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Factors influencing the sodium content of meadow grass

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Summary and conclusions

Cattle are not usually given minerals during the grazing period, and the use of salt lick and pickle (2½ % solution of sodium chloride) is uncommon. Consequently, the cattle's sodium supply during this period depends on the sodium content of the grass. It is important to study the factors influencing the sodium content of the grass, so that a detailed investigation has been undertaken.
The factors influencing the sodium content of meadow grass have been divided into three groups, *viz.* soil fertility, fertilisers (K, N, Mg and Na) and botanical composition.
The following conclusions are drawn:

1. The sodium content of grass is largely determined by sodium content and K-number of the soil.
2. At a given sodium content of the soil the sodium content of grass decreases with increasing K-numbers of the soil. This decrease in the sodium content of grass is small at high K-numbers (> 30).
3. The sodium content of grass increases with increasing sodium content of the soil. The influence of the sodium content of the soil is higher at a low soil-potassium status than at a high one.
4. Potash fertilisers reduce the sodium content of grass at a low soil-potassium status.
5. The soil-sodium content may be used as a basis for sodium-fertiliser recommendations, since with the present potassium-fertiliser policy in the Netherlands, the K-number has generally reached a level at which it has a virtually constant effect on the sodium content of grass.
6. The influence on the sodium content of grass, mentioned under 2 and 3, can be expressed by means of the $\frac{15 \text{ K-number}}{Na_2O + 6}$ and $\frac{25 \text{ K-number}}{Na_2O + 14}$ ratios for sandy and clay soils respectively, the numerator at K-numbers > 30 being the same as that at K-number = 30. With increasing ratios the sodium content of grass decreases. The influence of a given amount of sodium in potash fertilisers on sodium content of grass is correlated to these ratios.
7. The influence of nitrogen fertilisers on the sodium content of grass is not clear.
8. The influence of magnesium fertilisation on the sodium content of grass is negligible.
9. The Chilean-nitrate sodium has the same effect as that in sodium chloride. Unlike the case of NaCl, the calcium content of grass is decreased by Chilean nitrate. Both fertilisers slightly reduce the magnesium content of grass.
10. Herbs and clovers have a higher sodium content than grass. The sodium content of the plants belonging to each group is correlated to the calculated ratios in the soil as mentioned under 6.

1. Introduction

It has long been known that animals require sodium. The sodium supply in winter time is usually sufficient as minerals are commonly given and mineral mixtures generally contain sodium chloride. During the grazing period, however, cattle usually have

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no mineral supply, and the use of salt lick and pickle (2½ % solution of NaCl) is not widespread. The cattle's sodium supply during this period therefore depends on the sodium content of the grass.
It is therefore important to know in the first place how the sodium content of meadow grass is influenced by various factors, and to suggest ways of increasing sodium content where necessary.
The factors influencing the sodium content of meadow grass are: –
1. soil fertility,
2. manuring,
3. botanical composition of the grass.

Literature. Many investigations have shown that the sodium uptake of plants decreases with increasing potassium uptake. VAN ITALLIE (1938) concluded from pot experiments that the sodium content of Westerwolds ryegrass (*Lolium multiflorum* var. *westerwoldicum*) depends on the ratio of the amount of soluble and exchangeable sodium to potassium, calcium and magnasium in the soil, *viz.* $\frac{10 \text{ Na}}{0{,}1 \text{ Ca} + 0{,}2 \text{ Mg} + 2 \text{ K}}$ (in m.eq.).
OOSTENDORP (1962) concluded that the sodium content of grass depends on the K_2O/Na_2O-ratio (both soluble in 1/10 N HCl).
The sodium uptake has been frequently studied, especially with beets, and the part played by sodium as a substitute for potassium (VAN ITALLIE, 1937a) has been taken into account. A review of the literature on the influence of potassium on the sodium uptake of the plant has been given by HEIMANN and RATNER (1962). LEHR's experiments showed that high potash dressings in the form of 60 % potash salt considerably reduce the sodium content of grass. But with moderate dressings of 20 % sodium-containing potash salt, the sodium content appeared to increase.
VAN ITALLIE (1934) pointed out that the composition differences between grass species with regard to sodium are greater than those caused by any other element. *Holcus lanatus, Lolium perenne* and *Anthoxantum odoratum* contain on an average more sodium than *Poa trivialis, Poa pratensis, Agrostis alba, Festuca rubra* and *Alopecurus pratensis.* LEHR (1960) reports that, according to the rate of sodium uptake, species of grasses and *Trifolium repens* can be placed in the following order: *Lolium perenne* > *Trifolium repens* > *Dactylis glomerata* > *Poa trivialis* > *Festuca pratensis* > *Phleum pratense* > *Poa pratensis.* VAN DER KLEY (1957) mentions large differences between sodium contents of grass species, clovers and herbs. BRUGGINK (1960) comes to the same conclusion. GARANDEAUX (1959) points out that differences exist in the sodium content of grass even within the species.

2. Influence of soil fertility on the sodium content of meadow grass

2.1. Procedure

The analytical results of the following investigations were used in order to study the influence of soil fertility on the sodium content of grass.
1. Trial fields laid down all over the Netherlands in 1958 and 1959 and conducted by OOSTENDORP (series 68).
2. A series of small experiments on sandy soils in 1952 conducted by VENEKAMP (Exp. 1326).
3. The "soil-plant-animal" investigations at Woudenberg (1957) and Borculo (1959). In these investigations soil and plant samples were taken in order to relate the results of analytical investigations to each other and also to animal health.

4. In addition use was made of the analytical results of samples taken in re-allotments. In re-allotments soils and plant samples are taken and analysed to obtain some idea of their fertility status.

In the investigations mentioned under 3 and 4 the soil and plant samples were collected at the same time; in those mentioned under 1 the soil samples were collected at the beginning of the experiments. In this research work the plant analyses only relate to the treatments without potash, and in investigation 4 the soil samples were taken after the first cut and only the results of the treatments without potash were taken into consideration.
Altogether we had at our disposal 208 samples of sandy soils, *viz.* 48 of the soil-plant-animal investigation at Borculo, 95 samples of Woudenberg, 57 of Exp. 1326 and 8 of series 68. There were 93 clay-soil samples, all taken from re-allotments.
Although we processed the results of all the investigations separately, for the sake of brevity we will first discuss the results of the S.P.A. investigation Borculo and then the results of the joint processing.
The results of the separate processing of all investigations has been published in *Versl. Landbk. Onderz.* (HENKENS and VAN LUIT, 1963).

2.2. Results

The considerable influence of potassium on the sodium uptake of the plant was mentioned above. FIG. 1 shows the correlation between the potassium and sodium contents of the grass. The sodium content decreases with increasing potassium content.

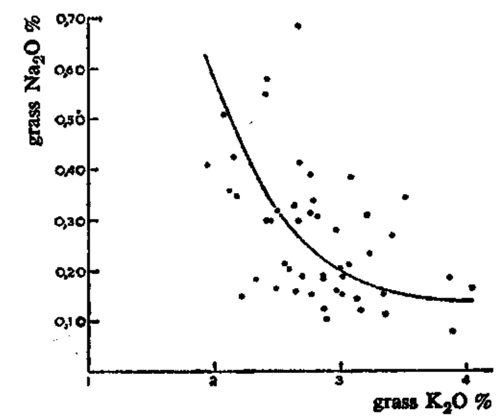


FIG. 1
Relation between potash and sodium contents of grass in the Borculo (1959) S.P.A. [1] investigation

[1] = Soil — Plant — Animal.

The potassium content of grass depends on the potash status of the soil. The potash status can be represented by the potassium content (K-HCl) [1] or the K-number [2]. VAN DER PAAUW (1953) stated that the K-number is a more reliable index of the potash status of the soil than K-HCl. This is also demonstrated in the present material. The advantage of the K-number is that the humus content need not be taken into consideration in the interpretation. In this study we have therefore used the K-number.

[1] K-HCl is the amount of K_2O in the soil (in 1/1000 %) soluble in 1/10 N HCl.
[2] K-number is the agricultural interpretation of K-HCl in which the empirically assessed influence of the organic-matter content is taken into account.

There is a correlation between K-number of the soil and sodium content of the grass (FIG. 2). The scatter of the dots around the curve is caused by other factors and errors. To study the influence of other factors (pH, organic-matter and sodium content of the soil and potassium and protein content of the grass) the vertical deviations of the dots from the average curve were plotted against these factors. The only influence found was that of the sodium content of the soil. In FIG. 3 the vertical deviations of the dots from the average curve in FIG. 2 at K-numbers ⩽ 20 are plotted against the sodium content [1] of the soil. The same is done with the dots at K-numbers > 20 (FIG. 4). Comparison of both figures shows that the influence of the sodium content of the soil at low K-numbers is larger than at high K-numbers.

The advantage of combining all analyses is that the interaction between the potash and sodium status of the soil in relation to the sodium uptake of grass can be better studied.

To study the influence of the sodium content of the soil on the sodium content of

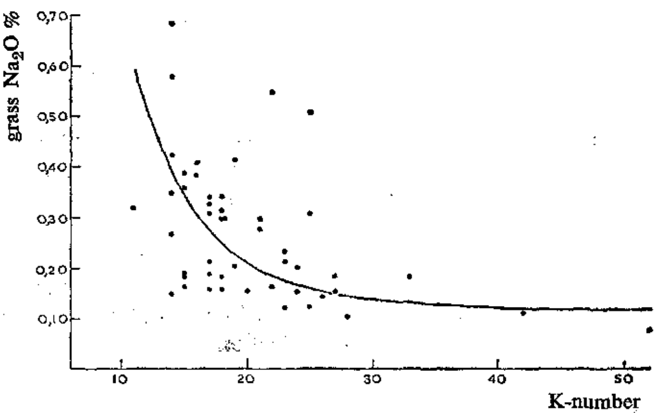


FIG. 2
Relation between K-number of the soil and sodium content of the grass in the Borculo (1959) S.P.A. [1] investigation

[1] = Soil — Plant — Animal.

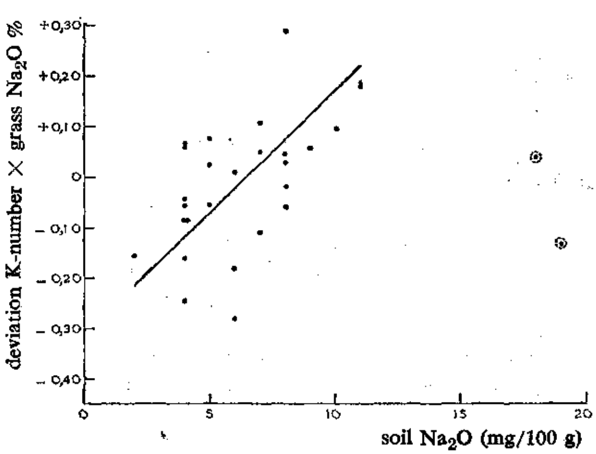


FIG. 3
Effect of the sodium content of the soil on the relation between K-number of the soil and sodium content of the grass in the Borculo (1959) S.P.A. [1] investigation at K-numbers ⩽ 20 (vertical deviations from average curve of the dots in FIG. 2 at K-numbers ⩽ 20 are plotted against the sodium content of the soil)

[1] = Soil — Plant — Animal.

[1] Sodium is the amount of Na_2O soluble in 1/10 N HCl in mg/100 g of soil.

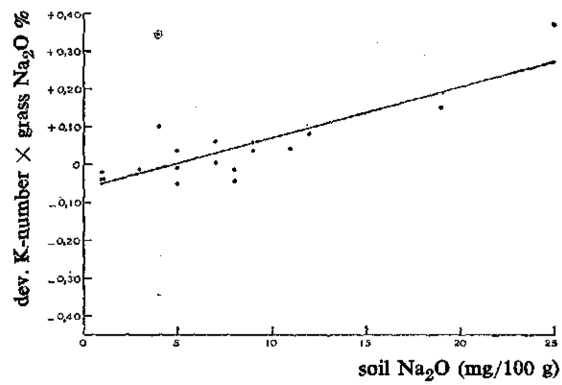


FIG. 4
Effect of the sodium content of the soil on the relation between K-number of the soil and sodium content of the grass in the Borculo (1959) S.P.A.[1] investigation at K-numbers > 20 (vertical deviations from average curve of the dots in FIG. 2 at K-numbers > 20 are plotted against the sodium content of the soil)

[1] = Soil — Plant — Animal.

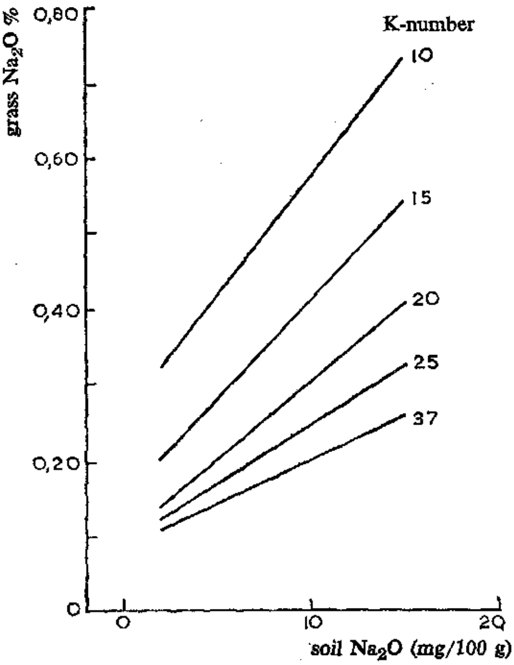


FIG. 5
Relation (adjusted) between sodium content of the soil and that of the grass on sandy soils at varying K-numbers

the grass the analyses were therefore divided into groups with different K-numbers. Similarly, to study the influence of the K-number the analyses were divided into groups with different sodium content of the soil.

The adjusted relation between the Na_2O-contents of soil and grass at different K-numbers is shown in FIG. 5. FIG. 6 shows the adjusted relation between K-number of the soil and sodium content of the grass at different sodium contents of the soil.

Both figures show that an interaction exists between the sodium and the potash status of the soil with respect to the uptake of sodium by grass.

The relation between sodium status of the soil and sodium content of the grass suggests that the latter can increase to an unlimited extent with an increasing sodium status of the soil. But it should be noted that in this study there was only one soil

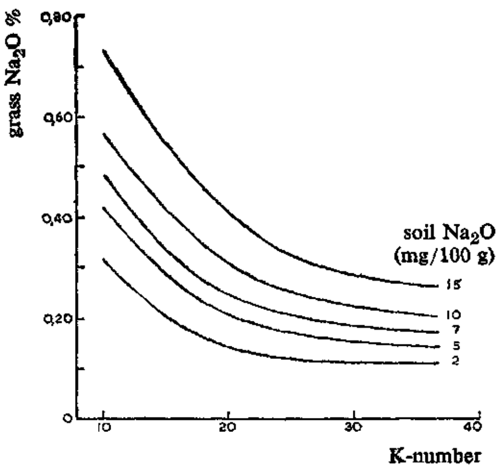


FIG. 6
Relation (adjusted) between K-number of the soil and sodium content of the grass on sandy soils at varying sodium contents of the soil

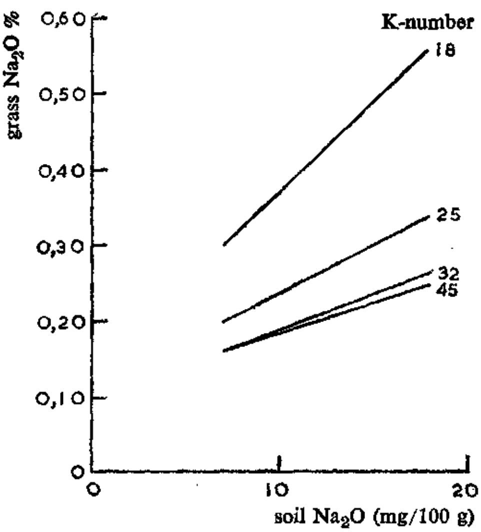


FIG. 7
Relation (adjusted) between sodium content of the soil and sodium content of the grass on clay soils at varying K-numbers

sample with a sodium content higher than 20 mg/100 g of soil. Most of the soils analysed had sodium-content values below 10. It is unlikely that the rectilinear curve would still be found at the high sodium levels of the soil.

FIG. 6 shows that when the K-number of the soil exceeds a value of 26 at low sodium levels, there is no further decrease in the sodium content of the grass. But higher K-numbers have still an effect at higher sodium levels of the soil. We would therefore appear justified in concluding that K-numbers higher than 30 only have a negligible influence on the sodium content of the grass. This conclusion is also supported by an investigation of VAN DER PAAUW (1956) who pointed out that K-numbers higher than 30 hardly increase the potash content of grass.

On clay soils (analyses of re-allotments) there is also a clear interaction between the sodium and the potassium status of the soil with respect to the sodium uptake of the grass (FIG. 7 and 8). As in sandy soils, potassium also has a negligible influence on

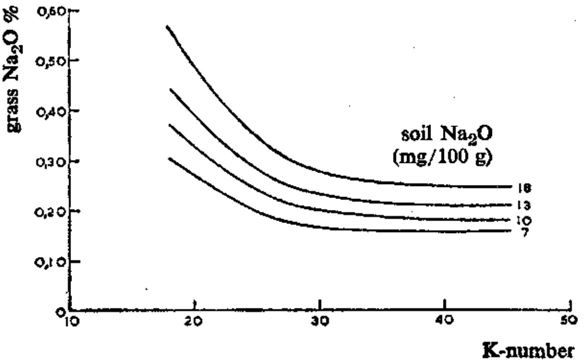


FIG. 8
Relation (adjusted) between K-number of the soil and sodium content of the grass on clay soils at varying sodium contents of the soil

the sodium content of grass in clay soils with K-numbers higher than 30.
As K-numbers above 30 only have a negligible effect on the sodium content of grass, the soil-sodium content is important in sodium-fertiliser recommendations. With the present potassium-fertiliser policy in the Netherlands the K-number is generally raised to a level at which it has a virtually constant effect on the sodium content of grass.
In the case of sandy soils the effect of potassium and sodium status of the soil on the sodium content of grass can both be expressed by means of the ratio $\frac{15 \text{ K-number}}{Na_2O + 6}$ and in the case of clay soils by $\frac{25 \text{ K-number}}{Na_2O + 14}$. These ratios are calculated by a method described by VAN DER PAAUW and RIS (1960) which is mainly applicable at lower K-numbers.

It is found (FIG. 5 and 6) that a difference of 1 unit in the soil-Na_2O content has an effect similar to that of a difference of 1,2 K-number units, in the range of K-numbers between 12,1 and 16,0 (average K-number equals 14,5 and average soil-Na_2O content equals 6,0). If the Na_2O-content of the soil differs from 6,0, the K-number (14,5) can be corrected with the use of the correction factor 1,2 (6,0 — soil-Na_2O content in 0,001 %). Since soil-Na has a positive effect on the Na-content of pasture, at any soil-Na_2O content the evaluation of a K-number equal to 14,5 (soil-Na_2O content = 6,0) may be the same as that of a K-number equal to 14,5 — 1,2 (6,0 — Na_2O). Assuming the ratio of these K-numbers to be valid beyond the range 12,1 to 16,0, the following ratio can be given characterising the Na-status of the soil: $\frac{14,5}{14,5 - 1,2\ (6,0 - Na_2O)} \times \text{K-number} = \frac{12,1 \times \text{K-number}}{Na_2O + 6,1}$.
The coefficient of the numerator is not essential, and for practical reasons, the ratio $\frac{15 \times \text{K-number}}{Na_2O + 6}$ will be used. This assumption also proved acceptable in the range of K-numbers between 16,1 and 20,0.

Since there were too few observations, it was not possible to verify whether these ratios are exact at high K-numbers. Moreover, there is much doubt about the validity of these ratios at high potash numbers, since the decrease in the Na_2O-content of the grass caused by K-numbers above 30 is negligible (even before this at lower sodium contents of the soil). This means that at K-numbers higher than 30 it is no longer permissible to use the product as numerator (*i.e.* 15 × and 25 × K-number respectively) but it should have the same value as at K-number 30 (*i.e.* 450 for sandy soils and 750 for clay soils).

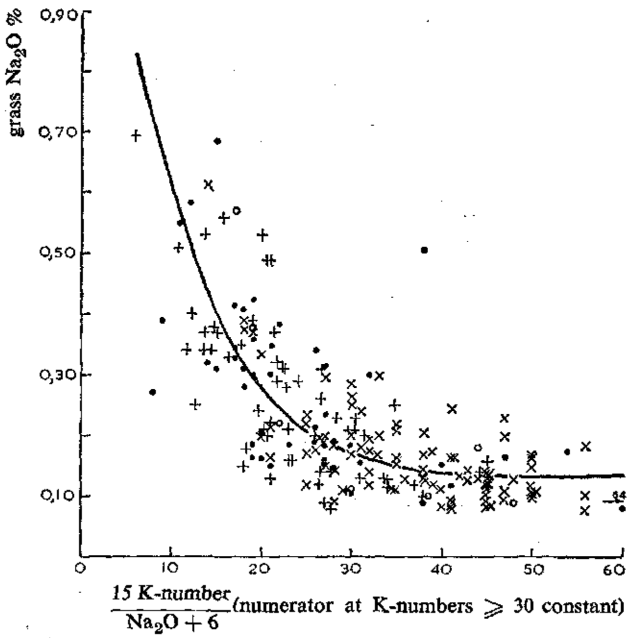


FIG. 9
Relation between the $\frac{15 \text{ K-number}}{Na_2O + 6}$ ratio in the soil (numerator at K-numbers > 30 is the same as at K-number 30) and the sodium content of grass on sandy soils

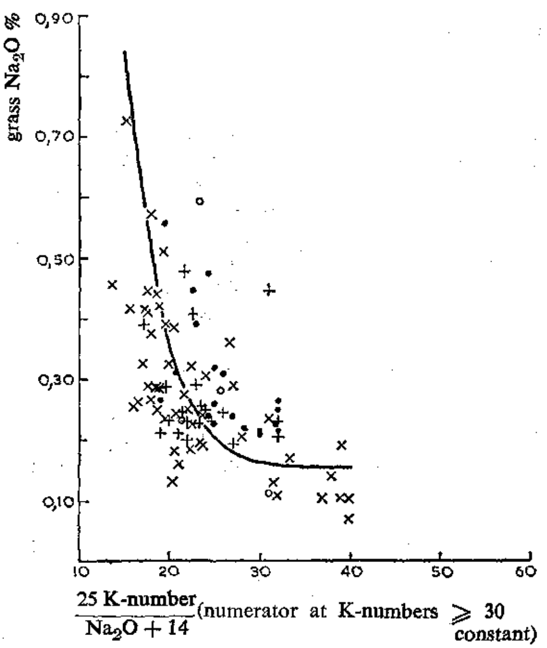


FIG. 10
Relation between the $\frac{25 \text{ K-number}}{Na_2O + 14}$ ratio in the soil (numerator at K-numbers > 30 is the same as at K-number 30) and the sodium content of grass on clay soils

FIG. 9 and 10 show the correlation between the sodium content of the grass and the ratio $\frac{15 \text{ K-number}}{Na_2O + 6}$ and $\frac{25 \text{ K-number}}{Na_2O + 14}$ respectively when the numerators at K-numbers higher than 30 have constant values. It can be seen from both figures that the sodium content of grass decreases with increasing ratios.

3. Influence of fertilisers on the sodium content of meadow grass

3.1. Potash fertilisers

It may be expected that potash fertilisers will only influence the sodium content of grass at lower K-numbers as the sodium content of grass is not affected by very high K-numbers. The differences between the sodium contents of grass on plots without potash and those with a potash dressing of 200 kg K_2O/ha (in the form of 60 % potash salt) on the Exp. 1326 series of trial fields were plotted against the K-numbers of the plots without potash dressing (FIG. 11). This figure shows that the sodium content of grass is reduced by potash dressing at a low K-number of the soil, irrespective of low or high sodium status.

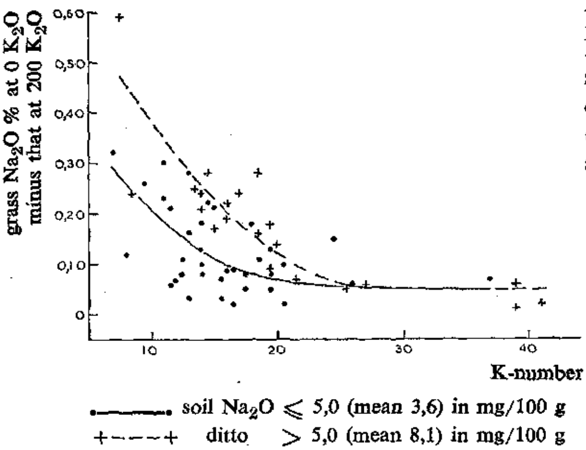


FIG. 11
Relation between K-number of the soil and decrease of the sodium content of the grass by a dressing of 200 kg K_2O per ha (60 % potash salt) at two sodium levels at Exp. 1326 (1952)

The part played by the sodium content in the different potash salts may also be assessed in this connection. In our opinion the influence of a certain amount of sodium in potash fertilisers depends on the ratios $\frac{15 \text{ K-number}}{Na_2O + 6}$ and $\frac{25 \text{ K-number}}{Na_2O + 14}$ in the case of sandy and clay soils respectively. At a low ratio (*i.e.* a high sodium content of grass) we expect the sodium in potash fertilisers to be incapable of counterbalancing the decrease in sodium content of the grass caused by potash, while at a high ratio (*i.e.* a low sodium content in the grass) the sodium in potash fertilisers may even increase the sodium content of grass.

This is shown in TABLE 1 which sets forth the sodium content of grass at different ratios in the soil of the trial fields of the series 71 and 68 without potash and with a dressing of 100 kg K_2O/ha (in the form of 40 % potash salt). 40 % potash salt normally contains 7—18 % Na_2O; the sodium content of the salt used in these experiments had not been determined. TABLE 1 shows that the dressing of 40 % potash salt resulted in a reduction in the sodium content of the grass on sandy and clay soils when the ratios $\frac{15 \text{ K-number}}{Na_2O + 6}$ and $\frac{25 \text{ K-number}}{Na_2O + 14}$ are below 20—30. This reduction is

TABLE 1. Na_2O-content of grass with and without potash dressing (in the form of 40 % potash salt) at varying $\frac{15\ \text{K-number}}{Na_2O + 6}$ ratios on sandy soils and $\frac{25\ \text{K-number}}{Na_2O + 14}$ ratios on clay soils (%)

Ratio	Na_2O-content of grass (%)					
	series 71			series 68		
	0 kg K_2O/ha	100 kg K_2O/ha	No. of samples	0 kg K_2O/ha	100 kg K_2O/ha	No. of samples
Sandy soils						
⩽ 20	0,72	0,44	2	0,48	0,35	2
21—30	0,24	0,21	6	0,17	0,19	2
31—40	0,21	0,22	8	0,12	0,15	2
> 40	0,10	0,19	6	0,14	0,13	2
Clay soils						
⩽ 20	0,52	0,38	6	—	—	—
21—30	0,36	0,25	5	0,31	0,23	4
31—40	0,19	0,19	7	0,11	0,14	1

TABLE 2. Influence of potash dressing with two different amounts of nitrogen on the sodium

Treatment	1st cut				2nd cut				3rd cut	
	40 kg N		80 kg N		40 kg N		80 kg N		40 kg N	
	K_2O	Na_2O	K_2O	Na_2O	K_2O	Na_2O	K_2O	Na_2O	K_2O	Na_2O
Year 1954										
0 kg K_2O/ha	2,14	0,50	2,07	0,49	1,88	0,71	2,20	0,47	1,73	0,80
400 kg K_{20} (80 kg K_2O/ha)	2,59	0,43	2,71	0,35	3,36	0,50	3,59	0,38	3,37	0,66
200 kg K_{40} (80 kg K_2O/ha)	2,71	0,36	2,52	0,34	3,58	0,42	3,29	0,32	3,35	0,36
135 kg K_{60} (80 kg K_2O/ha)	3,01	0,46	2,34	0,36	3,63	0,44	3,37	0,28	3,57	0,46
470 kg kainite (80 kg K_2O/ha)	2,58	0,44	2,53	0,35	3,29	0,53	3,46	0,31	3,52	0,59
300 kg sulphate of potash magnesia (80 kg K_2O/ha)	2,58	0,36	2,59	0,32	3,67	0,32	3,57	0,28	3,78	0,42
mean	2,60	0,43	2,46	0,37	3,24	0,49	3,25	0,34	3,22	0,55
Year 1955										
0 kg K_2O/ha	1,78	0,75	1,36	0,77	1,24	0,61	1,24	0,73	1,18	0,67
400 kg K_{20} (80 kg K_2O/ha)	3,06	0,42	3,13	0,57	3,07	0,42	2,83	0,71	2,94	0,51
200 kg K_{40} (80 kg K_2O/ha)	2,94	0,36	2,84	0,43	—	—	3,02	0,51	2,84	0,44
135 kg K_{60} (80 kg K_2O/ha)	2,86	0,32	2,73	0,46	3,01	0,34	2,63	0,53	2,52	0,36
470 kg kainite (80 kg K_2O/ha)	3,04	0,38	2,82	0,54	2,94	0,36	3,23	0,54	2,63	0,43
300 kg sulphate of potash magnesia (80 kg K_2O/ha)	2,81	0,32	2,84	0,40	2,70	0,35	2,79	0,47	2,63	0,47
mean	2,75	0,43	2,62	0,53	2,59	0,42	2,62	0,58	2,46	0,48
Year 1956										
0 kg K_2O/ha	0,90	0,61	0,88	0,51	1,00	0,74	0,82	0,65	0,89	0,63
400 kg K_{20} (80 kg K_2O/ha)	2,51	0,34	2,34	0,38	3,02	0,46	3,28	0,50	3,45	0,40
200 kg K_{40} (80 kg K_2O/ha)	2,29	0,31	2,31	0,40	3,13	0,42	3,07	0,55	3,43	0,35
135 kg K_{60} (80 kg K_2O/ha)	2,61	0,30	2,29	0,30	3,12	0,30	3,34	0,39	3,46	0,34
470 kg kainite (80 kg K_2O/ha)	2,32	0,26	2,36	0,34	2,90	0,46	2,98	0,59	3,18	0,40
300 kg sulphate of potash magnesia (80 kg K_2O/ha)	2,54	0,31	2,11	0,28	3,16	0,34	3,11	0,31	3,13	0,28
mean	2,20	0,36	2,05	0,37	2,72	0,45	2,77	0,50	2,92	0,40

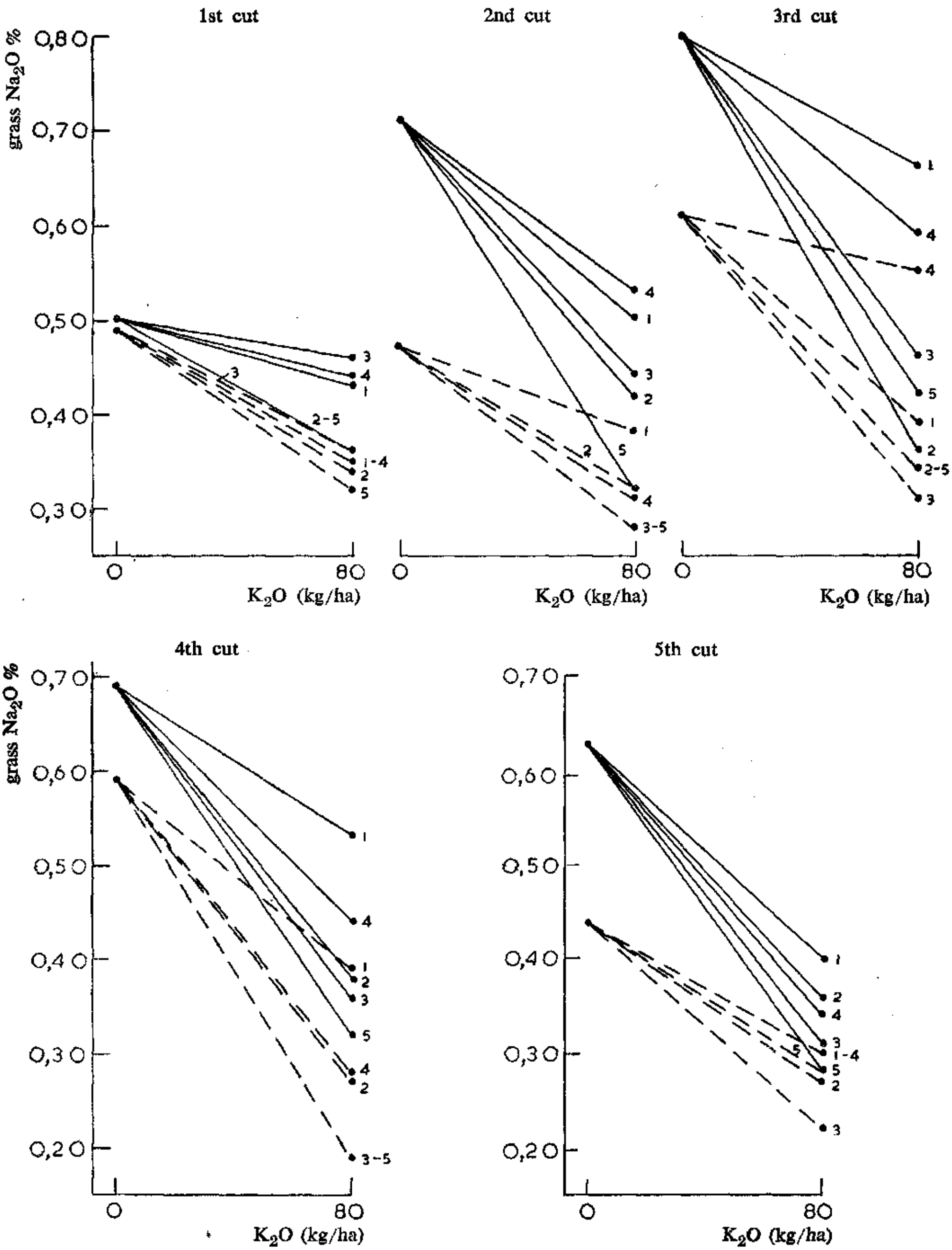
not harmful, however, since the sodium content of the grass is high at both ratios. As pointed out earlier, with ratios above 40 a dressing with 40 % potash salt led to an increase in the sodium content of the grass.

The Netherlands Potash Import Company was kind enough to place the results of their trial fields at our disposal. In one of these the influence was studied of a dressing with 80 kg K_2O/ha (in the form of 20 %, 40 % and 60 % potash salt, kainite and sulphate of potash-magnesia) with 40 and 80 kg N/ha (in the form of ammonium-nitrate limestone). The sodium content of the treatment without potash was found to be high, indicating the $\frac{25 \text{ K-number}}{Na_2O + 14}$ ratio in the soil to be low (the experiments were laid down on a clay soil with a peaty subsoil). The results set out in TABLE 2 and FIG. 12, 13 and 14, show that the sodium content of grass was reduced by all kinds of potash fertilisers, which is in agreement with the results given in TABLE 1. The reduction is lowest with fertilisers containing fairly large amounts of sodium (20 % potash salt and kainite). The difference between 40 % and 60 % potash salt and sulphate of potash magnesia is only slight and not consistent. It is known that the sodium content of 40 % potash salt may be somewhat variable (7—18 % Na_2O). Unfortunately, the fertilisers had not been analysed.

and potassium contents of grass in 1954, 1955 and 1956 (%)

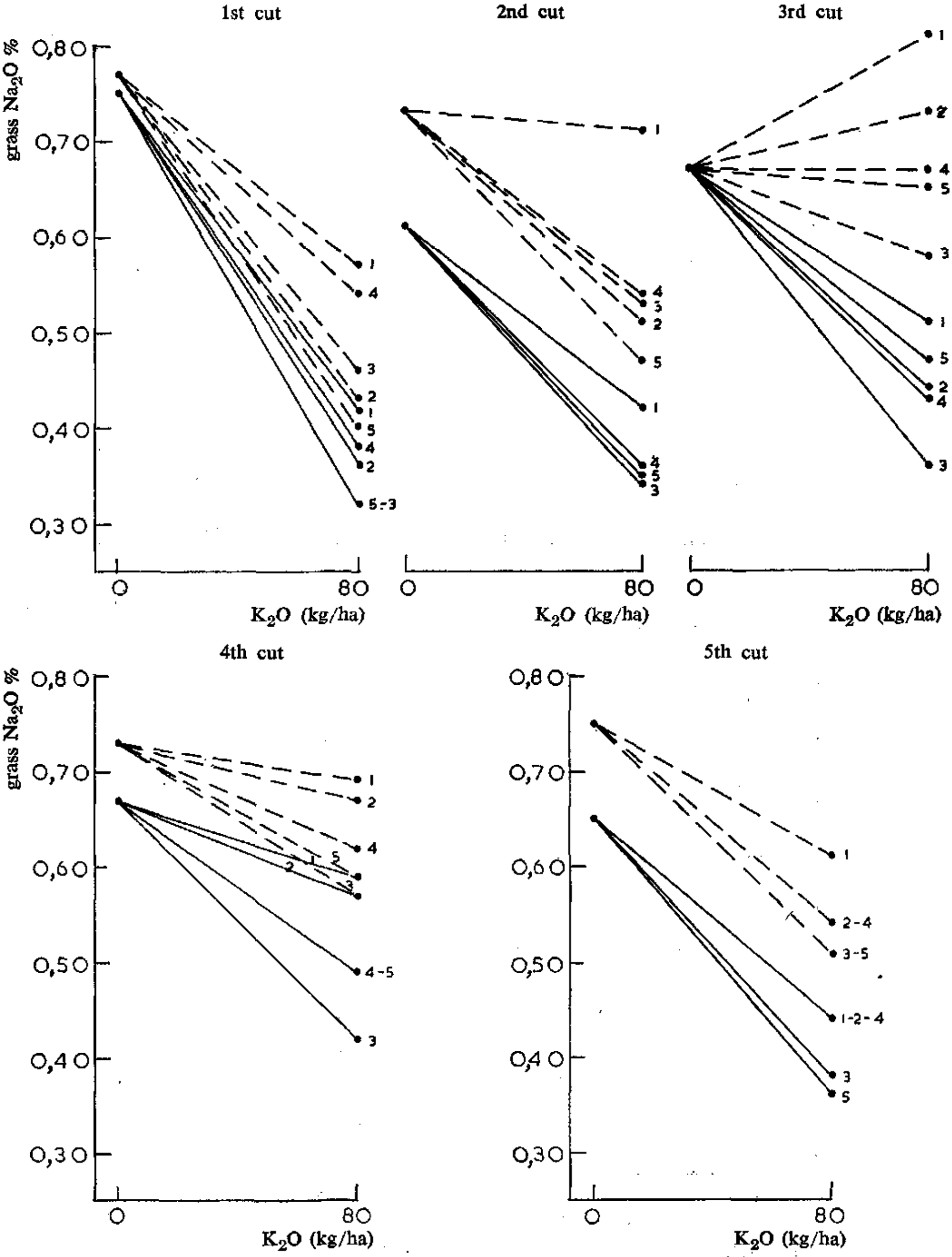
3rd cut		4th cut				5th cut				Mean			
80 kg N		40 kg N		80 kg N		40 kg N		80 kg N		40 kg N		80 kg N	
K_2O	Na_2O	K_2O	Na_2O	K_2O	Na_2O	K_2O	Na_2O	K_2O	Na_2O	K_2O	Na_2O	K_2O	Na_2O
1,93	0,61	1,31	0,69	1,37	0,59	1,20	0,63	1,93	0,44	1,65	0,67	1,90	0,52
3,52	0,39	3,61	0,53	3,83	0,39	3,20	0,40	3,57	0,30	3,23	0,50	3,44	0,36
3,47	0,34	4,07	0,38	4,08	0,27	3,32	0,36	3,32	0,27	3,41	0,37	3,34	0,31
3,28	0,31	4,10	0,36	4,06	0,19	3,19	0,31	3,47	0,22	3,50	0,41	3,30	0,27
3,48	0,55	4,28	0,44	3,95	0,28	3,57	0,34	3,57	0,30	3,45	0,47	3,40	0,36
3,65	0,34	3,82	0,32	4,14	0,19	3,57	0,28	3,58	0,28	3,48	0,34	3,51	0,28
3,22	0,42	3,53	0,45	3,57	0,32	3,01	0,39	3,24	0,30				
0,76	0,67	1,36	0,67	1,05	0,73	1,76	0,65	1,07	0,75	1,46	0,67	1,10	0,73
2,76	0,81	3,02	0,59	3,07	0,69	2,95	0,44	3,23	0,61	3,01	0,48	3,00	0,68
2,63	0,73	2,92	0,57	3,00	0,67	3,24	0,44	3,28	0,54	2,99	0,45	2,95	0,58
2,49	0,58	2,93	0,42	2,96	0,57	3,35	0,38	2,79	0,51	2,93	0,36	2,72	0,53
2,65	0,67	2,83	0,49	2,98	0,62	3,04	0,44	3,37	0,54	2,90	0,42	3,01	0,58
2,57	0,65	2,92	0,49	2,99	0,59	3,55	0,36	3,14	0,51	2,92	0,40	2,87	0,52
2,31	0,69	2,66	0,54	2,68	0,65	2,98	0,45	2,81	0,58				
0,76	0,51	0,67	0,65	0,67	0,54	0,77	0,65	0,90	0,55	0,85	0,66	0,81	0,55
3,24	0,40	2,99	0,44	3,00	0,51	3,25	0,46	3,23	0,46	3,04	0,42	3,02	0,45
3,10	0,40	3,19	0,38	2,95	0,49	3,90	0,39	3,72	0,47	3,19	0,37	3,03	0,46
3,23	0,26	3,48	0,32	3,00	0,35	4,02	0,34	3,48	0,34	3,34	0,32	3,07	0,33
3,18	0,38	2,70	0,38	2,76	0,46	3,25	0,47	3,24	0,53	2,87	0,39	2,90	0,46
3,06	0,28	3,47	0,24	3,08	0,34	3,70	0,34	3,48	0,38	3,20	0,30	2,97	0,32
2,76	0,37	2,75	0,40	2,58	0,45	3,15	0,44	3,01	0,46				

FIG. 12. Influence of potash dressing with two different amounts of nitrogen on the sodium content of grass in 1954



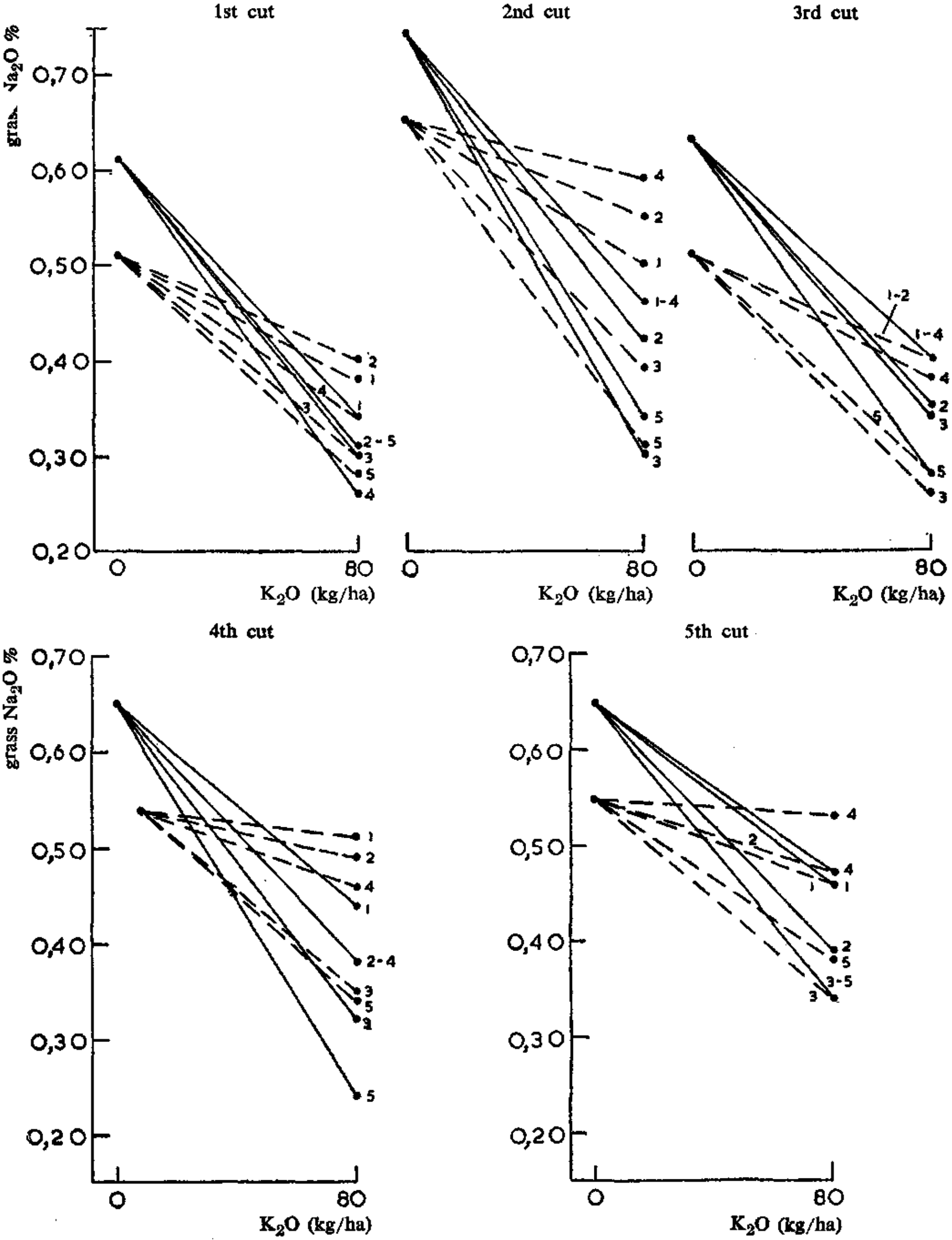
1 20 % potash salt
2 40 % „ „
3 60 % „ „
4 kainite
5 sulphate of potash magnesia
——— 40 kg N/ha
— — — 80 „

FIG. 13. Influence of potash dressing with two different amounts of nitrogen on the sodium content of grass in 1955



1 20 % potash salt
2 40 % „ „
3 60 % „ „
4 kainite
5 sulphate of potash magnesia
——— 40 kg N/ha
— — — 80 „

FIG. 14. Influence of potash dressing with two different amounts of nitrogen on the sodium content of grass in 1956



1 20 % potash salt
2 40 % „ „
3 60 % „ „
4 kainite
5 sulphate of potash magnesia
——— 40 kg N/ha
— — — 80 „

The results of another trial field also lend support to our conclusion that the influence of sodium-containing potash fertilisers depends on the above-mentioned ratio in the soil. The Potash Company laid down a trial field on clay soil to study the influence of the type of potash fertiliser in combination with a dressing of calcium nitrate or Chilean nitrate. The potash dressing was only given in spring, a nitrogen dressing following each cut (TABLE 3). The sodium content of the grass is low in the treatment without potash and with a dressing of calcium nitrate. It may be assumed that the ratio $\frac{25 \text{ K-number}}{Na_2O + 14}$ is high. In the first cut the supply of 120 kg K_2O/ha (20 % potash salt) greatly increases the sodium content but, when supplied in the form of 40 % and 60 % potash salt, the increase is too small. With Chilean nitrate, however, the influence of potash fertilisers is negligible. The explanation may be that the use of Chilean nitrate, as expected, increased the sodium status of the soil and decreased the ratio $\frac{25 \text{ K-number}}{Na_2O + 14}$. The same observation may be made of the second and third cut. For the later cuts the influence of potash is only slight.

3.2. Nitrogen fertilisers

It is known that the potash content of grass increases with an increase in protein content. But in our study we found no influence of the protein content of the grass.

For studying the influence of a fresh nitrogen dressing we had at our disposal the experiments of series 68 and some field experiments of the Netherlands Potash Import Company. The trial fields of series 68 were fertilised with 30 and 60 kg of nitrogen in the form of ammonium-nitrate limestone. TABLE 4 shows the sodium content of the grass of series 68 with 30 and 60 kg of N and a potash supply of 0 and 100 kg K_2O/ha (40 % potash salt). According to this table, on sandy soils at least, nitrogen reduces the sodium content of grass, unless potash has been supplied. With a potash dressing, however, the sodium content is increased by nitrogen fertilisers. The reduction at low ratios may be in agreement with the reduction of sodium by nitrogen dressing when no potash is given simultaneously.

But the results outlined in TABLE 4 are not in agreement with the results of the field experiments of the Netherlands Potash Import Company. In the experiments mentioned in TABLE 2 (FIG. 12, 13 and 14) an increase of nitrogen supply from 40 to 80 kg of N/ha caused in the first year (1954) a decrease in the sodium content of all cuts both at high and low potash levels. In the second year (1955), however, the sodium content of the grass was higher with 80 kg of N/ha. The results of the third year are in agreement with those of TABLE 4. In 1956 nitrogen reduced the sodium content when potash had not been applied. With a potash dressing of 80 kg K_2O/ha, nitrogen was, however, found to increase the sodium content in most cases. Seven other trial fields of the Netherlands Potash Import Company showed that an increase of nitrogen supply from 20 to 40 kg of N/ha increased the sodium content of the grass (mean of 1st and 2nd cut) by 0,08 % (TABLE 5). KEMP (1960) states that a heavy nitrogen dressing increases the sodium content of herbage. After comparing the TABLES 2, 4 and 5, we are inclined to conclude that the influence of the nitrogen dressing on the sodium content of grass is uncertain, although in most cases it seems to be positive. The effect of Chilean nitrate as a nitrogenous fertiliser is not considered here, but the effect of the sodium is discussed under 3.4.

3.3. Magnesium fertilisers

It was already mentioned that the sodium content of Westerwolds ryegrass (*Lolium*

TABLE 3. Influence of potash fertilisers on the sodium and potassium contents of grass dressed

Potash fertiliser	1st cut				2nd cut				3rd cut	
	calcium nitrate		Chilean nitrate		calcium nitrate		Chilean nitrate		calcium nitrate	
	K_2O	Na_2O	K_2O	Na_2O	K_2O	Na_2O	K_2O	Na_2O	K_2O	Na_2O
0 kg K_2O/ha	2,94	0,11	2,96	0,28	2,78	0,19	2,78	0,63	4,52	0,18
Potash salt (20 %) [1]	3,23	0,51	2,93	0,36	3,07	0,36	3,24	0,55	4,37	0,18
Potash salt (40 %) [1]	3,06	0,15	3,32	0,27	3,37	0,18	2,65	0,70	4,46	,28
Potash salt (60 %) [1]	3,31	0,13	2,93	0,36	3,23	0,13	3,00	0,69	4,80	0,16

[1] 120 kg K_2O/ha.

TABLE 4. Na_2O-content of grass with and without potash dressing and dressings of 30 and 60 kg of N/ha ammonium-nitrate limestone at varying K-number/sodium-content ratios of a sandy soil (series 68) in percentages

Sandy soils						Clay soils					
15 K-number	0 K_2O/ha		100 K_2O/ha		No. of samples	25 K-number	0 K_2O/ha		100 K_2O/ha		No. of samples
$Na_2O + 6$	30 N	60 N	30 N	60 N		$Na_2O + 14$	30 N	60 N	30 N	60 N	
$\leqslant 20$	0,54	0,41	0,32	0,37	2	$\leqslant 20$	—	—	—	—	—
21—30	0,17	0,17	0,16 [1]	0,20	2	21—30	0,30	0,32	0,22	0,23	4
31—40	0,13	0,11	0,15	0,13	2	31—40	0,11	0,11	0,15	0,13	1
> 40	0,14	0,13	0,11	0,15	2	> 40	—	—	—	—	—

[1] One sample only.

multiflorum var. *westerwoldicum*) depends on the ratio of soluble and exchangeable sodium to potassium, calcium and magnesium in the soil according to the formula $\frac{10 \text{ Na}}{0{,}1 \text{ Ca} + 0{,}2 \text{ Mg} + 2 \text{ K}}$ (in m.eq.) (VAN ITALLIE, 1938). VAN DER PAAUW (personal communication) also found a decrease in the sodium content of beets with an increasing magnesium content of the soil, which was also accompanied by an increase in potassium content. We examined the influence of magnesium dressing on the sodium content of grass, using the series of field trials Exp. 1326 and 71 dressed with and without magnesium, at two levels of potash supply. The results of the series Exp. 1326 are given in TABLE 6, and those of Exp. 71 in TABLE 7.

TABLE 6 shows that a magnesium dressing of 60 kg MgO/ha hardly influences the sodium content of grass.

The experimental series 71 (TABLE 7) shows, however, that at low ratios of K-number to sodium content of the soil, a dressing with magnesium (100 kg MgO/ha) decreases the sodium content of the grass. But this decrease is less pronounced when potash is applied simultaneously. The influence of magnesium is only slight at higher ratios of K-number to sodium content of the soil.

3.4. Sodium fertilisers

Apart from sodium-containing potash fertilisers we have at our disposal Chilean nitrate and sodium chloride. Within the framework of series 68 trial fields were laid down with Chilean nitrate at two nitrogen levels (30 and 60 kg of N).

with calcium nitrate and Chilean nitrate (%)

3rd cut		4th cut				5th cut				Mean			
Chilean nitrate		calcium nitrate		Chilean nitrate		calcium nitrate		Chilean nitrate		calcium nitrate		Chilean nitrate	
K_2O	Na_2O	K_2O	Na_2O	K_2O	Na_2O	K_2O	Na_2O	K_2O	Na_2O	K_2O	Na_2O	K_2O	Na_2O
4,04	0,73	4,23	0,19	3,75	0,63	3,82	0,23	3,82	0,31	3,66	0,18	3,47	0,52
4,24	0,73	4,24	0,20	3,87	0,63	4,16	0,22	3,67	0,40	3,82	0,29	3,59	0,53
3,65	0,66	4,11	0,31	3,98	0,57	3,84	0,26	3,66	0,40	3,77	0,24	3,21	0,52
3,71	0,61	3,72	0,27	3,60	0,59	3,79	0,24	3,75	0,30	3,77	0,19	3,40	0,51

TABLE 8 shows that 200 kg of Chilean nitrate increases the sodium content of grass to a sufficient level, even at a high ratio $\frac{15\ \text{K-number}}{Na_2O + 6}$, whereas in the case of a dressing of 400 kg, the sodium content of the grass is high, even when potash is applied.

To trace the after-effect of a Chilean-nitrate dressing we had at our disposal the trial fields laid down by the Chilean Nitrate Agricultural Service at Wageningen. In these trial fields the sodium content of grass was studied when ammonium-nitrate limestone and Chilean nitrate were applied in spring. On some plots the Chilean nitrate dressing was repeated after the first cut (TABLE 9). This table shows that when nitrogen is given in the form of Chilean nitrate in spring, the sodium content increases up to the fourth cut, but at the end of the year it is about the same as in the case of ammonium-nitrate limestone. The sodium content of the first cut in the following year is hardly increased, even when the Chilean nitrate dressing has been repeated after the first cut in the previous year. We may therefore conclude that the residual effect of Chilean nitrate only lasts for one season.

The Chilean Nitrate Agricultural Service laid down four trial fields to study the value of sodium chloride in comparison with Chilean nitrate. The following treatments were included in these experiments:

1. 60 kg of N/ha in the form of Chilean nitrate in spring (375 kg of Chilean nitrate containing 97 kg Na),
2. 30 kg of N/ha in the form of Chilean nitrate + 30 kg of N as ammonium nitrate limestone in spring,
3. 60 kg of N/ha in the form of ammonium nitrate limestone in spring,
4. 60 kg of N/ha in the form of ammonium nitrate limestone + 250 kg of sodium chloride in spring,
5. 60 kg of N/ha in the form of ammonium nitrate limestone + 125 kg of sodium chloride in spring.

For the later cuts all treatments were dressed with ammonium-nitrate limestone.

TABLE 10 shows the mean values of the four trial fields. It can be seen that the influence of Chilean nitrate on the sodium content of grass is equal to that of an equivalent amount of sodium chloride. The calcium and magnesium contents of grass are also specified in TABLE 10. It can be seen that Chilean nitrate reduces the CaO-content by nearly 0,1 % compared with sodium chloride. VAN ITALLIE (1937) also found on an average a 0,1 % lower CaO-content in the grass with Chilean nitrate than with sodium chloride. This decrease in CaO-content of grass may be favourable in areas

TABLE 5. Na_2O-content of grass dressed with 20 and 40 kg of N/ha in the form of

	40 % Potash-salt application and nitrogen dressings							
	0 kg K_2O				40 kg K_2O			
	20 kg N		40 kg N		20 kg N		40 kg N	
	K_2O	Na_2O	K_2O	Na_2O	K_2O	Na_2O	K_2O	Na_2O
First cut								
Oldeboorn; clay, peaty subsoil	1,31	0,89	1,48	0,89	1,71	0,66	1,64	0,70
Oosterwolde; peat, sandy subsoil	1,99	0,24	1,60	0,35	2,17	0,24	2,10	0,30
Emmen; peat, sandy subsoil	2,04	0,20	2,24	0,28	2,67	0,24	2,87	0,27
Emmen; (kainite)					1,96	0,22	2,45	0,31
Emmen; peat, sandy subsoil	2,82	0,36	2,22	0,35	2,19	0,35	2,55	0,28
Schoonebeek; clayish peat	2,14	0,27	2,42	0,32	2,61	0,22	2,55	0,26
Uitwellingerga; clay, peaty subsoil	1,83	0,46	2,06	0,55	2,35	0,36	2,36	0,40
Oosterhesselen; sandy soil	2,17	0,28	2,07	0,40	2,24	0,27	2,32	0,31
Oosterhesselen; (kainite)					2,34	0,27	2,39	0,44
Second cut								
Oldeboorn; clay, peaty subsoil	1,31	0,70	1,19	0,67	1,98	0,43	1,92	0,61
Oosterwolde; peat, sandy subsoil	2,05	0,24	2,04	0,35	2,64	0,26	2,66	0,31
Emmen; peat, sandy subsoil	2,30	0,23	2,13	0,36	2,36	0,22	2,32	0,32
Emmen; (kainite)					2,89	0,27	2,59	0,39
Emmen; peat, sandy subsoil	2,45	0,47	2,20	0,55	2,76	0,42	3,02	0,51
Schoonebeek; clayish peat	2,47	0,31	2,94	0,34	2,83	0,23	3,13	0,30
Uitwellingerga; clay, peaty subsoil	2,26	0,39	2,34	0,46	2,40	0,30	2,46	0,43
Oosterhesselen; sandy soil	2,40	0,31	2,29	0,55	2,75	0,35	3,05	0,39
Oosterhesselen; (kainite)					2,92	0,34	2,89	0,53

All dressings were repeated for each cut.

where the grass has a high Ca/P-ratio, but it may be unfavourable with grass having a low Ca/P-ratio.

The magnesium content of grass is slightly reduced both by Chilean nitrate and sodium chloride. The reduction is the same in both cases.

The question may arise as to how far the ratios $\frac{15 \text{ K-number}}{Na_2O + 6}$ and $\frac{25 \text{ K-number}}{Na_2O + 14}$ are also indicative when potash and sodium is applied, as these ratios change under the influence of potash and sodium fertilisers. To study this point use can be made of experiments of series 68. In these the K-number and the sodium content of the soil before dressing are known. Some of the plots were fertilised with 100 kg of K_2O per ha in the form of 40 % potash salt and with 200 and 400 kg Chilean nitrate. The K-number of the dressed plots can be calculated by means of the K-number unit [1]. The potash dressing given in the form of 40 % potash salt increased both the K-number and the sodium content of the soil. The sodium content of the plots to which potash was applied was therefore calculated by means of the volume weight and the amount of sodium added (it was assumed that 40 % potash salt contains 18 %, and Chilean nitrate 33,7 % Na_2O). FIG. 15 and 16 show that the treatments with and without potash and sodium are equally scattered around the curve. It is still necessary to know the increase in the sodium content of the soil due to the application of sodium. The

[1] This is the amount of K_2O needed to increase the K-number of the soil by one unit.

ammonium-nitrate limestone at varying potash levels (40 % potash salt) in percentages

60 kg K_2O				80 kg K_2O				Mean			
20 kg N		40 kg N		20 kg N		40 kg N		20 kg N		40 kg N	
K_2O	Na_2O	K_2O	Na_2O	K_2O	Na_2O	K_2O	Na_2O	K_2O	Na_2O	K_2O	Na_2O
1,94	0,66	1,90	0,63	2,06	0,59	1,90	0,65	1,76	0,70	1,73	0,72
2,28	0,24	2,26	0,27	2,35	0,24	2,36	0,30	2,20	0,24	2,08	0,31
2,48	0,27	3,16	0,28	2,34	0,16	2,82	0,27	2,38	0,22	2,77	0,28
				2,35	0,23	2,82	0,31	2,16	0,23	2,64	0,31
2,30	0,36	2,32	0,30	2,52	0,40	2,19	0,34	2,46	0,37	2,32	0,32
2,72	0,19	2,49	0,27	2,78	0,18	2,67	0,23	2,56	0,22	2,53	0,27
2,43	0,35	2,51	0,38	2,31	0,31	2,43	0,35	2,23	0,37	2,34	0,42
2,72	0,27	2,65	0,31	2,86	0,26	2,42	0,27	2,50	0,27	2,37	0,32
				2,63	0,30	2,47	0,38	2,49	0,29	2,43	0,41
2,22	0,49	2,26	0,51	2,05	0,42	2,84	0,46	1,89	0,51	2,05	0,56
2,92	0,23	2,84	0,24	3,14	0,22	3,00	0,28	2,69	0,24	2,64	0,30
2,65	0,22	2,84	0,39	3,06	0,19	2,94	0,34	2,59	0,22	2,56	0,35
2,82	0,36	2,82	0,39	2,90	0,32	2,96	0,36	2,90	0,30	2,78	0,38
				3,07	0,38	3,40	0,40	2,78	0,41	2,86	0,46
3,13	0,22	3,37	0,30	3,10	0,20	3,29	0,26	2,88	0,24	3,18	0,30
2,73	0,26	2,81	0,32	2,73	0,27	2,46	0,34	2,53	0,31	2,52	0,39
3,26	0,32	3,10	0,36	3,29	0,32	3,20	0,35	2,93	0,33	2,91	0,41
				3,43	0,38	3,08	0,47	3,18	0,36	2,99	0,50

calculated sodium content may be too high, giving too low a ratio. This is less important for the K-numbers, since owing to the potash applications recommended in the Netherlands the K-number usually rises to a level at which the influence of K-number on sodium content is nearly constant ($\geqslant 30$). This is clear when FIG. 16 is superimposed on FIG. 10. It can be seen that the curve in FIG. 16 has shifted to the left compared with that in FIG. 10. This is caused by the fact that the calculated value for the sodium content of the soil is too high, thus reducing the ratio to below its actual value. The same is true of sandy soils (*cf.* FIG. 15 with 9), though to a lesser extent.

4. Influence of the botanical composition of grass

As mentioned in the literature cited, several investigators have found differences between the sodium content of grasses, clovers and herbs. The question arises as to whether our results can provide additional support when examined on the basis of the sward components. The botanical composition of the pasture in the Soil-Plant-Animal investigation at Borculo is known and the grasses, clovers and herbs have been sampled separately. But the different species of the three components have not been separated.

In FIG. 17, 18 and 19 the sodium content of grasses, clovers and herbs respectively,

TABLE 6. Na_2O-, K_2O- and MgO-contents of grass with and without magnesium and potash dressings at varying K-number/sodium-content ratios of sandy soils (series Exp. 1326) in percentages

Ratio	0 kg K_2O/ha							200 kg K_2O/ha (60 % potash salt)						
15 K-number	0 kg MgO/ha			60 kg MgO/ha [1]			No. of samples	0 kg MgO/ha			60 kg MgO/ha [1]			No. of samples
$Na_2O + 6$	Na_2O	K_2O	MgO	Na_2O	K_2O	MgO		Na_2O	K_2O	MgO	Na_2O	K_2O	MgO	
⩽ 20	0,37	2,66	0,27	0,35	2,73	0,39	20	0,16	4,10	0,24	0,15	4,24	0,26	20
21—30	0,23	3,10	0,28	0,22	3,12	0,40	28	0,11	4,43	0,26	0,12	4,44	0,29	28
31—40	0,15	4,02	0,24	0,18	3,84	0,36	7	0,10	4,96	0,25	0,10	5,11	0,28	7
> 40	0,15	4,81	0,23	0,13	4,42	0,32	2	0,09	5,39	0,26	0,10	5,45	0,26	2

1 In the form of Epsom salt.

TABLE 7. Na_2O-, K_2O- and MgO-contents of grass with and without magnesium and potash dressings at varying K-number/sodium-content ratios of the soil (series 71) in percentages

Ratio	0 kg MgO/ha							100 kg K_2O/ha (40 % potash salt)						
	0 kg MgO/ha			100 kg MgO/ha [1]			No. of samples	0 kg MgO/ha			100 kg MgO/ha [1]			No. of samples
	Na_2O	K_2O	MgO	Na_2O	K_2O	MgO		Na_2O	K_2O	MgO	Na_2O	K_2O	MgO	
15 K-number / $Na_2O + 6$	Sandy soils													
⩽ 20	0,71	2,02	0,30	0,55	2,20	0,37	2	0,44	2,99	0,27	0,39	3,20	0,32	2
21—30	0,25	2,81	0,29	0,21	2,88	0,39	6	0,21	4,02	0,25	0,20	3,98	0,36	6
31—40	0,21	3,42	0,26	0,22	3,36	0,36	8	0,22	4,18	0,23	0,22	4,23	0,31	8
> 40	0,10	3,42	0,26	0,13	3,72	0,36	6	0,19	4,09	0,23	0,15	3,99	0,32	6
25 K-number / $Na_2O + 14$	Clay soils													
⩽ 20	0,51	2,89	0,33	0,44	2,97	0,37	6	0,39	3,40	0,30	0,38	3,48	0,33	6
21—30	0,35	3,38	0,29	0,33	3,36	0,30	5	0,26	3,88	0,25	0,26	3,96	0,31	5
31—40	0,19	3,84	0,25	0,16	3,93	0,29	7	0,19	4,15	0,25	0,17	4,19	0,29	7
> 40	—	—	—	—	—	—	—	—	—	—	—	—	—	—

1 In the form of kieserite.

TABLE 8. Na_2O-content of grass with Chilean-nitrate and ammonium-nitrate limestone dressings with and without potash at varying K-number/sodium-content ratios in the soil (%)

Sandy soils									Clay soils								
ratio	0 kg K_2O/ha				0 kg K_2O/ha				ratio	100 kg K_2O/ha				100 kg K_2O/ha			
15 K-number	30 N		60 N		30 N		60 N		25 K-number	30 N		60 N		30 N		60 N	
Na_2O + 6	anl	ch	anl	ch	anl	ch	anl	ch	Na_2O + 14	anl	ch	ch	anl	anl	ch	anl	ch
⩽ 20 (2)	0,54	1,13	0,41	1,14	0,32	0,53	0,37	0,90	⩽ 20 (0)	—	—	—	—	—	—	—	—
21—30 (2)	0,17	0,40	0,17	0,74	0,16 [1]	0,34 [1]	0,20	0,59	21—30 (4)	0,30	0,47	0,32	0,76	0,22	0,38	0,23	0,54
31—40 (2)	0,13	0,37	0,11	0,52	0,15	0,29	0,13	0,43	31—40 (1)	0,11	0,19	0,11	0,30	0,15	0,22	0,13	0,32
> 40 (2)	0,14	0,51	0,13	0,82	0,11	0,37	0,15	0,61	> 40 (0)	—	—	—	—	—	—	—	—

1 One sample only. anl = ammonium-nitrate limestone. ch = Chilean nitrate.

TABLE 10. Influence of a Chilean-nitrate and a sodium-chloride dressing in spring on the sodium, calcium and magnesium contents of grass of five successive cuts

Cut	Na_2O-content of grass (%) [1]					CaO-content of grass (%) [1]					MgO-content of grass (%) [1]				
	anl	anl + 1 NaCl	1 ch	½ anl + ½ ch	anl + ½ NaCl	anl	anl + 1 NaCl	1 ch	½ anl + ½ ch	anl + ½ NaCl	anl	anl + 1 NaCl	1 ch	½ anl + ½ ch	anl + ½ NaCl
1st	0,20	0,61	0,61	0,46	0,39	0,75	0,70	0,61	0,65	0,74	0,31	0,27	0,28	0,28	0,28
2nd	0,27	0,67	0,67	0,51	0,48	0,86	0,92	0,79	0,81	0,91	0,31	0,31	0,27	0,31	0,32
3rd	0,30 [2]	0,68 [2]	0,57 [2]	0,46 [2]	0,50 [2]	0,91 [2]	0,93 [2]	0,82 [2]	0,81 [2]	0,92 [2]	0,34 [2]	0,31 [2]	0,31 [2]	0,31 [2]	0,32 [2]
4th	0,25	0,47	0,49	0,39	0,35	0,88	0,85	0,78	0,80	0,79	0,35	0,34	0,33	0,32	0,33
5th	0,14 [3]	0,31 [3]	0,24 [3]	0,20 [3]	0,22 [3]	0,73	0,73	0,68	0,74	0,74	0,37 [3]	0,36 [3]	0,34 [3]	0,38 [3]	0,33 [3]
Mean	0,23	0,55	0,52	0,40	0,39	0,83	0,83	0,73	0,76	0,82	0,34	0,32	0,31	0,32	0,32

1 Mean of 4 experiments. 2 Mean of 3 experiments. 3 Mean of 2 experiments.

1 ch = 375 kg Chilean nitrate (97 kg Na). 1 NaCl = 250 kg (97 kg Na). anl = Ammonium-nitrate limestone.

TABLE 9. Influence of Chilean-nitrate dressing on the sodium content of the grass

Experiment	Ammonium-nitrate limestone in spring and after each cut [1]						Chilean nitrate in spring and ammonium-nitrate limestone after each cut [1]						Chilean nitrate in spring and after first cut; after later cuts ammonium-nitrate limestone [1]				
	successive cuts						successive cuts						successive cuts				
	1st	2nd	3rd	4th	5th	1st of next year	1st	2nd	3rd	4th	5th	1st of next year	2nd	3rd	4th	5th	1st of next year
Silvolde 1957 (sandy soil)	0,08	0,12	0,11	0,18	0,11	—	0,57	0,50	0,18	0,32	0,20	—	0,98	0,47	0,53	0,26	—
Varsseveld 1957 (sandy soil)	0,23	0,19	0,18	0,50	0,50	—	0,67	0,46	0,44	0,50	0,40	—	0,94	0,81	0,71	0,70	—
Zeilberg 1958 (sandy soil)	0,24	0,19	0,23	0,44	0,05	0,15	0,71	0,67	0,66	0,61	0,31	0,24	1,05	0,90	1,16	0,81	0,34
Lochem 1958 (sandy soil)	0,22	0,28	0,19	0,36	0,50	0,04	0,77	0,65	0,23	0,55	0,51	0,05	1,50	0,36	0,65	0,86	0,07
Rhenen 1958 (sandy soil)	0,13	0,10	0,04	—	—	—	0,26	0,23	0,05	—	—	—	0,36	0,10	—	—	—
Ravenstein 1958 (river clay)	0,32	0,39	0,12	0,40	0,49	0,11	0,67	0,47	0,66	0,44	0,34	0,12	0,65	0,44	0,35	0,53	0,12
Moordrecht 1958 (peaty soil)	0,73	0,51	0,89	0,49	1,11	0,35	1,08	0,90	1,01	0,73	1,04	0,36	1,21	1,07	0,74	1,44	0,44
Odoorn 1958 (sandy soil)	0,42	0,46	0,16	—	—	0,23	1,11	0,57	0,40	—	—	0,19	1,01	0,70	—	—	0,18
Gelderingen 1958 (sandy soil)	0,27	0,20	0,26	0,23	0,38	0,07	0,74	0,57	0,59	0,49	0,40	0,11	0,73	0,67	0,59	0,53	0,12
Luchtenveld 1958 (sandy soil)	0,38	0,15	0,18	0,18	0,16	0,04	0,54	0,35	0,24	0,16	0,19	0,09	0,34	0,34	0,16	0,18	0,16
mean	0,30	0,26	0,24	0,35	0,41	0,14	0,71	0,54	0,45	0,48	0,42	0,17	0,88	0,59	0,61	0,66	0,20
Increase by Chilean nitrate							+0,41	+0,28	+0,21	+0,13	+0,01	+0,03	+0,62	+0,35	+0,26	+0,25	+0,06

[1] Dressings of 60, 40, 50, 40 and 40 kg of nitrogen before the 1st, 2nd, 3rd, 4th and 5th cut respectively.

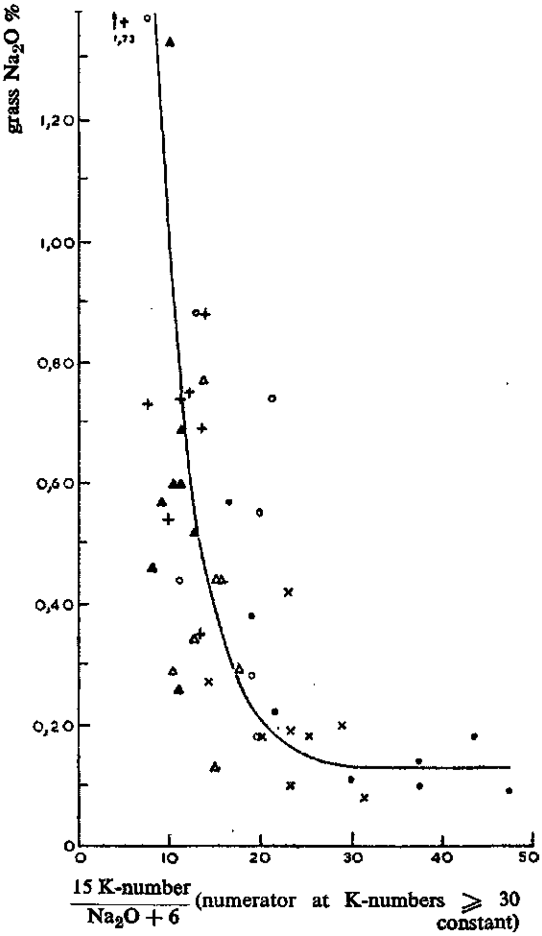


FIG. 15

Relation between the $\frac{\text{15 K-number}}{Na_2O + 6}$ ratio in the soil (numerator at K-number and sodium content of the K-number 30) and the sodium content of grass on sandy soils (K-numbers > 30 is the same as at soil of the dressed plots calculated)

• 0 kg K_2O + 30—60 kg N in the form of anl
o „ + 30 kg N in the form of ch
+ „ + 60 ditto
× 100 kg K_2O + 30—60 kg N in the form of anl
△ „ + 30 kg N in the form of ch
▲ „ + 60 ditto

is plotted against the ratio $\frac{\text{15 K-number}}{Na_2O + 6}$ (numerator at K-number > 30 the same as at K-number 30). The sodium content of the pasture is calculated from the botanical composition and the sodium content of each component and plotted against the ratio (FIG. 20). The sodium content of the three components separately as well as that of the mixture is related to the ratio $\frac{\text{15 K-number}}{Na_2O + 6}$ (FIG. 17—20). The deviations of the dots from the curve are, however, greater for clovers and herbs than for grasses. It

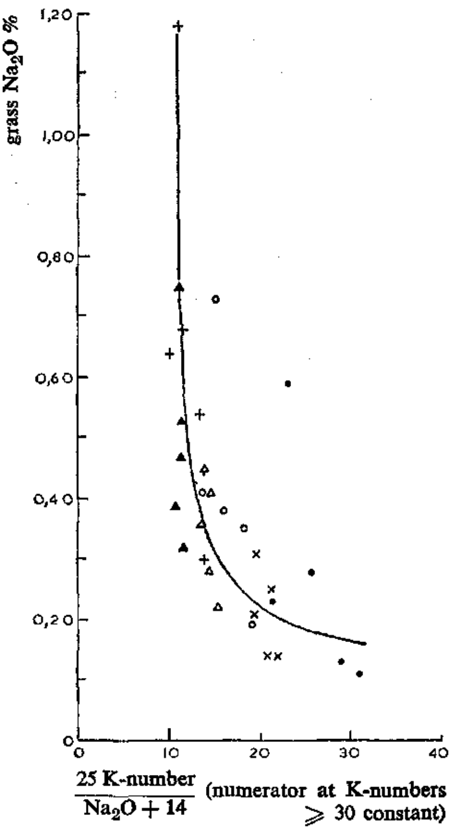


FIG. 16

Relation between the $\frac{25\ \text{K-number}}{\text{Na}_2\text{O} + 14}$ ratio in the soil (numerator at K-numbers > 30 is the same as at K-number 30) and the sodium content of grass on clay soils (K-number and sodium content of the soil of the dressed plots calculated)

- • 0 kg K_2O + 30—60 kg N in the form of anl
- o „ + 30 kg N in the form of ch
- + „ + 60 ditto
- × 100 kg K_2O + 30—60 kg N in the form of anl
- △ „ + 30 kg N in the form of ch
- ▲ „ + 60 ditto

is possible that, especially with herbs, the variation is increased by the presence of different species.

In agreement with the published evidence, herbs appear to have the highest sodium content and grasses the lowest. The differences are greatest at low $\frac{15\ \text{K-number}}{\text{Na}_2\text{O} + 6}$ ratios and decrease with increasing ratios.

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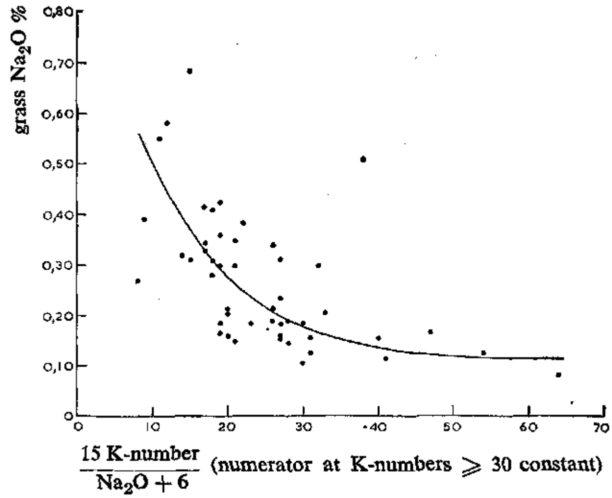

FIG. 17
Relation between the $\frac{15 \text{ K-number}}{Na_2O + 6}$ ratio in the soil (numerator at K-numbers > 30 is the same as at K-number 30) and the sodium content of *grass* on sandy soils

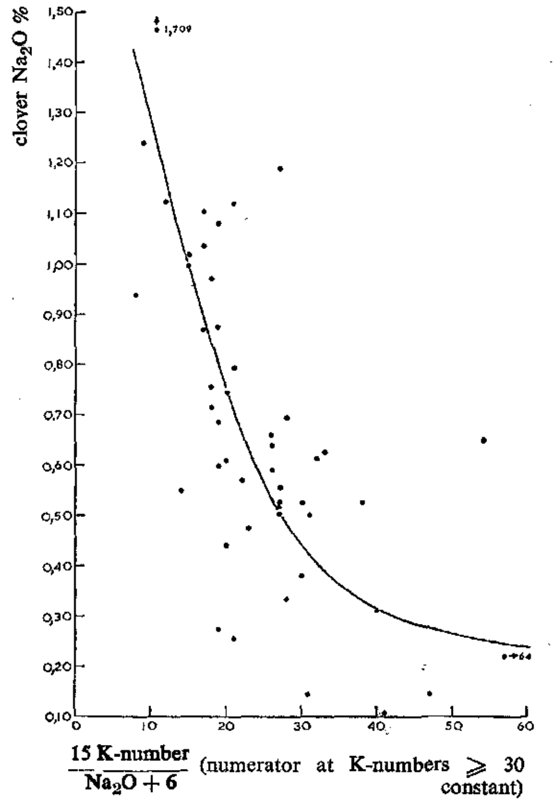

FIG. 18
Relation between the $\frac{15 \text{ K-number}}{Na_2O + 6}$ ratio in the soil (numerator at K-numbers > 30 is the same as at K-number 30) and the sodium content of *clover* on sandy soils

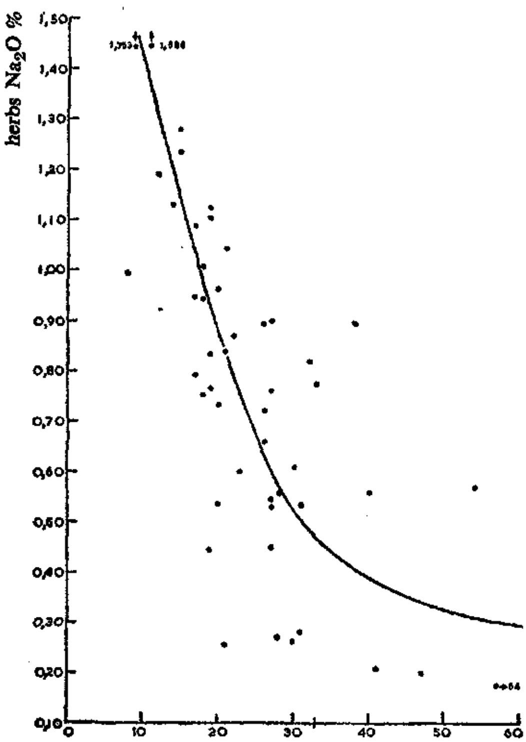

FIG. 19

Relation between the $\frac{15 \text{ K-number}}{Na_2O + 6}$ ratio in the soil (numerator at K-numbers > 30 is the same as at K-number 30) and the sodium content of *herbs* on sandy soils

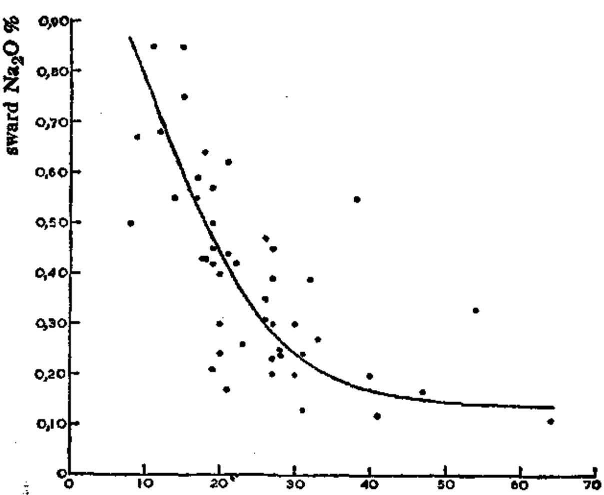

FIG. 20
Relation between the $\frac{15 \text{ K-number}}{Na_20 + 6}$ ratio in the soil (numerator at K-numbers > 30 is the same as at K-number 30) and the sodium content of the *sward* on sandy soils

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