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EFFECT OF FERTILIZERS
ON THE CHEMICAL COMPOSITION OF HERBAGE

DEPARTEMENT
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EINFLUSS DER DÜNGERMITTEL
AUF DIE CHEMISCHE ZUSAMMENSETZUNG
DES GRASBESTANDES

The chemical composition of herbage depends mainly upon the natural fertility of the soil and on the application of stable manure or fertilizers. The botanical composition of the vegetation, the climatic conditions prevailing during the growing season of the grass, and its stage of development when cut, are also of much importance.

The present experiments deal with the effect of nitrogenous, phosphatic, potassic and copper fertilizers on yield and chemical composition of the herbage. In general the results are derived from experimental fields laid out on permanent pastures. In some cases, however, pot experiments with different species of grasses were carried out.

TABLE 1. *Effect of nitrogen dressings on the yield of air-dried grass*

Kg N per ha (per cutting)	Air-dried grass in q ¹ per ha (first cutting)		
	A-plots cut June 16	B-plots cut June 4	C-plots cut May 27
0	26.80	16.30	10.20
20	—	—	14.30
30	—	24.90	—
40	—	—	18.80
60	45.60	32.20	22.40
80	—	—	23.80
90	—	37.50	—
100	—	—	28.60
120	58.80	42.30	30.10
140	—	—	34.80
150	—	47.20	—
180	74.10	47.50	35.20
210	—	53.40	—
240	75.00	54.30	41.10
300	75.50	57.60	40.90
360	77.40	57.10	42.80
420	78.40	58.10	43.20

¹) 1 q = 100 kg.

1. In the first set of experiments the effect of an application of different amounts of nitrogen supplied as nitro-chalk on the yield and composition of the herbage was investigated. The experimental fields were laid out on fertile soils and phosphatic and potassic fertilizers were applied abundantly. The grass was cut two or three times (A-plots), four times (B-plots) and six times (C-series) per season respectively. After every cutting the same amount of nitrogenous fertilizer was given. Table 1 shows the nitrogen dressings and the increasing yields of herbage of the first cut. ¹⁾

The grass of these experimental plots was analysed for a number of nitrogenous compounds. It should be stressed that these determinations have to be carried out with fresh herbage or with material dried quickly at 100 °C. Table 2 shows the effect of slow drying of the grass on its content of some nitrogenous compounds. Due to enzymatic reactions, proteins are readily broken down to amino acids and amides.

TABLE 2. *Effect of treatment of herbage after cutting on its content of some nitrogenous compounds*

Treatment	Total-N ¹⁾	Protein-N ¹⁾	Soluble-N ¹⁾	Ammonia- + Amide-N ¹⁾	NO ₃ -N ¹⁾	α-amino-N ¹⁾
Fresh grass	3.41	2.80	0.57	0.07	0.05	0.07
Dried quickly at 100 °C	3.20	2.65	0.51	0.06	0.05	0.05
1 day at 28 °C, then analysed	3.43	2.35	1.05	0.28	0.04	0.28
3 days at 28 °C, then analysed	3.35	1.86	1.45	0.73	0.04	0.24

¹⁾ In % of dry matter.

Table 3 shows the effect of the nitrogen dressings and of time of cutting grass on the content of crude protein (N % × 6.25) of the herbage of the first cut.

These data and those of other experiments show that an application of a small amount of nitrogen generally decreases the protein content of the herbage. This is partly due to the depression of clovers by application of nitrogenous fertilizers, partly to the higher yield of dry material which tends to lower the nitrogen content. At higher rates of nitrogen dressing, however, the protein content increases considerably. This is particularly true when the grass is cut young.

True protein showed the same trend as total nitrogen, although with high gifts of nitrogen the increase was relatively smaller.

The ammonia content was always very low, even when very high amounts of nitrogenous fertilizers had been supplied (table 4). This is due to the fact that in most plant species ammonia is readily converted into amides like asparagine and glutamine. Only in plant tissues of high acidity can ammonia accumulate without causing serious damage to the plant.

¹⁾ A more extensive report of these experiments will be published in „Verslagen van Landbouwkundige Onderzoekingen”.

TABLE 3. *Effect of nitrogen manuring and stage of growth at which the grass has been cut on the protein content of the grass of the first cut*

Kg of N per ha	Crude protein in % of dry matter		
	Cut on May 27	Cut on June 4	Cut on June 16
0	16.6	13.6	12.0
20	15.9	-	-
30	-	14.5	-
40	16.2	-	-
60	16.7	15.2	11.8
80	18.3	-	-
90	-	18.4	-
100	17.8	-	-
120	19.9	14.9	12.6
140	20.6	-	-
150	-	16.8	-
180	24.8	18.1	14.8
210	-	19.0	-
240	22.2	20.4	15.6
300	27.6	21.4	18.2
360	27.6	23.3	19.6
420	27.8	24.1	18.5

Nitrate, however, can accumulate to high concentrations without causing damage to the plant. The content can rise so much that cattle feeding on the grass may show symptoms of poisoning.

TABLE 4. *Effect of nitrogen manuring on nitrate, amide and ammonia content of the herbage*

Kg of N per ha	Cutting	Nitrate-N ¹⁾	Amide-N ²⁾	Ammonia-N ³⁾
0	C, 1 st	0	-	-
40		0	-	-
80		0	-	-
140		0.02	-	-
300		0.03	-	-
420		0.38	-	-
0	C, 6 th	0.03	0.03	0.03
40		0.11	0.08	0.05
80		0.18	0.03	0.09
140		0.29	0.07	0.05
300		0.32	0.12	0.07
420		0.33	0.14	0.08

¹⁾ In % of dry matter.

²⁾ Total N fixed in amides is twice as high.

2. In a second series of experiments the effect of an application of phosphate and potash on the response of the herbage to different amounts of nitrogen was investigated. Experimental fields were laid out on permanent pastures poor in phosphate and potash. It was shown that both phosphate and potash stimulated the effect of the applied nitrogen considerably.

Comparison of the yield curves at different periods of the season revealed that in spring the response of pasture grass to phosphate was much more pronounced than in summer. The plots with different supplies of potash did not show this result.

The herbage of these experimental plots was analysed for nitrogen, phosphate and potash. Part of the results are shown in table 5.

TABLE 5. Effect of N-, P- and K-dressings to permanent pastures on the chemical composition of the herbage. (Exp. 583, 1 st cut)

Kg N per ha	No potash applied		240 kg of K ₂ O per ha								
	200 kg P ₂ O ₅ /ha		No phosphate applied		80 kg P ₂ O ₅ /ha		200 kg P ₂ O ₅ /ha			600 kg P ₂ O ₅ /ha	
	% N ¹⁾	% K ₂ O ¹⁾	% N	% P ₂ O ₅ ¹⁾	% N	% P ₂ O ₅	% N	% P ₂ O ₅	% K ₂ O	% N	% P ₂ O ₅
0	2.55	1.72	2.60	0.77	2.51	0.81	2.51	0.90	4.27	2.55	1.01
50	2.85	1.29	2.81	0.65	2.50	0.82	2.68	0.97	4.20	2.83	1.06
120	3.34	1.54	3.15	0.73	3.03	0.84	3.01	0.88	4.15	2.97	1.06
190	3.98	1.36	3.60	0.71	3.65	0.91	3.28	0.99	3.87	3.63	1.09
260	4.37	1.61	3.72	0.90	3.10	0.87	3.90	1.07	4.00	3.92	1.24
330	4.89	1.57	4.32	0.86	4.16	0.91	4.30	1.22	4.11	4.09	1.23
400	4.99	1.55	4.36	0.77	4.44	0.90	4.59	1.15	4.04	4.58	1.32

¹⁾ In % of dry matter

These data show that a dressing of potash depressed the nitrogen content of the herbage. The potash content was much more increased by potassic manuring than the phosphate content by applying phosphate.

On the plots well-supplied with phosphate and potash, application of nitrogenous fertilizers increased the phosphate content, whereas the potash content showed a slight drop.

3. With a third series of experiments the influence of time of cutting of the grass upon the effect of application of nitrogenous fertilizers on soil with varying phosphate and potash contents was investigated.

Experimental fields were laid out on permanent pastures on a peat soil and a sandy soil respectively, poor in phosphate and potash. Nitrogen in nitro-chalk was applied at a rate of 60, 160 and 260 kg N per ha. Each nitrogen dressing was repeated on plots with four different phosphate applications (0, 20, 100 and 400 kg of P₂O₅ per ha respectively) and two potash applications (0 and 300 kg of K₂O per ha). Each treatment was repeated on eight plots and the grass was cut at four different stages of growth.

The actual yield curves corresponded with those of the above-mentioned experiments, the highest effect of the nitrogen dressings being obtained on the plots well-supplied with phosphate and potash and with grass of the latest cut.

The herbage of these experimental plots was analysed for nitrogen, phosphate and potash. It was shown that in young grass the nitrogen content increased with the supply of phosphate, whereas a dressing of potash resulted in a lower nitrogen content. When the grass grew older this phosphate-nitrogen relation faded out more or less due to the fact that the yields of the plots applied with phosphate increased much more than those which remained untreated. Fig. 1 shows the nitrogen contents of herbage dressed amply with phosphate and potash.

The phosphate contents increased considerably with the supplies of nitrogen as is shown in fig. 2. This was particularly so with young herbage. In this grass not only the phosphate but also the potash content increased with a higher nitrogen supply (fig. 3).

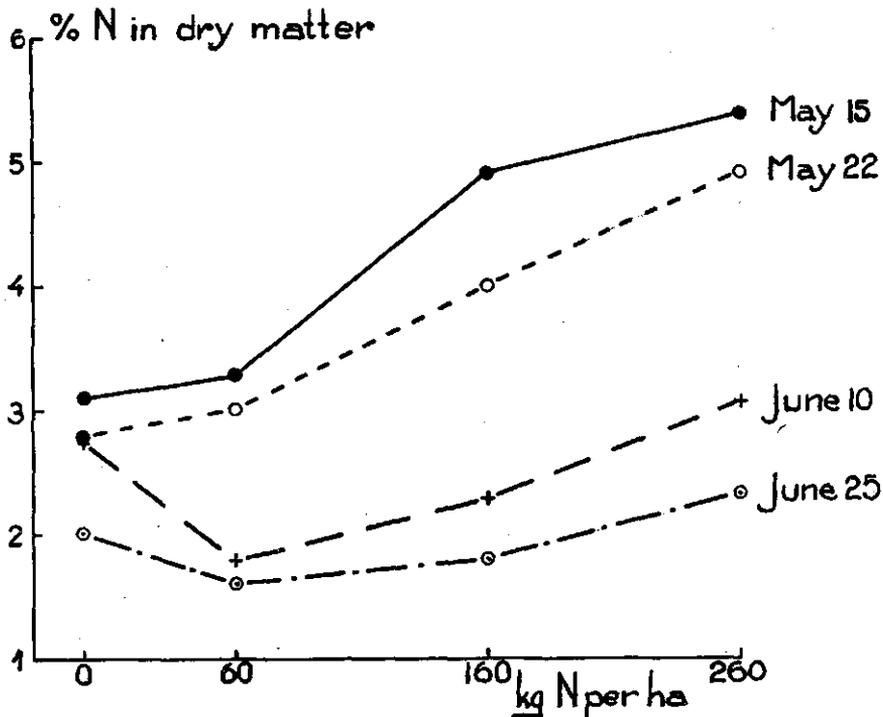


Fig. 1 Effect of nitrogen applications on the N-content of herbage, dressed amply with phosphate and potash.

4. RELATION OF COPPER AND NITROGEN IN GRASSES

On many sandy and peat soils in Holland and other countries of Western Europe cereal crops respond to applications of copper. A favourable effect of copper on pasture grasses, however, has been found only sporadically. The copper content of grasses growing on these soils, although high enough to secure normal plant growth, is too low to supply cattle, fed with this kind of herbage, with an adequate amount of copper. As a result cases of deficiency diseases in cattle which can be prevented or cured by giving small doses of copper salts are rather frequent on these soils.

Results of an experiment with wheat plants showed a relation between copper and nitrogen nutrition. Plants growing on soil supplied with large quantities of nitrogen needed much more copper than those supplied with small quantities.

This experiment was repeated with two pasture grasses viz. *Lolium perenne* and *Lolium italicum* var. *Westerwoldicum*. Although slight differences were noticeable between the plants growing with high amounts of nitrogen, whether supplied with copper or not, the yields of dried matter, were practically not effected by the copper.

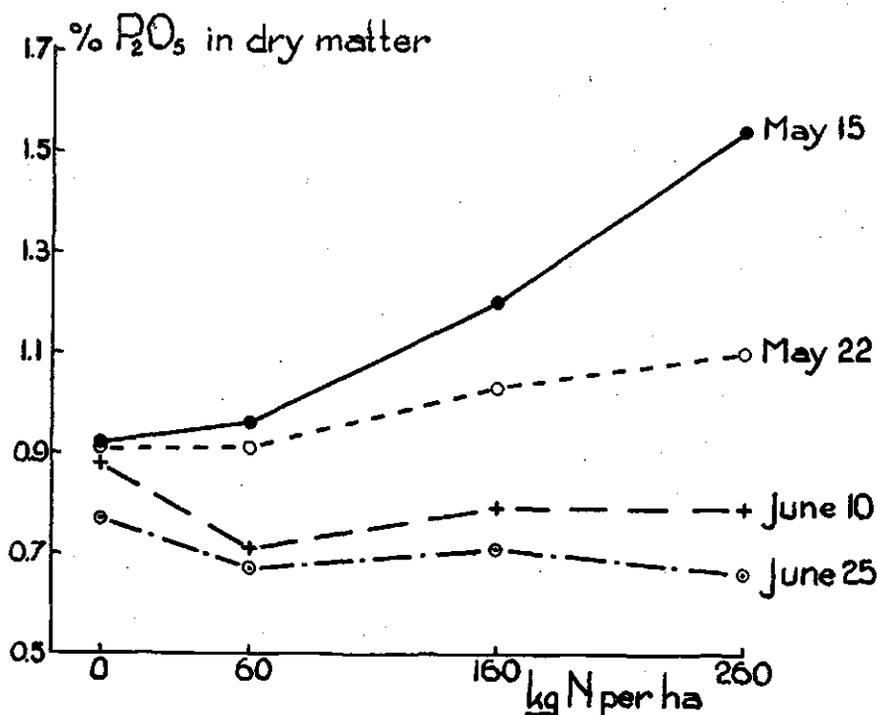


Fig. 2 Effect of nitrogen applications on the P-content of herbage, dressed amply with phosphate and potash.

Under the influence of the nitrogen supply, however, considerable differences in copper content were found, as is shown in table 6.

TABLE 6. Effect of nitrogen and copper dressings on the copper content ¹⁾ of *Lolium perenne* grown on a copper-deficient soil (cut at the hay stage)

NH ₄ NO ₃ g per pot	No copper supplied	5 mg CuSO ₄ per pot	20 mg CuSO ₄ per pot	50 mg CuSO ₄ per pot	200 mg CuSO ₄ per pot
0.5	8.8	9.0	6.6	7.1	13.1
1	6.8	7.2	7.3	8.7	9.3
2	6.0	8.0	7.3	6.8	7.8
4	4.2	5.2	6.0	7.1	11.5

¹⁾ mg per kg of dry matter.

From these results it can be concluded that application of copper salts to pastures on copper-deficient soils is advisable particularly when nitrogenous fertilizers are supplied.

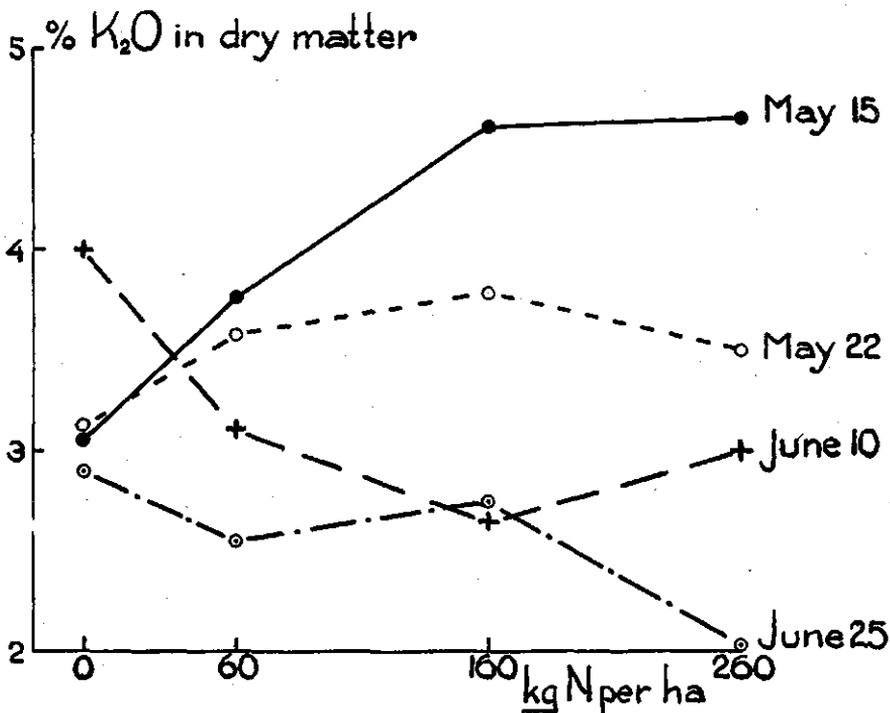


Fig. 3 Effect of nitrogen applications on the K-content of herbage, dressed amply with phosphate and potash.

ZUSAMMENFASSUNG

Es wurde der Einfluss von Stickstoff-, Phosphorsäure-, Kalium- und Kupferdüngungen auf Ertrag und chemische Zusammensetzung von Gras auf Versuchsfeldern untersucht.

Der erste Versuch befasste sich mit gestaffelten Stickstoffgaben auf Grasland und drei verschiedenen Schnittzeiten des Grases (Tab. 1). Das Gras dieser Versuche wurde analysiert auf einige Stickstoffverbindungen. Es wird darauf hingewiesen, dass für diese Analysen frische oder rasch getrocknete Grasproben benutzt werden müssen. Tab. 2 zeigt den Einfluss kurzfristiger Aufbewahrung frischer Grasproben auf den Gehalt an einigen Stickstoffverbindungen.

Tab. 3 zeigt Gehalte an Roheiweisz, Tab. 4 Gehalte an Nitrat-, Amide- und Ammoniak-Stickstoff im Gras dieser Versuche.

In einer zweiten Versuchsreihe wurde der Einfluss von Phosphat und Kali auf die Wirkung gestaffelter Stickstoffgaben auf Grasland studiert. Das Gras wurde analysiert auf Stickstoff, Phosphorsäure und Kali. Diese Gehalte sind zum Teil in der Tabelle 5 enthalten. Eine Kalidüngung hat den Stickstoffgehalt im Pflanzenmaterial herabgesetzt. Eine Düngung mit Kalisalzen hat den Kaligehalt bedeutend mehr erhöht als eine Phosphatdüngung den Phosphorsäuregehalt. Auf gut mit P und K gedüngten Parzellen hat eine Stickstoffdüngung den Phosphatgehalt des Grases erhöht, den Kaligehalt hingegen herabgesetzt.

In einer dritten Versuchsreihe wurde der Einfluss verschiedener Schnittzeiten des Grases auf die Stickstoffwirkung in Abhängigkeit von Phosphat- und Kalidüngung untersucht. Auch in diesem Versuche wurden viele N-, P- und K-Bestimmungen ausgeführt. Beim jungen Gras erhöhte eine Phosphatdüngung nicht nur den Phosphorsäuregehalt, sondern auch den Stickstoffgehalt; eine Kalidüngung dagegen setzte den Stickstoffgehalt herab. Fig. 1, 2 und 3 zeigen den Einfluss von gestaffelten Stickstoffgaben auf den Gehalt des Grases an N, P und K.

In einem Gefäßversuch mit kupferarmem Boden wurde der Einfluss von gestaffelten Stickstoff- und Kupferdüngungen auf den Kupfergehalt von *Lolium perenne* ermittelt (Tab. 6).