1.5 to 0.6.

Although the percentage of White Clover in old permanent grassland is not high, generally, a decrease of it must be seen as less desirable. Owing to this a source of protein in more mature grass will be cut off, but that is not the greatest difficulty in our country. More important is that the mineral content will tend towards the unfavourable side,

particularly the supply of divalent ions (calcium and magnesium – grass tetany!) is going to suffer.

The above mentioned applies more especially to fields used for haying, fields which are generally used for grazing will show a quite different picture. First of all the two factors which are unfavourable to White Clover, viz. nitrogen fertilization and haying, do not occur simultaneously here. Moreover by patch-wise grazing cattle is able to take up comparatively more clover (or herbs such as Dandelion, Plantain-species and others) than is indicated by the proportion by quantity. Later on the subject of the replacement of clover by other dicotyledons will be discussed again.

Nitrogen fertilization and medium-value grasses

It is impossible to express a definite opinion on the influence of nitrogen fertilization on the group of medium-value grasses. From table 3 it appears that after nitrogen fertilization a percentage-increase occurs more often than a -decrease. In table 1, however, there is not much difference in the treatments with high and with low nitrogen. As a result of the examination of 47 experimental fields for mowing, DE VRIES and KRUIJNE (10) call this group of medium-value grasses 'moderately nitrogen-loving'.

In the first part of table 4 the figures (average per farm) from the medium-value grasses have been given according to the analyses carried out on the nitrogen experimental farms at the beginning of the experiment and after 6–8 years.

The results of a prolonged nitrogen fertilization consequently cannot be determined beforehand and are dependent on e.g. the type of use. Considering the composition of the group of medium-value grasses in different cases, this is quite obvious. One time Meadow Foxtail or Yorkshire Fog may dominate, both species feeling more at home on fields used for haying, another time Cocksfoot or Creeping Bent-grass will dominate, being found more often on fields used for grazing. At the experimental mowing fields of the State mines DE VRIES (7) at one time established that Yorkshire Fog increased after nitrogen fertilization. Likewise DE VRIES and KRUIJNE (10) found a distinct increase of this species on 47 experimental fields used for mowing. In both cases no positive effect could be established for Creeping Bent-grass. 'T HART (4), however, could establish a slight decrease of Yorkshire Fog on fields used for grazing. With modern treatment and under grazing conditions this species, on which cattle does not like to feed and which is not very hardy, does not seem to disperse after nitrogen fertili-

TABLE 4 – *Average percentages by dry weight of medium-value grasses and inferior grasses per nitrogen experimental farm at the beginning of the experiment and after 6–8 years of rather heavy nitrogen fertilization*

	medium-value grasses		*inferior grasses*	
	beginning	*after 6—8 years*	*beginning*	*after 6—8 years*
farm 1 (3 fields)	23	15	9	14
„ 2 (3 „)	8	1	5	11
„ 3 (4 „)	20	13	10	10
„ 4 (4 „)	14	10	8	9
„ 5 (4 „)	20	6	5	7
„ 6 (2 „)	24	24	19	16

zation. During an experiment on grazing ENNIK (3) found in addition to a distinct influence of grazing a lower weight-share with a higher nitrogen application. The indifference of Creeping Bent-grass established more than once on the experimental fields for mowing, expressed itself also in this experiment with intensive grazing. On the nitrogen experimental farms a distinct decline of Creeping Bent-grass was observed more than once (5); some striking decreases of Yorkshire Fog were determined there as well.

If mowing of the field in itself is already favourable to them, the medium-value species will be generally stimulated by nitrogen fertilization on hay-fields. This means that Yorkshire Fog and especially Meadow Foxtail and Coach-grass are 'nitrogen-loving' on fields used for haying. The same cannot be said about fields used for grazing, as the medium-value species which have a preference for grazing, such as Crested Dogstail, Cocksfoot and Creeping-Bentgrass, cannot bear up sufficiently against the competition of good grasses, especially Perennial Rye-grass.

On fields with modern use (intensive grazing combined with mowing for hay production, silage or the drying of grass) and heavy nitrogen applications the spreading of Coach-grass should be watched in particular, especially on those fields with higher pH-values. His attention having been drawn to this fact by the State Agricultural Advisory Office, DE VRIES established centres of this productive but not very palatable grass, which is equal to drought as well as to a high degree of moisture.

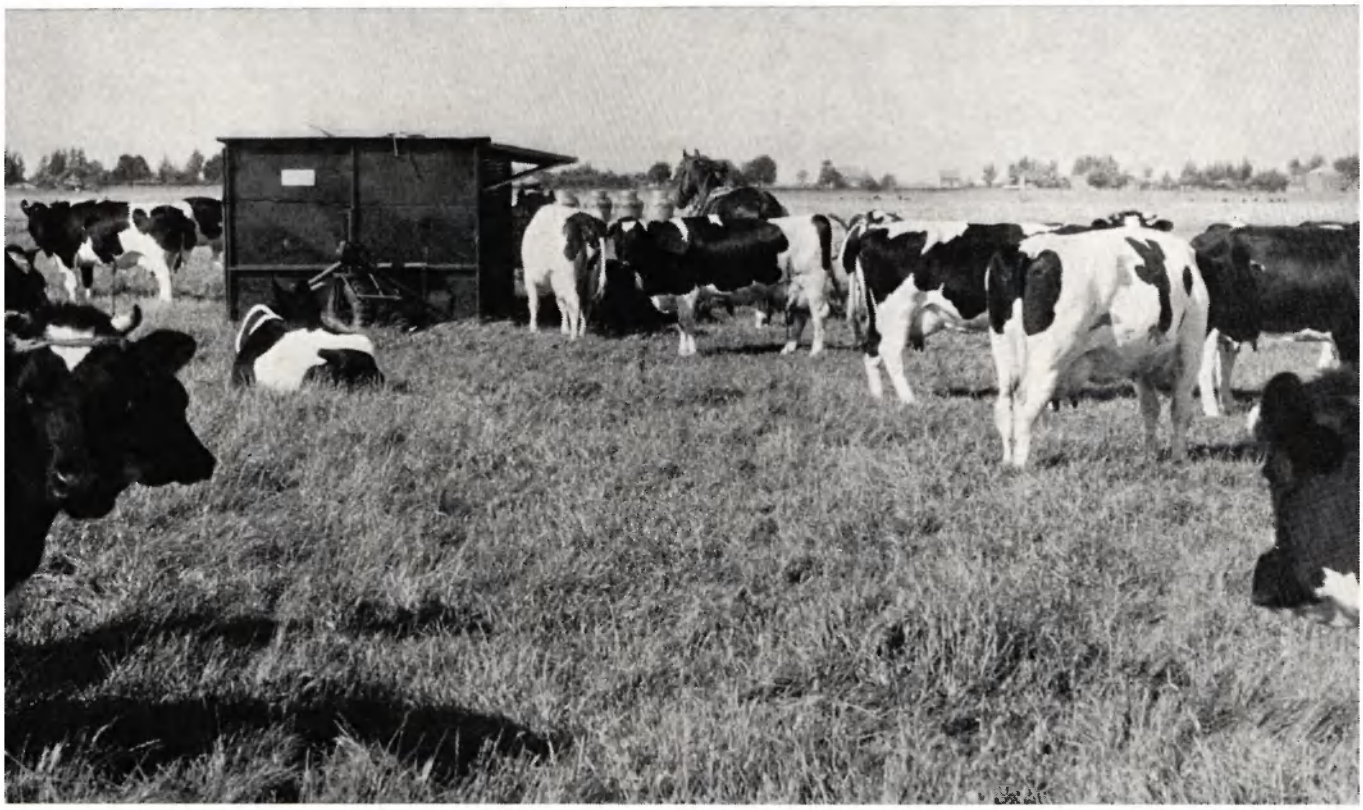
LATIN NAMES OF THE SPECIES DEALT WITH

Annual Meadow-grass	*Poa annua L.*
Autumnal Hawkbit	*Leontondon autumnalis L.*
Broad-leaved Dock	*Rumex obtusifolius L.*
Chickweed	*Stellaria media Vill.*
Coach-grass	*Agropyron repens P.B.*
Cocksfoot	*Dactylis glomerata L.*
Common Bent-grass	*Agrostis tenuis Sibth.*
Creeping Bent-grass	*Agrostis stolonifera L.*
Creeping Buttercup	*Ranunculus repens L.*
Crested Dogstail	*Cynosurus cristatus L.*
Curled Dock	*Rumex crispus L.*
Daisy	*Bellis perennis L.*
Dandelion	*Taraxacum officinale Web.*
Floating Foxtail	*Alopecurus geniculatus L.*
Meadow Buttercup	*Ranunculus acris L.*
Meadow Fescue	*Festuca pratensis Huds.*
Meadow Foxtail	*Alopecurus pratensis L.*
Perennial Rye-grass	*Lolium perenne L.*
Plantain-species	*Plantago species*
Red Fescue	*Festuca rubra L.*
Rough-stalked Meadow-grass	*Poa trivialis L.*
Smooth-stalked Meadow-grass	*Poa pratensis L.*
Soft Brome-grass	*Bromus mollis L.*
Sorrel	*Rumex acetosa L.*
Stinging Nettle	*Urtica dioica L.*
Sweet Vernal-grass	*Anthoxanthum odoratum L.*
Timothy	*Phleum pratense L.*
White Clover	*Trifolium repens L.*
Yorkshire Fog	*Holcus lanatus L.*

Nitrogen fertilization and inferior grasses

What has been said about the medium-value grasses also refers to a certain extent to the group of inferior grasses. The tables 1 and 3 hardly show any difference in the percentages after nitrogen fertilization, in table 4, however, a few distinct increases may be found. Here too, the type of use of the field is apparently of great influence, this in connection with the species composing this group of grasses. DE VRIES and KRUIJNE (10) observed on 47 experimental mowing fields that Common Bent-grass and Sweet Vernal-grass were 'nitrogen-avoiding', but that Red Fescue was slightly 'nitrogen-loving'. In this connection it is worth noticing that the first mentioned species feels much more at home on pastures than on hayfields, while Red Fescue has a preference for hayfields. In accordance ENNIK (3) found during an experiment on grazing the lowest percentages for this species with the treatment 'rotational grazing with high nitrogen application'.

Annual Meadow-grass, Floating Foxtail and Soft Brome-grass also are to be classed among the inferior grasses. During favourable con-



ditions these species may multiply quickly by means of seed. All three are moderately to strongly 'nitrogen-loving'. In consequence it could be observed more than once on intensively grazed fields, where Perennial Ryegrass had been damaged rather badly by frost (e.g. Feb. 1956) that Annual Meadow-grass and Floating Foxtail were rapidly increasing. Soft Brome-grass occurs most frequently on hayfields and as a rule it profits highly by nitrogen applications there, as was obvious from the adaptation of 47 experimental mowing fields by DE VRIES and KRUIJNE (10).

Nitrogen fertilization and forbs

In addition to some grass-like weeds this group consists also of well-known grassland weeds, such as Dandelion, Plantain-species, Sorrel, etc. Of the most important and frequently occurring species in this group there is none which shows a marked preference for nitrogen. Some less common weeds on grassland however, such as Stinging Nettle, Curled Dock, Broad-leaved Dock and Chickweed are positively 'nitrogen-loving'. Now and again they are to be found frequently on fields fertilized with nitrogen.

The heavy competition of the increasing good grasses usually causes a decrease in these forbs, if not to such an extent as in the case of the legumes. Being principally dicotyledonous they would otherwise have been able to compensate in some degree the shift in the mineral-content caused by the diminishing percentage of legumes. On grazed fields cattle may take up herbs in a more favourable proportion

than they show in relation to grasses by means of patch-wise grazing, similar as to legumes.

In table 1 only a slight decrease is to be found after fertilization. According to table 3 from an adaptation of 47 experimental mowing fields, a receding percentage was established considerably more often than a rising one. In accordance DE VRIES (7) frequently observed a decrease in the percentage, if not very large, on the State mines experimental fields. When calculating the total amount of forbs produced, he could even establish an increase of 16%, if he brought the production figures into account.

The nature of the nitrogen fertilizer applied

The various kinds of nitrogen fertilizer have a different effect physiologically, e.g. sulphate of ammonia (s.a.) reacts distinctly acid and nitrate of lime (n.l.) distinctly alkaline. It is to be expected that grassland species being susceptible to the acidity of the soil will respond in different ways to the fertilizer applied. DE VRIES (5) made a list in which the reaction of some species is indicated. In it the percentages by dry weight of some species from the treatments fertilized with sulphate of ammonia were compared to the percentages found on the treatments fertilized with nitrate of lime. He found that Meadow Fescue and Rough-stalked Meadow-grass had a somewhat higher percentage after fertilization with n.l. (alkaline effect), while Yorkshire Fog, Sweet Vernal-grass and Bent-grass had the same with s.a. (acid effect). Still more obvious was the number of times that the species concerned was found to be higher or lower during the comparison, in which the parallel could generally be extended. Thus the average percentage of Meadow Fescue was found to be 12 on the treatments fertilized with n.l., on the treatments fertilized with s.a. it was 9. A higher percentage with n.l. fertilization, however, was etablished 5 times out of 6, while in one case only the percentage remained the same.

When comparing the quantities produced in total by bringing into account the yield of each separate treatment, he could establish the productions as they have been reflected in table 5. The specific yields from the 0-treatments had been put at 100.

TABLE 5 — *The production of some groups of species and some separate species after fertilization with sulphate of ammonia (s.a.) or nitrate of lime (n.l.) expressed in percentages of the 0-treatment production. Results of the mown State mines experimental fields*

	s.a.	*n.l.*
Grasses	186	185
Legumes	34	47
Forbs	111	121
Timothy	417	403
Rough-stalked Meadow-grass	213	337
Yorkshire Fog	289	258
Smooth-stalked Meadow-grass	205	217
Sweet Vernal-grass	200	135
Perennial Rye-grass	169	161
Red Fescue	128	176
Meadow Fescue	125	147
Bent-grass	161	106

Nitrogen fertilization and the quality of the sod

In some cases it may be observed that the quality of the sod deteriorates after nitrogen fertilization. This, however, is caused by the type of use which has not been adjusted to the more intensive growth of grass. If the cattle is put into pasture at the usual time, the chances are that the grass has already grown somewhat too tall. Moreover, the number of cattle should be in keeping with the more rapid growth of the grass. If the land is used according to modern treatment a deterioration of the sod is scarcely to be feared.

SUMMARY

A higher production involving, moreover, an increase in the grade of quality of the herbage is the usual favourable effect of a prolonged nitrogen fertilization. On the other hand, however, the herbage will grow somewhat one-sided making it more susceptible to extreme weather influences.

The decrease of legumes generally established, is worth mentioning, because the mineral content of the herbage is influenced unfavourably by it. Mowing and intensive grazing alternately in addition to an ample potassium and phosphate fertilization will serve to maintain as far as possible the White Clover appreciated so much.

The most important good grasses Perennial Ryegrass and Rough-stalked Meadow-grass profit highly on the whole. The type of use of the land, the degree of humidity and the general fertility determine which of these species, but also which of the other good grasses, such as Timothy and Smooth-stalked Meadow-grass will increase the most. Consequently Perennial Ryegrass will profit the most from nitrogen fertilization with intensive grazing, while with an ample water supply or with drought Rough-stalked Meadow-grass or Smooth-stalked Meadow-grass respectively will be the most successful.

With the group of medium-value grasses the reaction of the most important species is uncertain and very much dependent on the use of the land. Yorkshire Fog and Meadow Foxtail are greatly stimulated on hayfields, on pastures they recede. Coach-grass may often dominate com-

pletely in patches on grasslands with higher pH-values, especially if these are mown for the production of hay, silage or the drying of grass, this in combination or not with grazing. Creeping Bent-grass generally reacts scarcely on a nitrogen fertilization.

Among the inferior grasses Common Bent-grass and Sweet Vernal-grass diminish after nitrogen fertilization on hayfields. Red Fescue on the other hand increases moderately and Soft Brome-grass even sharply. On grazed fields Annual Meadow-grass and Floating Foxtail profit highly, especially if they may occupy the patches damaged by frost. Red Fescue however, decreases somewhat with intensive grazing.

The group of forbs generally shows a percentual decrease, though presumably not in the actual quantity. None of the most important species of this group are especially stimulated by nitrogen.

Worth mentioning is also the influence of certain kinds of nitrogen fertilizer on the acidity of the soil. Consequently some 'acid-loving' species will react more favourably to the physiologically acid sulphate of ammonia and other more 'lime-loving' species will do so to the alkaline acting fertilizers.

Because the sward grows more one-sided, the sod will become sometimes less firm resulting in damage by treading, especially on wet soils.

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