Annales Agriculturae Fenniae

Maatalouden tutkimuskeskuksen aikakauskirja

Vol. 9, 5

Journal of the Agricultural Research Centre

Helsinki 1970

ANNALES AGRICULTURAE FENNIAE

Maatalouden tutkimuskeskuksen aikakauskirja
Journal of the Agricultural Research Centre

Ilmestyy 4—6 numeroa vuodessa; ajoittain lisänidoksia
Issued as 4—6 numbers yearly and occasional supplements

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ANNALES AGRICULTURAE FENNIAE, VOL. 9: 315—324 (1970)

Seria ANIMALIA NOCENTIA N. 47 — Sarja TUHOELÄIMET n:o 47

ECOLOGY AND FLUCTUATIONS IN ABUNDANCE OF MEGADELPHAX SORDIDULA (STÅL) (HOM., DELPHACIDAE)

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Received October 9, 1969

Many reports have been published on the ecology and the dimorphism of *Megadelphax sordidula* (e.g. SAHLBERG 1871, KONTKANEN 1950 a, 1950 b, 1952, 1954, LINNAVUORI 1952, MARCHAND 1953, RAATIKAINEN 1960, 1961, JÜRISOO 1964), and distribution of the species is fairly well known (e.g. METCALF 1943). It has been shown to spread Phleum green stripe virus (PGSV) to wheat, oats and timothy, and the saliva also has a slightly toxic effect on the height and grain yield of cereals (NUORTEVA 1962, p. 19, HEIKINHEIMO, unpublished). The species is known to be a pest and, consequently, the ecology and population dynamics of the species were investigated in connection with studies on virus vectors. Concurrently, there was an opportunity to compare fluctuations in abundance of *M. sordidula* populations found close to their northern limit with those of *Javesella pellucida* (F.) populations found in their optimum region.

Material and methods

The field studies were carried out in 1956—1964 in six communes east of the city of Vaasa in western Finland, comprising some 1 700 km². Material was also gathered elsewhere in Finland. A detailed description of the main area has been published previously (RAATIKAINEN 1967). The same publication describes, or refers to other publications describing, the method, equipments and material employed in the present study.

Results

Distribution

According to the literature, samples in museums and collections made by the Department of Pest Investigation, *M. sordidula* has so far been found in southern and central Finland (Fig. 1). In order to investigate the abundance in different areas, netting samples consisting of 60 sweeps made between 23 May and 7 June 1959, were taken from 55 first-year leys established under cereals between longitudes 21 and 25 in western Finland. The abundance appears in the following table:

Latitude	Samples with nymphs/ All samples	Nymphs/ 60 sweeps
<62	10/19	4.6
62—63	3/18	0.2
>63	1/18	0.1

This material shows that *M. sordidula* occurs most frequently and most abundantly in southern Finland, and that the species becomes rarer and

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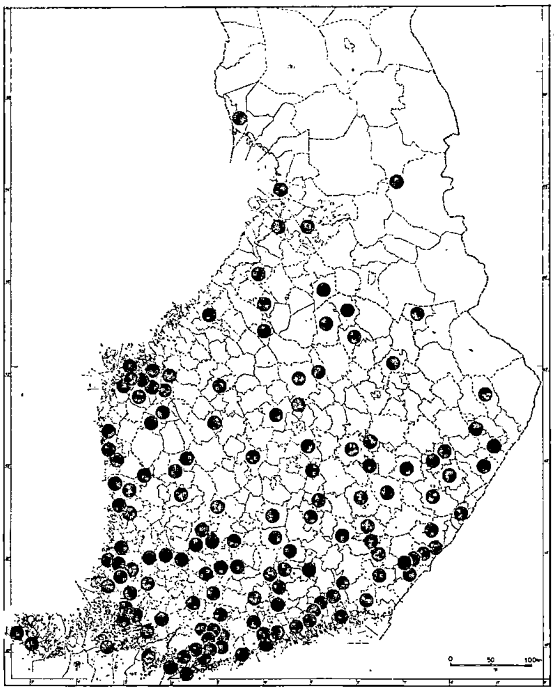

Fig. 1. Known localities of *M. sordidula* in Finland.

less abundant towards the north. The same thing is shown in Fig. 1, where the material was fairly evenly distributed over the different parts of the main area of cereal cultivation in Finland.

Overwintering

The univoltine *M. sordidula* hibernates usually in nymphal instars II and III in leys, ditches, grass verges, meadows and similar places where perennial grasses grow. It was not found among winter cereals. In 1959, 56.3 per cent of the land in the communes of the research area consisted of forest, 33.6 per cent of arable land, 8.1 of waste land, 0.6 of cleared pastures, 0.5 of natural meadows and 1.0 per cent of land in other use (ANON. 1962). Leys covered 18.4 per cent of the whole area, and cereals 11.9. As 80 per cent of the fields were open-ditched, roughly one-tenth of the field area consisted of ditch verges. The density of nymphs was highest in old leys (RAATIKAINEN 1960) and ditch verges. For instance, the suction samples taken on 6—9 May 1962 (6×0.1 m^2 each) showed an average of 1.8 nymphs per square metre from 14 first-year leys established under cereal. Near these leys, 6.9 nymphs/m^2 ($F = 2.54$, $P > 0.05$) were obtained from ditch verges around fields where spring cereals had been cultivated the previous year. Thus, verges are comparable to leys as hibernation and reproduction sites for *M. sordidula*. Probably more than one half of the *M. sordidula* spend the winter in leys, chiefly in old leys, perhaps one-tenth in ditch verges, and the remainder mainly in waste land, meadows and pastures, while some hibernates in forests and peat-covered areas. In hibernation sites the nymphs usually live during autumn and spring on grasses, which serve as their chief food plant (RAATIKAINEN 1960).

Migration

In fields, *M. sordidula* remained over the winter in leys, verges and cereal fields. The cereal fields where leys were not established (roughly three-fifths of the total) were, however, ploughed in autumn. Most of the nymphs were then destroyed, and only a few moved to the ditch verges or hibernated in the ploughed area, where they got nutrition from the sparse weeds. On 6—9 May 1962, for instance, samples of 6×0.1 m^2 were taken from 14 fields that had been under spring cereal the previous year and had been ploughed during the autumn, and from the ditch verges of these fields. Not a single *M. sordidula* was obtained from these fields, while a total of 58 nymphs were obtained from 11 verges. No *M. sordidula* were found after the preparation of seed-beds on the ploughed fields in the spring. In spring 1961 oats were sown on two fields of this type, with underground drainage. Adjacent

Table 1. Number of *M. sordidula* per 1 440 sweeps at different distances from verge of oat fields.

	Distance from the border of the ley and oat field, in metres					
	Leys	Oats				
	5	5	15	25	35	45
Nymphs	45	0	0	0	0	0
Brachypters	196	1	2	3	0	0
Macropters	768	165	176	127	123	111

to each of these fields was a timothy ley, with *M. sordidula* nymphs. On 14 June and 1 and 17 July, netting samples were taken from the timothy leys at a distance of 5 metres from the oats. The netting samples from the oats were taken at distances of 5, 15, 25, 35 and 45 metres from the border between the timothy and the oats. The samples taken from the two places and at different times were combined.

The results (Table 1) show that there is no general movement of nymphs to oats. Other observations show that there were nymphs in the oats and also in other spring cereals a few metres from the edge of the field. They were always very few, however, and always at the edge of the field. Neither were there many brachypterous specimens in the spring cereals, although these were nevertheless more frequent than nymphs and also approached the centre of the field more closely than the nymphs. The results in Table 2 suggest the same thing, although they do not suffice to prove the point. Most of the brachypterous specimens, however, remained in the leys.

Macropterous specimens, which fly about, occurred in roughly equal density at all distances investigated from the edges of the fields, but many of these, too, also remained in the leys. Although a fairly high percentage of the adults in the cultivated areas were brachypters, these occurred very sparsely in the cereal fields. For instance, in the material shown in Table 6, taken at the end of the nymphal period, all the specimens were adults, and, of the 907 specimens obtained from the oat fields, only 0.6 per cent were brachypters, while, of the 461 taken from the wheat fields, 0.4 per cent were brachypters.

Netting apparatus was used in three localities to investigate the migration of macropterous specimens. As the materials obtained were very small and similar, they were combined to give an overall picture. The results (Fig. 2) show that in 1957—1964 migrations began, on average, on 20th June, though the initial date varied a great deal from year to year. The higher the sum of daily temperatures in the spring and early summer preceding the migration season, the earlier migration began. The date also seems to have

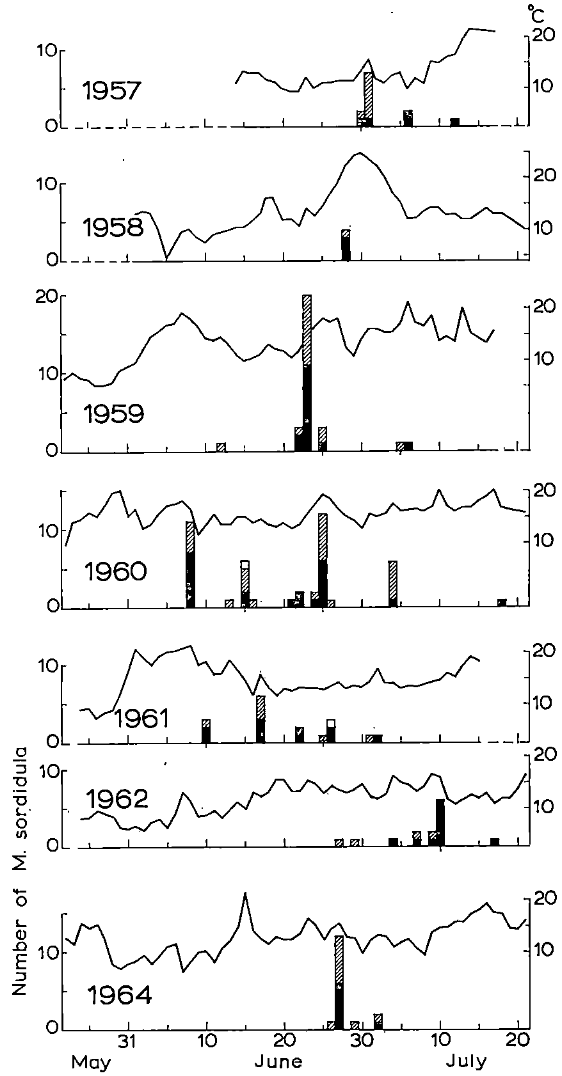

Fig. 2. Migration of macropterous *M. sordidula* in 1957—1964, according to material collected with netting apparatus. The solid part of abscissa axis shows the period during which observations were made, while the dashed part indicates that no observations were made. Black part of columns = numbers of females, hatched part = numbers of males, and white part = numbers of *Dicondylus helleni* parasitized females.

been affected by the sum of temperatures in the late summer of the preceding year, for the nymphs reached a later nymphal instar when the temperature of the late summer was high than when it was low. Migration was liveliest on warm days, and probably continued for about a month or even longer.

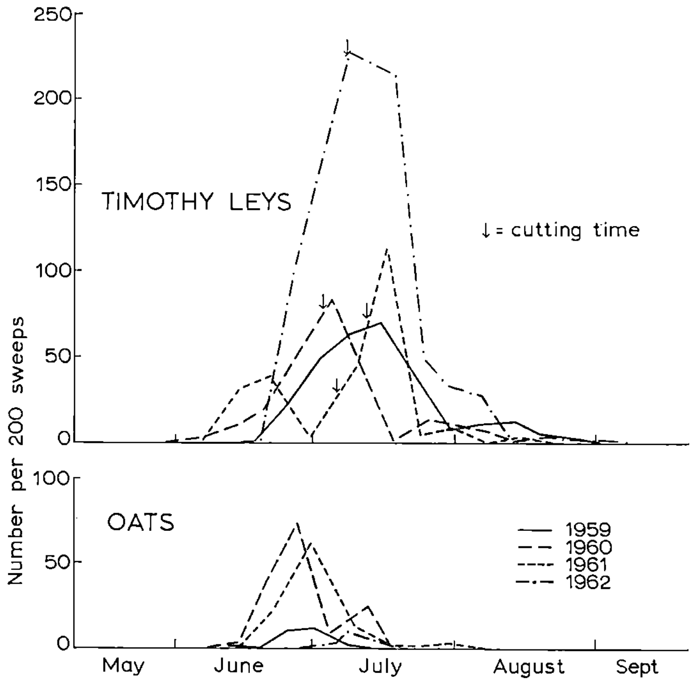

Fig. 3. Numbers of *M. sordidula* adults in netting samples taken in first-year timothy leys established under spring cereals and oats.

Occurrence of adults

In the leys, where most of the adults lived, the adults occurred for some 2.5—3 months (Fig. 3). In the early and middle period of adult emergence, while there was still no noteworthy migration of the macropters, the proportion of brachypters was still fairly low in the leys, but by the end of the migration season the proportion was roughly twice as high (Table 2). Migration began before and continued after hay making. The macropters migrated to spring cereals, winter cereals and, to some extent, also leys. At the end of migration period, between 27 June and 1 July 1960, netting samples (each consisting of 200 sweeps) were taken from different cereals in seven localities. These samples contained the following numbers of *M. sordidula* adults per 200 sweeps:

Oats	85	Spring wheat	44
Barley	57	Rye	9

F = 4.83*. Smallest significant difference, 42 specimens

Table 2. Proportion of brachypterous *M. sordidula* in weekly netting samples taken from first-year leys in 1961 and 1962. The samples for both years were grouped into three consecutive groups of approximately equal size.

Group	Sampling period	Total adults	Brachypters %	χ^2
1.	14.—21. 6. 1961	69	15	—
2.	30. 6.—10. 7. 1961	47	36	9.64**
3.	17. 7.—14. 8. 1961	130	29	4.45*
1.	19. 6.— 6. 7. 1962	179	16	—
2.	8. 7. 1962	228	38	26.00**
3.	19. 7.— 3. 9. 1962	336	38	29.00***

On spring cereals, the females laid their eggs chiefly in the stems, but also in the leaves. In tests carried out under gauze cylinders 98.9 per cent of the 1 976 eggs of *M. sordidula* were found in the stems of oats, and the remainder in the leaves. The egg-laying period lasted for several weeks, and the females laid several clutches a day. They changed plants many times during the oviposition period. No adults were found on oats or other spring cereals later than six weeks after migration. A great proportion of them died, and when the spring cereals had grown the population was sparse and it was difficult to get adults from a sweep. The leys were short after haymaking, however, and it was easier to obtain specimens there, even late in the summer.

Variations in abundance

V a r i a t i o n s i n s p a t i a l a b u n d a n c e. There was considerable variation in abundance of *M. sordidula* from region to region. The density was highest in warm fields, on mineral soil, adjacent to the rivers. The species was less abundant in fields on peat soils. On mineral soils, too, there was a considerable variation in density. The densities were highest in areas where rather a lot of timothy was cultivated, and low on areas with underground drainage, used exclusively for cereal growing.

F l u c t u a t i o n. Counts of *M. sordidula* were made at five different times during the year. From 15 April to 21 May each spring, suction samples were taken from first-year leys (see RAATIKAINEN 1967, p. 129) (Table 3 and Fig. 4 A). From 5 May to 18 June, early each summer, netting samples were taken of the nymphs in first-year leys, slightly before the occurrence of the first adults (op. cit., p. 129) (Table 4 and Fig. 4 B). During the migration seasons, in June and July, macropterous specimens were caught in three different localities by means of netting apparatus (op. cit. p. 33) (Table 5 and Fig. 4 C). In the middle of the migration season, i.e. from 23 June to 7 July, netting samples were taken of the *M. sordidula* adults in oats and spring wheat (op. cit. pp. 126—127) (Table 6 and Figs 4 D, 4 E). From 3 to 26 October each autumn, before the arrival of the permanent snow cover, suction samples of nymphs were taken from the stubble fields of spring cereal which were sown with timothy (op. cit. p. 128) (Table 3 and Fig. 4 F).

Table 3. Number of *M. sordidula* in suction samples taken in autumn from spring cereal stubbles undergrown with timothy and in spring in first-year timothy leys established under spring cereals.

Year	Number of fields	In autumn			In spring		
		No.	No./m²	% of delphacid nymphs	No.	No./m²	% of delphacid nymphs
1958	7	0	0	0	0	0	0
1959	7	2	1.0	0.1	3	1.4	0.4
1960	7	?	?	?	0	0	0
1961	20	91	15.2	2.6	54	9.0	9.8
1962	20	0	0	0	11	1.8	0.8
1963	20	1	0.2	0.0	1	0.2	0.1
1964	20	0	0	0	2	0.3	0.1

Table 4. Number of *M. sordidula* in first-year timothy leys established under spring cereals. In 1958 60 net sweeps were made in each field, in the other years 200 sweeps. Examinations made May 5.—June 18.

Year	No. of fields	Nymphs			Adults No.
		No.	No./200 sweeps	% of delphacid nymphs	
1958	20	2	0.3	0.1	0
1959	20	2	0.1	0.0	0
1960	17	102	6.0	2.1	0
1961	20	832	41.6	17.5	3
1962	20	12	0.6	0.7	0
1963	20	0	0.0	0.0	0
1964	20	9	0.5	0.1	0

Table 5. Number of males, females and parasitized specimens of *M. sordidula* in samples taken with three sets of netting apparatus.

Year	Males	Females	Females parasitized by *D. helleni*	Total
1957	7	5	0	12
1958	1	3	0	4
1959	14	15	0	29
1960	22	21	1	44
1961	7	9	1	17
1962	4	10	0	14
1963	0	0	0	0
1964	9	7	0	16

Table 6. Abundance of *M. sordidula* and *M. sordidula* parasitized by *D. helleni* and *E. tenuicornis* in oats and spring wheat. Examinations made June 23.—July 7. In 1959 and 1960 200 net sweeps were made in each field, in the other years 60 sweeps.

Year	No. of fields	*M. sordidula*		No. per 60 sweeps	*M. sordidula* parasitized by *D. helleni*		*M. sordidula* parasitized by *E. tenuicornis*	
		No.	% of delphacids		No.	% of *M. sordidula*	No.	% of *M. sordidula*
Oats								
1958	7	1	0.1	0.1	0	0	0	0
1959	10	39	0.7	1.2	2	5	0	0
1960	13	762	15.8	17.6	41	5	1	0
1961	20	49	6.6	2.5	7	14	0	0
1962	20	28	1.5	1.4	0	0	0	0
1963	20	7	0.3	0.4	0	0	0	0
1964	20	21	2.0	1.1	1	5	0	0
Spring wheat								
1958	5	1	0.1	0.2	0	0	0	0
1960	8	310	18.4	11.6	14	5	0	0
1961	20	93	10.0	4.7	12	13	0	0
1962	20	28	1.7	1.4	1	4	1	4
1963	20	5	0.3	0.3	0	0	0	0
1964	20	24	1.6	1.2	0	0	0	0

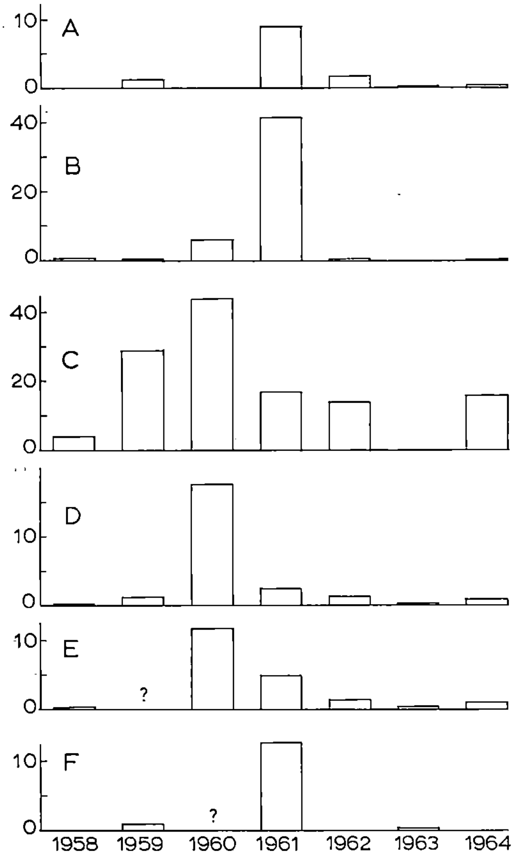

Fig. 4. Numbers of *M. sordidula* in 1958—1964. A = numbers of nymphs in spring in first-year leys per 1 m², B = nymphs in late May and early June in first-year leys per 200 net sweeps, C = migrating macropters per three sets of netting apparatus, D = adults in late June and early July in oats per 60 net sweeps, E = adults in late June and early July in spring wheat per 60 net sweeps, and F = nymphs in autumn in spring cereal stubbles per 1 m².

It appears from Tables 3—6 and Fig. 4 that there was little *M. sordidula* in 1958. Some specimens were found in the suction samples in the spring of 1959, and that summer the number of macropterous migrating specimens obtained was above average. A greater number than during the previous summer was also obtained in oat fields. In the following year the number of migrating specimens was highest, as were the numbers obtained from oats and wheat. By summer 1961, incidence was already slightly lower. In this latter year, a great number of specimens were nevertheless obtained in the suction samples in spring, but 69 per cent came from two samples taken close to each other. 72 per cent of the nymphs in nymphal samples netted early that summer came from a single sample. Thus, while the standard deviation was great, there was no increase in the frequency. Subsequently, the frequency of *M. sordidula* seems to have declined until 1963, after which it rose slightly again.

Resons for variations in abundance

F o o d was plentiful every year. During the dry and warm summer of 1959 cereals ripened earlier than usual, and the aftermath of timothy was very sparse and short. This, however, caused no catastrophic mortality. On the contrary, the number of *M. sordidula* reached maximum the following year.

F a r m i n g m e a s u r e s have a considerable effect on the abundance of this species. One of the most important factors affecting the fluctuation was the extensive ploughing of leys, which was a failure on account of the drought, throughout the autumn of 1959 and the following spring, during which an exceptionally high number of *M. sordidula* was destroyed.

In spring 1959 the aphid *Rhopalosiphum padi* (L.) occurred in great abundance, and at that time 22—35 per cent of the oat fields, 14—31 per cent of the barley fields and 7—9 per cent of the spring wheat fields were treated with insecticides towards the end of the *M. sordidula* migration period (Raatikainen and Tinnilä 1961). These insecticides were also effective against *M. sordidula*. Roughly 5 per cent of the *M. sordidula* habitats in the fields were treated. The effects of breaking-up the leys and the use of insecticides were small, however, and other factors tending to increase the population were so powerful that density increased.

B i o t i c f a c t o r s. *M. sordidula* eggs laid in stems are eaten by *Panstenon oxylus* (Walk.) (*Hym.*, *Pteromalidae*) and probably also by *Mesopolobus aequus* (Walk.) of the same family. Eggs in the leaves, and very occasionally those in the stems also, are destroyed by *Anagrus atomus* (L.) (*Hym.*, *Mymaridae*). Although pteromalids may destroy about half the *M. sordidula* eggs on cereals, they did not seem to have caused the variation established but rather to have levelled in out (see RAATIKAINEN 1967, p. 78). Only a very small proportion of *M. sordidula* eggs occur in the leaves even during years that are dry and badly plagued with oat sterile dwarf virus, and, consequently, the fluctuation could not have been caused by *A. atomus* either.

Delphacids parasitized by *Dicondylus helleni* Raat. (*Hym.*, *Dryinidae*) are unable to reproduce. The proportion of *M. sordidula* parasitized by this dryinid was very small in 1957—1958, and not very large even in 1959, according to numerous collections made in various parts of the research area (see also Tables 5 and 6 and RAATIKAINEN 1960 and 1961). The scarcity of this dryinid favoured an increasing density of *M. sordidula*, while, following upon this period of great abundance, the number of *D. helleni* tended to decrease the density of *M. sordidula* (Tables 5 and 6), but this was not the most important factor.

Elenchus tenuicornis (Kirby) (*Strepsiptera*, *Elenchidae*) also parasitized *M. sordidula*, although its main host was *Javesella pellucida* (F.) and it occurred sparsely in *M. sordidula* in each of the years covered by the study (Tables 5 and 6) and thus had hardly any effect on the fluctuation of this delphacid. It was most abundant in a netting sample taken from a first-year timothy ley on 19 July 1962, in which 4 per cent of the 215 adults were parasitized by it.

Nymphs and adults of *M. sordidula* are parasitized by *Erythraeus* (*Achorolophus*) *gracilipes* (Kramer) (*Acar.*, *Erythraeidae*) and probably also by some other similar mite. Trials revealed that 7 out of the 17 nymphs parasitized by the mite, and 15 out of 17 mite-free nymphs achieved adulthood. The difference is not a significant one, but it is apparent that mite-infested *M. sordidula* specimens usually die in the nymphal stage as do those of *Javesella pellucida* (see RAATIKAINEN 1967). *M. sordidula* parasitized by mites occurred particularly on old leys. The proportion infested varied considerably in the different years, but so little material was obtained on *M. sordidula*

Table 7. Frequency of *M. sordidula* nymphs parasitized by mites in first-year leys. Examinations made May 20.—June 5.

Year	No. of fields	Total	Nymphs Parasitized by mites	
			No.	%
1958	6	1	0	0
1959	6	0	0	—
1960	8	15	1	7
1961	11	455	10	2
1962	13	64	1	2
1963	7	4	0	0
1964	18	1	0	0

(Table 7) that the fluctuation in abundance of mites could not be investigated. It was, however, possible to investigate its fluctuation in abundance in *Javesella pellucida* (see RAATIKAINEN 1967, p. 114), and this material reveals that the proportion of *J. pellucida* parasitized by mites was small when the number of *M. sordidula* was on the increase and great when it was on the decrease. Thus the mites obviously had an effect on the fluctuation in abundance of *M. sordidula*, but they were not a chief factor either.

The effect of other biotic factors such as spiders and birds on the fluctuation in abundance of *M. sordidula* was also very small.

W e a t h e r f a c t o r s. Temperature and relative atmospheric humidity varied considerably from one research year to another. When the density of *M. sordidula* began to rise, in 1958, the summer was dry. The autumn, winter and following spring were exceptionally warm except for December and January, which were cold, but the snow cover was almost 100 per cent thicker than normal at that time, so that the cold could not be felt at the surface of the ground where the nymphs pass the winter. In 1959 the summer was exceptionally dry, and average temperatures were higher than usual, apart from September. Winter seems to be a critical period for *M. sordidula*. According to the suction samples taken every autumn and spring from 1956 to 1964, there were 95 nymphs of *M. sordidula* in the 81 suction samples (each 3 × 0.10 m²), taken in autumn and 17 in the samples taken from the same places in spring. In the winter seasons the mortality was consequently 82 per cent. In the same samples there were 14 690 *Javesella* nymphs in autumn and 6 932 in spring, giving a mortality of 53 per cent. When the population of *M. sordidula* declined in the winter 1960—1961, the autumn had been extremely cool and wet. The snow cover disappeared two months earlier than usual, and the nymphs were exposed to the hazards of the weather as early as late winter. In winter 1961—1962, too, there was a considerable decline in density. A hibernation experiment was then set up in the field. In the autumn 440 nymphs were placed in small cages; 90 per cent of them died during the winter. In suction samples taken from 20 fields there were 91 nymphs in that same autumn, but only 11 in the spring, showing a mortality rate of 88 per cent. The experiment also covered nymphs of *Javesella pellucida*, but only 56 per cent of the 1 985 placed in cages in the autumn died during the winter. In the above suction samples there were 3 204 *Javesella* nymphs in the autumn, but only 1 267 in the spring, which makes the mortality rate 60 per cent. Thus, in all the above cases the winter mortality rate of *M. sordidula* was higher than that of *Javesella pellucida*. Weather was probably the major factor controlling the fluctuations in abundance, while some enemies, whose abundance is also controlled by weather factors, also had an effect on fluctuations in abundance.

Discussion

M. sordidula is a virus vector, and its ability to transmit virus is consequently a question of primary interest. However, cereals infected with PGSV do not seem to be anywhere near as common as cereals infected with the oats sterile dwarf virus (OSDV), transmitted e.g. by *Javesella pellucida*, *Javesella obscurella* (Boh.) and *Dicranotropis hamata* (Boh.), or the European wheat striate mosaic virus (EWSMV) transmitted by *J. pellucida*, *J. obscurella* and *J. dubia* (Kbm.) (Raatikainen 1970).

The number of progeny of *M. sordidula* seems to be smaller than that of *J. pellucida* (see Raatikainen 1960 and 1967). This factor is one reason why *M. sordidula* cannot be as harmful a virus vector as *J. pellucida*.

M. sordidula is a species living principally in old leys, and it is chiefly in leys that it is able to transmit viruses. Some 50—70 per cent of those emerging in leys and meadows are macropters (Kontkanen 1952, Raatikainen 1960). The ratio is considerably smaller than that in *Javesella pellucida*, the main vector of OSDV and EWSMV, 94 per cent of which are macropters in first-year leys (Raatikainen 1967), but higher than that in *Dicranotropis hamata*, some 6—55 per cent of which are macropters (Lindberg 1949, Kontkanen 1952, Raatikainen and Vasarainen 1964). When the macropters migrate from their reproduction sites, e.g. to cereals and new leys, they may carry viruses with them. Material gathered with netting apparatus shows that in 1958—1964 the migration of macropterous *M. sordidula* began 15 days later than that of the *Javesella pellucida* (see Raatikainen 1967). The *M. sordidula* material, however, is smaller than the *J. pellucida* material and, consequently the difference may not be as great as this. If the difference between migration periods is reckoned as the difference between the dates by which 50 per cent of the macropters obtained had migrated, the difference between the migration periods of these species in 1959—1962 was 11 days. The cereals are thus more advanced at the time of the *M. sordidula* migration than at that of the *J. pellucida* migration, and the virus transmitted by *M. sordidula* obviously does not have the time to cause symptoms as severe as those caused by the viruses transmitted by *J. pellucida*.

In fields of oats or spring wheat the proportion of brachypterous specimens in the total number of specimens was higher in *M. sordidula* than in *J. pellucida*, of which only 0.01 per cent of the 24 090 of the adults gathered in 1958—1964 were brachypterous (see Raatikainen 1967, Tables 85 and 86). Brachypterous *M. sordidula* are thus able to transmit viruses to spring cereals and to leys established under them, but, as the brachypters migrates to cereals in small numbers only, and usually only to the edges of cereal fields, this transmission is not of noteworthy significance in cereals though in leys it is more important.

Table 8. Frequency of some vectors in leys, spring wheat and oats in South Ostrobothnia, 1958—1964.

	No. of del-phacids	*M. sordidula* %	Vectors of OSDV, %	Vectors of EWSMV, %
1st-year ley, nymphs	39 190	2.4	96.6	96.6
» », adults	5 281	0.1	99.8	99.8
Spring wheat, adults	8 863	5.2	93.4	93.0
Oats, adults	17 037	5.3	93.8	93.7

The frequency of *M. sordidula* was also much lower than the frequencies of the OSDV and EWSMV vectors, both in spring cereals and in first-year leys established under cereals, prior to the migration of the delpchacids (Table 8). Some 13—50 per cent of specimens of the OSDV vector species emerging in fields of oats and barley transmit OSDV, and some 6—7 per cent of those of the EWSMV vector species transmit EWSMV (see LINDSTEN 1961), and it thus follows that plants infected by the virus transmitted by *M. sordidula* would hardly be more common than the EWSMV in the research area even if all the *M. sordidula* specimens transmitted viruses.

In some years, however, there were several *M. sordidula* per square metre in spring cereals and dozens per square metre in leys, and its frequency was greater in southern Finland than farther north. The importance of food factors and enemies to the fluctuations in abundance seems to have been small. In areas where the temperature was highest, however, and also in cooler areas in those years when the temperatures in the autumn, the snowless part of winter and the spring and summer were high, the mortality rate of the species seems to have been lower than average and the species became more abundant. This is also supported by the findings of MARCHAND (1953) in Germany, i.e. that the species demands warmth, and by the conclusions reached by KONTKANEN (1950) in eastern Finland that the species is more abundant on dry than on fresh biotopes. The species did not seem to be as susceptible to drought as, e.g. *J. pellucida*. The importance of *M. sordidula* as a virus vector may be at its greatest in and after warm dry periods.

The fluctuations in abundance of *M. sordidula* are very similar to those of *Dicranotropis hamata* (RAATIKAINEN and VASARAINEN 1964). Both are southerly species, and warmth causes increases in their numbers. Almost the reverse is true, however, of fluctuations in abundance of *Javesella pellucida* (RAATIKAINEN 1967), although weather factors seem to have had a most powerful effect on this species, too. In the research area, however, *J. pellucida* is a long way from its distribution limits, and it is most abundant on spring cereals. *J. pellucida* seems to be fairly sensitive to drought, and heat and drought cause a decrease in its frequency. Conversely, high temperature and dry weather caused an increase in the frequencies of *M. sordidula* and *D. hamata* living in perennial leys at the northern limits of their geographic distribution. Weather factors acted directly on the fluctuation in numbers of all the species, and also indirectly by way of their enemies.

Summary

The abundance of *Megadelphax sordidula* was investigated in populations near the northern limit of their area of distribution in western Finland during the period 1958—1964. Material was also gathered elsewhere in Finland.

The species was most abundant in southern Finland, but occurred as far north as 66°N.

From about 20 June the macropters migrated by flight for one month, chiefly from leys to cereals but also to other leys. The brachypters migrated over shorter distances than the macropters, and, in spring cereal fields, they were found mainly at the edges.

The fluctuation in abundance of *M. sordidula* varied considerable during the research period. The abundance seems to have been most strongly affected by weather factors. These factors influenced abundance directly, and also indirectly, through enemies of the species and hosts of these enemies.

The species was uncommon, a large proportion

of the adults were brachypters that remained on perennial stands, and migration was late. For these and other reasons the species was of very little significance in the transmission of viruses to cereals. It was occasionally a vector of importance in leys.

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SELOSTUS

Kyyttökaskaan ekologiasta ja runsaudenvaihtelusta

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Tämä työ on osa Tuhoeläintutkimuslaitoksella tehtävistä viljan viruksia siirtävien kaskaiden ekologian ja torjunnan selvityksistä. Kenttätyöt suoritettiin Vaasan itäpuoleisissa pitäjissä v. 1956—1964. Aineistoa koottiin myös muista osista Suomea.

Kyyttökaskaan tiheys oli suurin Etelä-Suomessa ja harventui pohjoista kohden (kuva 1). Pitkäsiipiset aikuiset lensivät keskimäärin kesäkuun 20. päivästä alkaen kuukauden aikana nurmista viljoihin ja toisiin nurmiin. Lyhytsiipiset siirtyivät nurmista kasvustoa pitkin lyhyehköjä matkoja, ja niitä oli kevätviljapeltojen reunaosissa.

Lajin runsaus vaihteli tutkimuskautena huomattavasti (taulukot 3—7). Säätekijät näyttivät vaikuttaneen voimakkaimmin pohjoisrajallaan olevan lajin runsaudenvaihteluun. Säätekijät vaikuttivat runsauteen myös kyyttökaskaan vihollisten ja näiden isäntäeläinten välityksellä.

Vaikka kyyttökaskas levittää vehnään, kauraan ja timoteihin erästä virusta, on laji vähämerkityksellinen virusten kuljettaja viljoihin. Nurmissa lajin merkitys virusten kuljettajana saattaa olla suurempi.

ANNALES AGRICULTURAE FENNIAE, VOL. 9: 325—330 (1970)
Seria AGROGEOLOGIA, -CHIMICA ET -PHYSICA N. 48
Sarja MAAPERÄ, LANNOITUS JA MUOKKAUS n:o 48

JUURISTON KEHITYKSEN MITTAUS LABORATORIOSSA

Summary: **The measurement of root development in the laboratory**

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Saapunut 30. 10. 1969

Juuriston kehittymisellä, sen tiheydellä ja laajuudella, on ratkaiseva merkitys mm. viljakasvien menestymiselle. Monien ympäristötekijöiden, kuten maalajin, kosteuden, ravinteiden määrän, kyntö- ja kylvömenetelmien vaikutus kohdistuu juuristoon ja sitä kautta satotuloksiin. Juuriston myöhemmän kehityksen kannalta tärkein ajanjakso on itämisen jälkeiset kaksi viikkoa, jolloin myös juurten suhteellinen kasvunopeus on suurimmillaan (MAY ym. 1967). Paitsi eri viljalajien myös eri lajikkeiden juurten kasvunopeutta ja -tapaa on tutkittu ja havaittu niiden välillä sel viä eroja (SUBBIAH ym. 1968).

Juuristotutkimuksissa eniten käytetty menetelmä on ollut juurten huuhtominen, jossa kasvin juuristo kokonaisuudessaan kaivetaan maasta tai otetaan maanäytteitä kasvin ympäriltä eri syvyyksistä ja eri etäisyyksiltä ja maa huuhdotaan varovasti pois vedellä. Suomessa on mm. SALONEN (1949) suorittanut tällaisia tutkimuksia. Kasvien vedenottoa eri maakerroksista on myös käytetty juurten tehokkuuden ilmaisijana, edellytyksenä on tällöin kuitenkin se, että maan koko vesihäviö johtuu kasvista ja että kokeen aikana ei sada. Myös erilaisia merkkiaineita, kuten väriaineita ja maassa harvinaisia alkuaineita (litium, rutenium) on kokeiltu.

Merkkiaineisiin kuuluvat myös radioaktiiviset isotoopit, joiden käyttö on nykyään syrjäyttämässä aikaisempia menetelmiä. Radioisotooppitekniikka tarjoaa useita eri mahdollisuuksia juuriston tutkimiseen. Radioaktiivinen aine voidaan injektoida kasvin maanpäälliseen osaan, tavallisesti varteen, jolloin aktiivisuuden toteaminen tapahtuu juurista ottamalla maa-juuri -näytteitä kasvin ympäriltä ja mittaamalla niiden aktiivisuus (RACZ ym. 1964, RENNIE ja HALSTEAD 1965, RUSSELL ja ELLIS 1968, SUBBIAH ym. 1968), tai radioaktiiviset juuret voidaan havaita asettamalla valolta ja kosteudelta suojattu röntgenfilmi tiiviisti kohtisuoraa maaleikkausta vasten, joka on kaivettu kasvin kohdalle. (RENNIE ja HALSTEAD 1965). Aine voidaan myös sijoittaa maahan tiettyyn syvyyteen, ja aktiivisuuden ilmaantuminen versoihin osoittaa juurien saavuttaneen ko. syvyyden. Suurin osa tutkimuksista on ollut kenttäkokeita (LIPPS ym. 1957, LIESHOUT 1960, FOX ja LIPPS 1964, PRICE 1965, HAAHR ym. 1966, HAAHR 1968). Radioaktiivinen fosfori (P 32) on eniten käytetty merkkiaine, koska sillä on sopiva puoliintumisaika (14 päivää), se ei huuhtoudu maasta, kasvit pystyvät ottamaan sitä helposti ja se kulkeutuu nopeasti juurista kasvin maanpäällisiin osiin ja päinvastoin, mistä aine on helppo havaita. On todettu, että radiofosfori kulkeutuu viljakasveilla juurista varsiin ja lehtiin jo 2 tunnissa (COHEN ja TADMOR 1966).

Tämän tutkimuksen päämääränä oli kokeilla ja kehittää mahdollisimman helppoa astiakoemenetelmää, jossa radioaktiivinen isotooppi levitetään tasaisesti maahan haluttuun syvyyteen ja juuriston kehitystä seurataan päivittäin mittaamalla oraista niihin kulkeutunut radioaktiivisuus pienellä, kannettavalla ja kenttäkäyttöön soveltuvalla laskurilla. Menetelmä soveltuu erityisesti kasvinjalostuksen käyttöön mitattaessa nopeasti ja vaivattomasti juuriston varhaiskasvunopeutta suuresta koeaineistosta. Juuriston kehitysnopeuden tunteminen auttaa osaltaan aikaisempaan valintaan eri lajikkeiden joukosta. Menetelmää voidaan myös käyttää juuriston kehitykseen vaikuttavien ympäristötekijöiden tutkimiseen, mitä ei tässä yhteydessä ole suoritettu.

Aineisto ja menetelmät

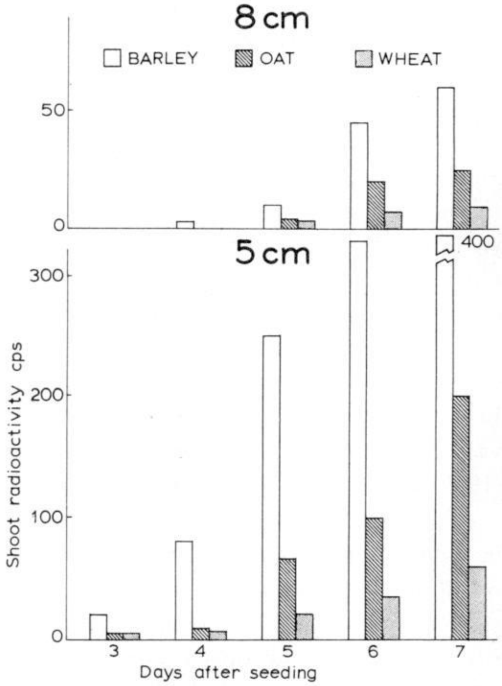
Koeastioina käytettiin 5 litran muoviämpäreitä, halkaisijaltaan 19 cm. Astioita täytettäessä asetettiin haluttuun syvyyteen (8 tai 16 cm) halkaisijaltaan 15 cm:n suodatinpaperi. Se kasteltiin tasaisesti pipetillä 2 ml:lla radiofosforiliuosta, joka sisälsi noin 5 mg/l inaktiivista kantajafosforia. Lisätyn aktiivisuuden määrä oli noin 100 μCi P 32/suodatinpaperi. Astiaa kohden käytetty fosforimäärä (0.01 mg P) oli siten niin vähäinen, ettei sillä ollut lannoitusvaikutusta. Radioaktiivisen paperin ja astian reunan väliin jätetty 2 cm:n väli esti astian seinämiä myöten nopeasti tunkeutuvien juurten merkkaantumisen radiofosforilla. Koemaina olivat hieta, savi, multamaa ja rahkaturve. Jokaiseen astiaan kylvettiin 80 jyvää kyseessä olevaa lajiketta.

Oraiden radioaktiivisuusmittaukset suoritettiin päivittäin Wallacin RD-11 -tyyppisellä kannettavalla laskurilla käyttäen yleisilmaisinta GMP-533. Mittausgeometria pyrittiin pitämään mahdollisimman samanlaisena. Radioaktiivisuuden ilmaannuttua oraisiin jatkettiin mittauksia vielä 4—8 päivän ajan. Välittömästi viimeisen mittauksen jälkeen oraat leikattiin, kuivattiin 105 asteessa, punnittiin ja poltettiin tuhkaksi 450 asteessa, ja aktiivisuus mitattiin punnitusta määrästä tuhkaa kasvavista oraista saatujen mittaustulosten tarkistamiseksi. Mittaukset suoritettiin Wallacin laskurilla SC-33 käyttäen beta-putkella varustettua ilmaisinta GMH-278. Koekasveina olivat seuraavat Kasvinjalostuslaitokselta Jokioisista saadut lajit ja lajikkeet: Jyvä, Nisu, Jo 01177, Jo 03015, Jo 03016 ja Jo 03021 (syysvehnä) sekä Voima, Ensi, Petkus, Pekka, Värne ja Jo 01922 (syysruis). Kerranteita oli kolme.

Radioaktiivisuusmittausten tuloksia vertailtaessa käytettiin varianssianalyysia. Todennäköisyydet (P = 5 % ja P = 1 %) esitetään kirjaimilla a, b, c jne. Tapaukset, joiden välillä ei ole merkitseviä eroja, esitetään samalla kirjaimella. Korrelaatiokertoimet on laskettu oraista ja niiden tuhkista mitattujen aktiivisuusarvojen välille sekä oraiden aktiivisuuden ja sadon kuivapainojen välille.

Tulokset ja niiden tarkastelu

Tutkimuksessa keskityttiin selvittämään, oliko yläkuvatulla menetelmällä yleensä mahdollista saada esiin eroja eri lajikkeiden juurten kehitysnopeudessa. Erilaisten ympäristötekijöiden, ku-



Kuva 1. Ohran, kauran ja vehnän oraiden radioaktiivisuuden päivittäinen lisääntyminen, P 32-kerros 5 ja 8 cm:n syvyydessä.

Fig. 1. The daily increase in the radioactivity of barley, oat and wheat seedlings, P 32 layer in 5 and 8 cm depth.

ten valon, lämmön, kosteuden, maalajin ja ravinteiden vaikutusta juuriston kehitykseen ei tutkittu. Jokaisen samanaikaisen kokeen tulokset ovat sen tähden esitetty erillisinä, koska eri koekerroilla tavallisesti jokin tai jotkut näistä tekijöistä muuttuivat.

Alustavissa kokeissa suoritettiin vertailuja eri lajien kesken. Aktiivisuutta käytettiin enemmän ja mittauksia tehtiin useammin kuin mihin myöhemmin päädyttiin. Kuvassa 1 on esitetty ohran, kauran ja vehnän (lajikeseoksia) oraiden radioaktiivisuuden lisääntyminen, kun aktiivinen kerros oli 5 ja 8 cm:n syvyydessä. Tämän mukaan ohran juuristo oli nopeakasvuisin, ja vehnä jäi selvästi jälkeen muista. Ohran juuristo kehittyi myös nopeammin kuin rukiin, joka ei ollut mukana tässä kokeessa. Kuvasta näkyy myös, kuinka juuret ottivat 8 cm:ssä suhteellisesti paljon vähemmän fosforia kuin lähempänä pintaa.

Taulukko 1. Vehnälajikkeiden radioaktiivisuuksien keskiarvot ja niiden merkitsevyydet 1 ja 5 %:n tasolla sekä F-arvot

Table 1. The mean values of radioactivity of wheat varieties and F-values. Mean values not followed by a lower case letter differ significantly at the 1 and 5 % levels respectively

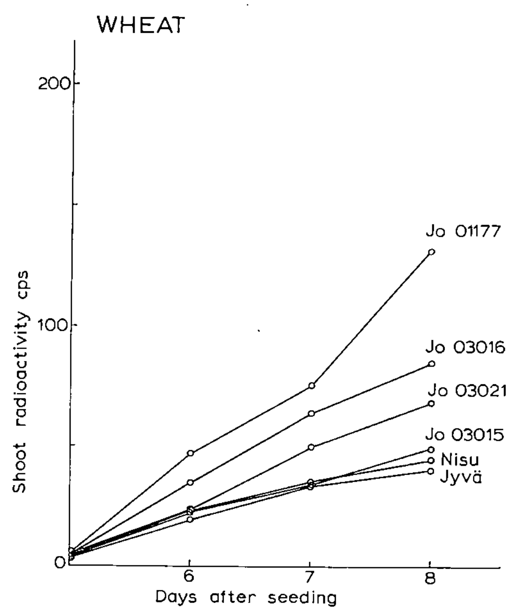
Lajike *Variety*	$\bar{x}$ cps	P 1 %	P 5 %	Syvyys ja maalaji *Depth and soil type*
Jo 01177	99			8 cm hieno kivennäismaa *fine mineral soil*
Jo 03016	81			
Jo 03015	66			
Nisu	57			
Jo 03021	51			
Jyvä	41			
		F = 1.89		
Jo 01177	31	a	a	16 cm hieno kivennäismaa *fine mineral soil*
Jo 03015	12	b	b	
Jo 03016	6	b	c	
Jo 03021	5.7	b	c	
Nisu	5	b	c	
Jyvä	3	c	c	
		F = 53.97***		
Jo 01177	102		a	8 cm multamaa *mould*
Jo 03016	78		a	
Jo 03021	62		a	
Jo 03015	43		b	
Jyvä	42		b	
Nisu	39		b	
		F = 4.95*		
Jo 01177	26		a	16 cm multamaa *mould*
Jo 03021	16		a	
Jo 03016	10		b	
Jo 03015	8		b	
Jyvä	7.6		b	
Nisu	6		b	
		F = 5.51**		

Taulukko 2. Ruislajikkeiden radioaktiivisuuksien keskiarvot ja niiden merkitsevyydet 1 ja 5 %:n tasolla sekä F-arvot

Table 2. The mean values of radioactivity of rye varieties and F-values. Mean values not followed by a lower case letter differ significantly at the 1 and 5 % levels respectively

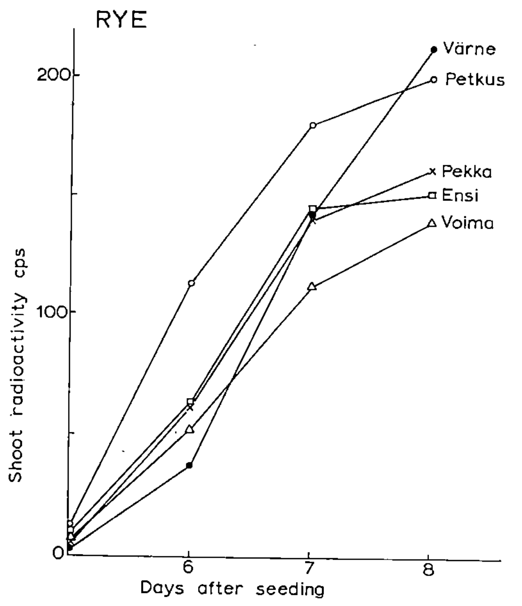
Lajike *Variety*	$\bar{x}$ cps	P 1 %	P 5 %	Syvyys ja maalaji *Depth and soil type*
Petkus ...	24		a	8 cm multamaa *mould*
Ensi	20		ab	
Värne ...	10		c	
Pekka ...	9.6		bc	
Voima ...	8		bc	
		F = 5.27*		
Petkus ...	126			8 cm karkea kivennäismaa *coarce mineral soil*
Värne ...	99			
Pekka ...	91.6			
Ensi	91.5			
Voima ...	78			
		F = 0.65		
Petkus ...	8		a	16 cm karkea kivennäismaa *coarse mineral soil*
Pekka ...	4		b	
Ensi	3.6		b	
Värne ...	3.5		b	
Voima ...	3		b	
		F = 5.19*		
Jo 01922	125	a	a	8 cm karkea kivennäismaa *coarse mineral soil*
Petkus ...	70	ab	b	
Ensi	47	b	b	
Värne ...	38	b	b	
Pekka ...	19	b	b	
Voima ...	13	b	b	
		F = 7.09**		
Jo 01922	156	a	a	8 cm rahkaturve *peat soil*
Värne ...	124	ab	ab	
Petkus ...	104	abc	bc	
Pekka ...	74	bcd	cd	
Ensi	48	cd	de	
Voima ...	28	d	e	
		F = 15.07***		

Taulukossa 1 on esitetty vehnälajikkeiden eri mittauskertojen radioaktiivisuuksien keskiarvot (cps) ja F-arvot. Linjan Jo 01177 juuristo kehittyi nopeimmin, Nisu- ja Jyvä-lajikkeiden yleensä hitaimmin huolimatta siitä, että maalaji ja radiofosforin sijaintisyvyys vaihtelivat. Ruislajikkeista, taulukko 2, linja Jo 01922 sijoittui ensimmäiseksi juuriston kehitysnopeudessa, toiseksi tuli Petkus ja Voima oli hitain. Kerranteiden aktiivisuusarvojen hajonta oli suuri, mikä osaltaan vaikutti F-arvojen pieneen merkitsevyyteen. Yksittäisillä koejäsenillä oraiden aktiivisuuden lisääntyminen oli yleensä verrattain tasaista, joissakin tapauksissa kuitenkin eri lajikkeiden juuriston kehityksessä ilmenevät erot tulivat esiin vasta myöhäi-



Kuva 2. Kuuden vehnälajikkeen oraiden radioaktiivisuuden päivittäinen lisääntyminen, P 32-kerros 8 cm:n syvyydessä multamaassa.

Fig. 2. The daily increase in shoot radioactivity of six wheat varieties, P 32 layer in 8 cm depth in mould.



Kuva 3. Viiden ruislajikkeen oraiden radioaktiivisuuden päivittäinen lisääntyminen, P 32-kerros 8 cm:n syvyydessä karkeassa kivennäismaassa.

Fig. 3. The daily increase in shoot radioactivity of five rye varieties, P 32 layer in 8 cm depth in coarse mineral soil.

Taulukko 3. Korrelaatiokertoimet laskettuna kasvavan kasvin ja sen tuhkan radioaktiivisuuksien välille sekä kasvavan kasvin radioaktiivisuuden ja sadon kuivapainon välille

Table 3. Correlation coefficients between the radioactivity of the growing plants and the ash and between the radioactivity of the growing plants and the dry weight of the yield

Korrelaatiokerroin (r) *Correlation coefficient*		Syvyys ja maalaji *Depth and soil type*
Oras/Tuhka *Seedling/Ash* cps cpm	Oras/Sato *Seedling/Yield* cps mg	
Vehnä—*Wheat*		
0.828***	0.298	8 cm hieno kivennäismaa *fine mineral soil*
0.983***	—0.134	16 cm hieno kivennäismaa *fine mineral soil*
0.929***	0.153	8 cm multamaa *mould*
0.985***	0.428	16 cm multamaa *mould*
Ruis—*Rye*		
0.778***	0.797***	8 cm multamaa *mould*
0.809***	0.287	8 cm karkea kivennäismaa *coarse mineral soil*
0.747**	0.264	16 cm karkea kivennäismaa *coarse mineral soil*
0.935***	0.869***	8 cm karkea kivennäismaa *coarse mineral soil*
0.875***	0.716***	8 cm rahkaturve *peat soil*

semmässä vaiheessa. Kuvasta 2 näkyy erään vehnälajikekokeen oraiden melko tasainen päivittäinen aktiivisuuden lisääntyminen. Kuva 3 esittää erään ruislajikekokeen oraiden aktiivisuuden lisääntymistä, joka oli Värnellä aluksi heikointa, kuitenkin jo kolmen päivän kuluttua oli Värnen radiofosforipitoisuus noussut muita suuremmaksi.

Samankin lajikkeen siementen itämisnopeus vaihteli eri koekerroilla, mikä johtui erilaisista kasvuoloista. Tavallisesti 3—5 päivän kuluttua kylvöstä juuret olivat 8 cm:n ja 5—9 päivän kuluttua 16 cm:n pituisia. Eri lajikkeiden juurten kehitysnopeusjärjestys pysyi yleensä 16 cm:n syvyydessä samana kuin 8 cm:n syvyydessä. Se, että oraisiin kulkeutui radioaktiivisuutta kuitenkin paljon vähemmän ja hitaammin 16 cm:n kuin 8 cm:n syvyydestä, johtui ehkä osaksi siitä, että kaikki juuret saavuttivat lähempänä pintaa sijaitsevan radioaktiivisen kerroksen lähes samanaikaisesti, mikä ei enää tapahtunut syvemmällä. NEWBOULD ja TAYLOR (1964) tutkivat kasvien fosforin ja kalkin ottoa maasta eri syvyyksistä radioaktiivisilla isotoopeilla ja totesivat, että kasvit ottivat ko. aineita eniten maan pintakerroksista, 5—10 cm:n syvyydestä, minkä seikan he arvelivat johtuvan ennen kaikkea kasvien juuriston ominaisuuksista, mutta myös maan kosteudesta.

Taulukossa 3 on esitetty korrelaatiokertoimet oraan ja sen tuhkan aktiivisuuksien välille sekä oraan aktiivisuuden ja sadon kuivapainon välille. Tuhkasta mitattu aktiivisuus korreloi hyvin kasvavasta kasvista viimeksi mitattujen arvojen kanssa, mikä tukee jälkimmäisen mittaustavan luotettavuutta. Laskuissa olivat mukana jokaisen lajikkeen kaikki kerranteet. Eri lajikkeilla satojen kuivapainot poikkesivat jonkin verran toisistaan. Koko aineistosta $\frac{1}{3}$:lla oli merkitsevä positiivinen korrelaatio sadon kuivapainon ja oraiden aktiivisuuden välillä.

Yhteenveto

Vehnän ja rukiin eri lajikkeiden juuriston kasvunopeutta tutkittiin astiakokeissa. Merkkiaineena käytettiin radioaktiivista isotooppia, fosfori 32:ta, jonka liuoksella kostutettu suodatinpaperi asetettiin koeastioihin 8 tai 16 cm:n syvyyteen, ja radioaktiivisuus mitattiin oraista kannettavalla laskurilla päivittäin. Juuriston kehitysnopeudelle saatiin muutamien lajikkeiden välille tilastollisesti merkitseviä eroja. Suoraan koeastioista mitatut ja kasvituhkasta mitatut radioaktiivisuusarvot korreloivat hyvin keskenään. Menetelmä osoittautui käyttökelpoiseksi ja luotettavaksi.

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SUMMARY

The measurement of root development in the laboratory

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In the pot experiment, seedling root development of six varieties each of wheat and rye was studied. Radioactive phosphorus was applied to the soil as follows: a 15 cm diameter filter paper was wetter with 100 μCi of P 32 solution and placed at depths of 8 or 16 cm when the pots were being filled with soil. The seeds were sown, and after the seedlings emerged, shoot radioactivity was measured daily with a portable GM counter. Figs. 2 and 3 show the daily increase in shoot radioactivity of the wheat and rye varieties, respectively.

Statistically significant differences in the physiological root activity were found between some varieties. Tables 1 and 2 show the mean shoot radioactivities and the F-values of different experiments. After the last counting, the shoots were cut and ashed; comparisons were made between shoot and ash radioactivity. Their correlation coefficients are shown in Table 3. The values support the reliability of the »living-shoot counting» method. Correlation coefficients have also been calculated for the shoot activity and the dry weight of yield. The method is timesaving, easily performed and it may be especially applicable in plant breeding, for the measurement of early root growth of cereals from large experimental material.

ANNALES AGRICULTURAE FENNIAE, VOL. 9: 331—335 (1970)
Seria AGROGEOLOGIA, -CHIMICA ET -PHYSICA N. 49
Sarja MAAPERÄ, LANNOITUS JA MUOKKAUS n:o 49

BOORILANNOITUKSEN JÄLKIVAIKUTUS

Summary: **Residual effect of boron fertilization**

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Saapunut 6. 11. 1969

Selvitettäessä boorin merkitystä viljelykasveille (mm. JAMALAINEN 1935, TAINIO 1955 ja 1957, HÄNNINEN 1966) on jouduttu kiinnittämään huomiota myös sen liiallisen käytön vahingollisuuteen. Tämä tulee kysymykseen etenkin viljeltäessä runsaasti booria vaativien viljelykasvien jälkeen boorille arkoja kasveja. Vuonna 1962 aloitettiin Maanviljelyskemian ja -fysiikan laitoksen toimesta koesarja boorilannoituksen jälkivaikutuksen tutkimiseksi.

Aineisto ja menetelmät

Eri puolille Suomea perustetuissa kokeissa oli koekäsittelynä myös hyvin suuria boorimääriä, jotta saataisiin selville myös boorin liiallisen käytön vaikutus. Booria annettiin vain ensimmäisenä koevuonna, jolloin se levitettiin ennen muokkausta.

Ensimmäisenä koevuonna viljeltiin juurikasveja (naattinauris, lanttu tai turnipsi) ja lannoiteboraattimäärät olivat 0, 20, 40, 80 ja 160 kg/ha. Vain kaksi koetta perustettiin kevätviljalle boraattimäärien ollessa 0, 10, 20, 40 ja 80 kg/ha. Kaikille koejäsenille annettiin vuosittain sama NPK-aluslannoitus, jonka määrä riippui koekasvista.

	Aluslannoitus kg/ha		
	oulunsalpietaria 25 % N	superfosfaattia 20 % P_2O_5	kalisuolaa 60 % K_2O
Juurikasvit	500	800	400
Nurmet	200	200	200
Viljat	200	200	200

Nurmen suojaviljalle ei kuitenkaan annettu typpilannoitusta, ja kokeen perustamisvuonna viljalle annettiin kaksinkertainen fosforimäärä.

Kokeet jatkuivat samoilla paikoilla 4—6 vuotta. Boorilannoituksen jälkivaikutusta pyrittiin selvittämään viljalla ja sitä seuraavilla nurmilla.

Satonäytteitä otettiin etupäässä nurmista koeruuduittain korjuuaikana timotein kukinta-ajan alkupuolella. Kasvilajien suhteellinen osuus määritettiin ilmakuivasta sadosta. Sadon sisältämistä kasvinravinteista määritettiin koejäsenittäin typpi, fosfori, kali, kalkki, magnesium (SALONEN ym. 1962) sekä boori (HATCHER ja WILCOX 1950).

Maanäytteet otettiin kaikkien koeruutujen ruokamultakerroksesta, ensimmäisenä koevuonna ennen lannoitteiden levitystä ja viimeisenä koevuonna sadonkorjuun jälkeen. Näytteistä tehtiin tavanomaisen viljavuusanalyysin lisäksi liukoisen boorin määritys (HATCHER ja WILCOX 1950) uuttamalla kiehuvalla vedellä (BERGER ja TRUOG 1939). Tietoja koepaikkojen maalajista ja kemiallisista ominaisuuksista koetta perustettaessa on taulukossa 1.

Koetulosten tilastollinen käsittely suoritettiin ortogonaalisilla vertailuilla F-testiä käyttäen (LI 1964).

Taulukko 1. Koekenttien maalaji ja viljavuus
Table 1. Soil types of the fields and results of soil testing

Koe n:o *Trial No.*	Paikkakunta *Location*	Maalaji *Soil type*	pH (H_2O)	Ca [1]) mg/l	K [1]) mg/l	P [1]) mg/l	B [2]) mg/l
1	Kuusamo	turve — *peat soil*	5.3	1 720	115	5.8	0.6
2	Utajärvi	multamaa — *humus soil*	5.1	2 560	83	4.6	0.4
3	Utajärvi	multamaa — *humus soil*	4.3	700	338	16.4	1.7
4	Ilomantsi	hieno hieta — *very fine sand*	6.2	1 320	304	14.4	0.5
5	Hartola	hiekkainen hieta — *sand*	5.8	1 840	118	5.6	0.2
6	Tammela	hiesuinen hieta — *loam*	6.4	2 540	184	18.9	0.2
7	Kälviä	karkea hieta — *fine sand*	5.9	1 860	325	34.1	0.6
8	Alajärvi	hieno hieta — *very fine sand*	6.6	1 960	166	7.6	0.1
9	Hartola	hiekkainen hieta — *sand*	5.8	1 920	106	4.8	0.2

[1]) *Soluble in acid ammonium acetate*
[2]) *Hot-water-soluble*

Tulokset ja tarkastelu

Sadot

Taulukossa 2 esitetään ilman booria saadut sadot ja boorilannoituksella saadut suhteelliset sadot. Eri koepaikoilla boorin vaikutus on ollut hyvin erilainen. Näissä kokeissa vaikutus ei ole ollut vuorosuhteessa maan liukoisen boorin määrään. Kahdeksalla koepaikalla yhdeksästä on maan booritila ollut huono tai välttävä. Maan alhaisesta liukoisen boorin määrästä huolimatta neljässä juurikasvikokeessa (1—3 ja 7) seitsemästä on ilmennyt jo pienimmälläkin boorimäärällä (20 kg) negatiivinen vaikutus, joka kolmessa kokeessa (1, 3 ja 7) on tilastollisesti merkitsevä. Lantulla ja turnipsilla on punnittu juuri- ja naattisadot erikseen ja voitu todeta naattien kasvun lisääntyneen boorilannoituksesta suhteellisesti enemmän kuin juurien (taul. 2). Kahdessa kevätviljalla aloitetussa kokeessa (8 ja 9), joissa lannoiteboraattimäärät olivat 0, 10, 20, 40 ja 80 kg/ha, on saatu pienimmällä boorimäärällä jyväsadon lisäystä. Nämä kokeet ovat sijainneet hyvin booriköyhillä mailla (0.1 ja 0.2 B mg/l).

Juurikasvien jälkeen on kasvatettu toisena koevuonna viljaa, minkä jälkeen on pyritty selvittämään heinäsatojen perusteella boorilannoituksen vaikutuksen säilymistä.

Boorilannoituksen niin positiivinen kuin negatiivinenkin jälkivaikutus on vähentynyt kokeissa varsin nopeasti. Toisena koevuonna on saatu enää kuudessa kokeessa (2, 3, 5, 7, 8 ja 9) merkitseviä satoeroja eri boorimäärien välillä. Aikaisemmin mainituissa neljässä juurikasvikokeessa (1—3 ja 7), joissa jo pieninkin boorimäärä ensimmäisenä koevuonna on aiheuttanut sadonalennusta, boorin negatiivinen vaikutus on tuntunut toisena vuonna vain kahdessa kokeessa (2 ja 7). Kolmantena koevuonna ei ole tätäkään ollut havaittavissa.

Jyväsadoissa (21 koetulosta) erot ovat olleet melko pieniä. Ohralla perustettujen kokeiden 8 ja 9 ensimmäisen koevuoden lisäksi on saatu vain toisena koevuonna neljällä koepaikalla (2, 3, 5 ja 7) boorin jälkivaikutuksesta tilastollisesti merkitseviä eroja.

Juurikasveilla aloitetuissa kokeissa on nurmi ollut kolmantena vuonna boorilannoituksen jälkeen tai myöhemmin ja viljakokeissa toisesta koevuodesta alkaen. Kokeissa 5 ja 9 hiekkaisella hietamaalla on pieninkin lannoiteboraattimäärä vaikuttanut positiivisesti satotulokseen. Kokeen 4 ensimmäisen vuoden nurmessa boori on alentanut satoa, mikä ilmenee myös kokeiden 2 ja 8 suurimman boorimäärän saaneilla koejäsenillä.

Taulukko 2. Lannoiteboraatin eri käyttömäärien vaikutus sadon suuruuteen ja tulosten luotettavuus

Table 2. The effect of different rates of fertilizer borate on the yield and the significance of the results

Koe n:o *Trial No.*	Koevuosi *Trial year*	Viljelykasvi *Cultivated plant*	Lannoiteboraattia kg/ha *Fertilizer borate kg/ha*						Merkitsevyys *Significance*	
			0	10	20	40	80	160		
			Sato — *yield*						Suorav. *Linear*	Käyräv. *Nonlinear*
			kg/ha	Suhdeluku, ilman booria = 100 *Relative value, without boron = 100*						
1	1	naattinauris — *big-leafed turnip*	77 800	—	82	66	67	40	***	
	2	naattinauris — *big-leafed turnip*	60 840	—	99	97	100	98		
	3	ohra, ei satoa — *barley, no yield*	—	—	—	—	—	—		
	4	1. heinä — *1. hay*	2 830	—	117	113	119	117		
	5	2. heinä — *2. hay*	3 180	—	112	110	110	114		
	6	3. heinä — *3. hay*	4 130	—	83	85	93	79		
2	1	naattinauris — *big-leafed turnip*	106 200	—	90	92	104	92		
	2	kaura, jyvät — *oats, grain*	1 050	—	89	82	83	72	***	
	3	kaura, jyvät — *oats, grain*	2 260	—	104	103	101	96		
	4	1. heinä — *1. hay*	5 240	—	100	102	97	90	**	
3	1	naattinauris — *big-leafed turnip*	83 440	—	99	90	90	84	***	*
	2	vihantakaura — *green-food oats*	10 000	—	105	107	113	102		**
	3	1. heinä — *1. hay*	7 280	—	94	101	101	96		
	4	2. heinä — *2. hay*	5 390	—	97	102	96	96		
	5	3. heinä — *3. hay*	4 460	—	97	98	101	96		
4	1	lanttu, juuret — *swede, roots*	42 560	—	153	146	149	137	*	***
		naatit — *tops*	17 400	—	167	182	184	167	*	*
	2	ohra, jyvät — *barley, grain*	3 450	—	109	122	104	110		
	3	1. heinä — *1. hay*	6 060	—	89	92	80	90	*	*
	4	2. heinä — *2. hay*	6 560	—	99	113	94	88		
	5	3. heinä — *3. hay*	4 210	—	91	86	92	94		
5	1	lanttu, juuret — *swede, roots*	37 100	—	101	106	88	53	***	*
		naatit — *tops*	11 800	—	106	99	99	100		
	2	kaura, jyvät — *oats, grain*	1 890	—	114	92	88	86	***	**
	3	1. heinä — *1. hay*	2 240	—	125	120	110	118		*
	4	2. heinä — *2. hay*	4 960	—	120	124	119	99		*
	5	kaura, jyvät — *oats, grain*	1 700	—	116	111	109	106		
	6	kaura, jyvät — *oats, grain*	2 930	—	100	91	89	93		
	7	kaura, jyvät — *oats, grain*	2 590	—	98	91	96	93		
6	1	lanttu, juuret — *swede, roots*	69 670	—	104	100	99	95	***	
		naatit — *tops*	25 840	—	103	103	106	114	***	
	2	ohra, jyvät — *barley, grain*	3 480	—	109	106	96	89		
	3	syysvehnä, jyvät — *wheat, grain* ...	3 100	—	102	99	95	101		
	4	kaura, jyvät — *oats, grain*	3 940	—	101	102	103	108		
	4	sokerijuurikas, juuret — *sugar beat, roots*	31 940	—	97	95	100	108		
		naatit — *tops*	42 970	—	104	101	101	105		
7	1	turnipsi, juuret — *turnip, roots*	68 700	—	99	97	95	88	***	
		naatit — *tops*	30 300	—	100	101	103	100		
	2	ohra, jyvät — *barley, grain*	4 330	—	106	103	97	88	***	
	3	1. heinä — *1. hay*	4 580	—	93	95	102	103		
	4	2. heinä — *2. hay*	7 970	—	89	95	93	84	*	
8	1	ohra, jyvät — *barley, grain*	1 860	121	107	92	91	—	***	***
	2	1. heinä — *1. hay*	4 150	123	130	105	87	—	***	***
9	1	kaura, jyvät — *oats, grain*	1 950	106	103	96	86	—	***	
	2	1. heinä — *1. hay*	4 350	106	104	103	80	—	*	
	3	2. heinä — *2. hay*	4 450	114	100	103	93	—		
	4	3. heinä — *3. hay*	6 010	109	110	103	101	—		*
	5	kaura, jyvät — *oats, grain*	1 810	103	102	104	104	—		
	6	kaura, jyvät — *oats, grain*	2 430	102	93	98	93	—		
	7	kaura, jyvät — *oats, grain*	1 720	101	100	105	102	—		

Tilastollinen merkitsevyys (F-testi) on ilmaistu asteriskeilla seuraavasti:
Statistical significance (F-test) is denoted by asterisks as follows:
$P \leq 0.001$ ***; $0.001 < P \leq 0.01$ **; $0.01 < P \leq 0.05$ *

Muissa kokeissa heinäsatojen vaihtelut ovat olleet vähäisiä eivätkä satoerot ole tilastollisesti merkitseviä. Nurmien kasvilajikoostumuksessa ei ole ollut havaittavissa boorin jälkivaikutusta.

Satojen booripitoisuus

Kasvinravinteet on määritetty muutamien kokeiden heinäsadoista erikseen apilasta ja timoteista (taul. 3). Kokeissa 1, 3 ja 7 oli melkein yksinomaan heinäkasveja, pääasiassa timoteita. Muissa kasvusto oli suurimmaksi osaksi puna-apilaa ja timoteita. Näissä oli ilman boorilannoitusta timotein booripitoisuus keskimäärin 5.7 B mg/kg kuiva-ainetta. Apilan booripitoisuus ilman boorilannoitusta oli vastaavasti 25.6.

Tarkasteltaessa apila-timoteisekakasvustossa (kokeet 4, 5 ja 9) boorin käyttömäärien aiheuttamia eroja erikseen apilan ja timotein booripitoisuuksissa voitiin todeta, että nämä kasvit ovat boorin käytön suhteen selvästi erilaisia. Timotein booripitoisuus kohosi boorilannoituksen lisääntyessä varsin huomattavasti ja suhteellisesti enemmän kuin apilan. Kun kysymyksessä oli boorilannoituksen 1.—3. jälkivaikutusvuosi, ainoastaan kokeessa 5 timotein booripitoisuus nousi samalle tasolle kuin apilan. Timotein booripitoisuudessa ilmeni erittäin selvästi myös boorilannoituksen jälkivaikutuksen heikkeneminen ajanmittaan. Apilan booripitoisuus ei ollut niin selvässä vuorosuhteessa aikaisemmin annettuun booraattimäärään kuin timotein. Näytteistä määritettiin myös typpi, fosfori, kali, kalkki ja magnesium. Saaduissa tuloksissa ei ollut todettavissa lannoiteboraatin jälkivaikutusta näiden ravinteiden pitoisuuksiin.

Taulukko 3. Puna-apilan ja timotein booripitoisuudet mg/kg kuiva-ainetta

Table 3. The boron contents mg/kg in dry matter of timothy and red clover

Koe n:o *Trial No.*	Koe-vuosi *Trial year*	Nurmen ikä *Age of ley*	B mg/kg kuiva-ainetta *B mg/kg in dry matter* — Lannoiteboraattia kg/ha *Fertilizer borate kg/ha* 0	10	20	40	80	160
Puna-apila — *Red clover*								
4	3	1	23	—	25	25	26	28
4	4	2	23	—	22	22	24	25
5	3	1	30	—	34	37	35	46
5	4	2	27	—	29	37	28	27
9	2	1	30	30	28	31	35	—
9	3	2	23	27	32	34	29	—
9	4	3	23	33	34	31	31	—
Keskiarvo — *Mean*			25.6	(30.0)	29.1	31.0	29.7	(31.5)
Timotei — *Timothy*								
4	3	1	8	—	8	8	9	17
4	4	2	6	—	6	8	8	8
5	3	1	9	—	13	26	29	45
5	4	2	4	—	7	9	15	33
9	2	1	4	5	7	15	28	—
9	3	2	6	7	10	14	18	—
9	4	3	3	4	8	11	10	—
Keskiarvo — *Mean*			5.7	(5.3)	8.4	13.0	16.7	25.8
1	4	1	6	—	6	9	10	14
3	3	1	12	—	15	25	—	36
7	3	1	—	—	15	25	50	59

Maan booripitoisuus

Boorilannoituksen maan liukoisen boorin määrää lisäävä vaikutus säilyi koealueilla, mikä näkyy koekauden päättyessä otettujen maanäytteiden analyysituloksista (taul. 4).

Boori huuhtoutuu maasta tutkimusten (mm. BAKER ja MORTENSEN 1966) mukaan runsaimmin alkuvuosina vähentyen vuosittain, ja maan booripitoisuuden lasku on suhteessa annettuun boorilannoitukseen. Käsillä olevassa aineistossa oli kuitenkin maan liukoisen boorin määrissä havaittavissa eri koejäsenten välillä luotettavia eroja (taul. 3). Kivennäismailla 5—6 vuotta aikaisemmin suoritettu boorilannoitus, 20, 40, 80 ja 160 kg/ha lannoiteboraattia, lisäsi maan liukoisen boorin pitoisuutta (B mg/l maata) kolmessa ko-

Taulukko 4. Lannoiteboraatin käyttömäärien vaikutus maan vesiliukoisen boorin määrään koekauden päättyessä ja tulosten luotettavuus

Table 4. The effect of applications of fertilizer borate on the water-soluble boron content in soils at the end of the experiment and the significance of the results

Koe n:o *Trial No.*	B-lannoituksesta vuosia *Years after B-fert.*	Lannoiteboraattia kg/ha *Fertilizer borate kg/ha* 0 — Maan booripitoisuus *The boron contents of soils* mg/l	20 — erotukset mg/l *differences mg/l*	40	80	160	Merkitsevyys *Significance* B lann. — ilman *B appl. — no B*	B määrät *B rates*
1	6	0.7	—0.4	—0.3	—0.2	+0.2		*
2	4	0.4	+0.4	+0.5	+0.7	+0.9	***	
4	5	0.2	+0.1	+0.5	+0.4	+0.9	**	**
5	6	0.4	+0.1	+0.4	+0.3	+0.1	*	*
6	5	0.4	+0.1	+0.5	+0.3	+0.7	*	

keessa (4, 5 ja 6) keskimäärin 0.1, 0.5, 0.3 ja 0.6. Multamaalla kokeessa 2 vastaavat lisäykset olivat 0.4, 0.5, 0.7 ja 0.9.

Tiivistelmä

Eri lannoiteboraattimäärien positiivinen tai negatiivinen vaikutus sadon määrään on näissä kokeissa tasoittunut muutaman vuoden kuluessa.

Nurmen booripitoisuudessa tuntui eri määrien vaikutus ainakin vielä neljäntenä koevuonna. Timotei reagoi tässä suhteessa huomattavasti herkemmin kuin apila. Suurinkaan boorimäärä ei yleensä nostanut timotein booripitoisuutta apilan booripitoisuuden tasolle, kun kysymyksessä oli 1.—3. jälkivaikutusvuoden sato.

Maan liukoisen boorin määrissä oli merkitsevät, joskin pienet erot koekäsittelyjen välillä vielä koejakson päättyessä 4—6 vuoden kuluttua.

Kenttäkokeet suunnitteli ja niiden suorituksen valvoi vanhempi tutkija Aarne T a i n i o.

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SUMMARY

Residual effect of boron fertilization

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The residual effect of boron fertilization was investigated through studies with different rates of boron dressing (fertilizer borate 46) on experimental fields situated in different parts of Finland.

The results, shown in Table 2, represent nine field trials, in which the boron fertilizer was applied at the beginning of the experimental period, in the spring before tillage. The residual effects of the borate application were kept under observation for four to six years.

The effect of the borate proved to be highly dissimilar in different fields, and no correlation between the differences in yield and the water-soluble boron content in the soil (from 0.2 to 1.7 B mg/l) could be perceived. The top-yield of root crops increased relatively more than the growth of the roots did in response to the borate dressing, and the top-yields suffered less from excessive borate than the root-yields.

The positive or negative effect on the yields due to different rates of borate application disappeared within a few years. However, the rates were clearly reflected both in the boron content of the yields and in the content of water-soluble boron in the soil at the end of the test period.

In red clover-timothy leys the boron content of timothy proved to be more susceptible to change than that of red clover due to the rate of borate fertilization (Table 3). The residual effect of even the most abundant application of borate dressing did not generally raise the boron content of timothy within a two to five-year period to the same level as that of the clover.

The significant, though small, increase in the soluble boron content of the soil produced by boron fertilization could be observed in humus and mineral soils as late as four to six years after the application (Table 4).

ANNALES AGRICULTURAE FENNIAE, VOL. 9: 336—342 (1970)
Seria AGROGEOLOGIA, -CHIMICA ET -PHYSICA N. 50
Sarja MAAPERÄ, LANNOITUS JA MUOKKAUS n:o 50

KARJANLANNAN JA VÄKILANNOITTEIDEN VAIKUTUKSEN VERTAILUA II

Erilaiset lannoitukset ja kalkitus

Summary: **The effects of farmyard manure and mineral fertilizers II**

Different fertilizer combinations and liming

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Kun aikoinaan laadittiin selostus Etelä-Pohjanmaan koeasemalla vuodesta 1931 käynnissä olleesta karjanlannan ja erilaisten väkilannoiteyhdistelmien vertailukokeesta (SALONEN ja HONKAVAARA 1954) todettiin, että koetta jatkettaessa on otettava kalkitus mukaan. Koekentän maa, vaikka se onkin hyvää jokivarsipeltoa, on kuitenkin Etelä-Pohjanmaalle luonteenomaisesti kalkkiköyhää ja hapanta. Kun lisäksi vertailtavina olevien lannoiteyhdistelmien vaikutuksessa maahan on suuria eroja, on maan happamuus kehittynyt hyvin ratkaisevaksi ainakin eräiden kasvien menestymiselle. Niinpä koeruudut, joiden alkuperäinen koko oli 100 m², jaettiin kahtia ja toinen puolisko sai ennen syysvehnän kylvöä 1954 kalkkikivijauhetta (50 % neutr. kalkkia) 4 tn/ha. On tultu kuitenkin siihen käsitykseen, että kalkitus on ollut liian pieni, joten se uusittiin kesällä 1968. Kun näin ollen kokeessa alkoi taas uusi jakso, on pidetty tarpeellisena selostaa tähän mennessä saadut tulokset.

Kokeen hoito 1954—67

Selostettavana aikana viljellyt kasvit on mainittu taulukossa 1, johon on merkitty myös milloin lannoitusta on annettu. Merkintä kl tarkoittaa, että ao. koejäsenelle on annettu karjanlantaa 25 tn/ha, ja merkintä vl, että suunnitelmaan kuuluvat väkilannoiteyhdistelmät on annettu. Kalilannoitus on ollut sama kaikissa väkilannoiteyhdistelmissä, nimittäin 300 kg/ha 50 % kalisuolaa. Fosforilannoitteena on ollut 250 kg/ha 19 % superfosfaattia, paitsi koejäsenessä tf 350 kg/ha 15 % tomasfosfaattia. Typpilannoitus on ollut koejäsenissä ks ja tf koko kokeen ajan 200 kg/ha kalkkisalpietaria, paitsi syysvehnälle 300. Chilensalpietarikoejäsenelle, ch, on selostettavana aikana annettu chilensalpietaria 194 kg/ha, syysvehnälle 287 kg/ha. Koejäsen su on saanut 150 kg/ha ammoniumsulfaattia, paitsi syysvehnälle 200. Yhteensä on vuosien 1955—67 sadoille annettu eri ravinteita seuraavasti kg/ha:

merkki *sign.*	Koejäsen — *Treatment* selostus — *explanation*	typpeä N kaikkiaan *total*	siitä nitr. *nitr.*	 amm. *amm.*	fosforihappo P_2O_5	kalia K_2O
0	ilman lannoitusta — *without liming*	—	—	—	—	—
kl	karjanlantaa — *farmyard manure*	454		135	226	435
ks	kalkkisalp. + superf. + kalis. — *nitrate of lime + superphos. + potass. chlor.*	263	226	37	333	954
su	amm. sulf. + superf. + kalis. — *amm. sulphate + superphos. + potass. chlor.*	259		259	333	954
ch	chilensalp. + superf. + kalis. — *Chilean salp. + superphos. + potass. chlor.*	263	263		333	954
tf	kalkkisalp. + tomasf. + kalis. — *nitrate of lime + basic slag + potass. chlor.*	263	226	37	368	954

Kuten havaitaan karjanlantaa saanut koejäsen on tänä aikana tullut saaneeksi kaikkia kasvinravinteita paljon vähemmän kuin eri väkilannoiteyhdistelmissä on ollut. Siten lannan ja väkilannoitteiden vaikutuksen suoranainen vertailu ei näiden koetulosten perusteella ole mahdollista. — Muusta kokeen hoidosta ei selostettavana aikana ole mainittavana mitään koetuloksiin vaikuttavaa.

Sadot aikana 1955—67

Esillä olevana aikana eri vuosina saadut satotulokset nähdään taulukossa 1, jossa on esitetty ilman lannoitusta saadut sadot, ja sekä ilman kalkitusta että kalkituksen ohella ja eri lannoituksilla saadut sadonlisäykset. Kaikki satoluvut on vertailujen helpottamiseksi laskettu rehuyksiköiksi (1 kg vehnän tai ohran jyviä, 5 kg perunan mukuloita, 2.2 kg heiniä). Satotaso on ollut hyvän puoleinen. Lannoitteiden ja kalkin vaikutukset ovat keskimäärin olleet suuret, mutta niissä on paljon vaihtelua paitsi eri lannoitteiden myös eri viljelyskasvilajien vuoksi.

Eri kasvilajit. Kun on kysymyksessä vain yksi koekenttä ja siitäkin vain 13 vuoden jakso, jäävät koesatojen lukumäärät eri kasvilajien kohdalla pieniksi, mutta kun niissä ilmenee kiintoisia seikkoja, esitetään ne taulukossa 2.

Taulukko 1. Vuosina 1955—67 saadut sadot; jyvät, mukulat tai 1. niitto heinäsato ry/ha
Table 1. Experimental yields in years 1955—67; grains, tubers or hay of 1st cut fu/ha

		Ilman kalkitusta *Without liming* Sato *Yield*	Sadonlisäys *Yield increase*					Kalkitus 4 tn/ha kalkkik. jauhetta *Liming 4 tn/ha ground limestone* Sato *Yield*	Sadonlisäys *Yield increase*				
		0	kl	ks	su	ch	tf	0	kl	ks	su	ch	tf
1955 Syysvehnä Vakka — *Winter wheat*	kl,[1] vl[2]	1 660	1 830	1 330	610	1 550	2 260	1 840	2 020	2 190	1 460	1 980	2 030
—56 Peruna Ruusulehti — *Potato*	kl, vl	3 930	1 980	1 810	1 710	1 920	1 960	3 810	2 160	2 000	2 000	2 140	2 140
—57 Ohra Pirkka — *Barley*	vl	2 330	280	460	170	370	570	2 380	530	550	540	520	510
—58 1. v:n nurmi — *1st year ley*		2 340	660	360	— 830	360	810	2 650	650	540	320	440	600
—59 2. » » — *2nd* » »		3 250	470	830	— 100	670	850	3 420	590	730	790	640	910
—60 3. » » — *3rd* » »		2 250	510	290	— 560	260	780	2 410	910	700	270	480	870
—61 Syysvehnä Vakka — *Winter wheat*	vl	890	650	2 160	850	1 880	3 140	1 690	1 090	2 360	1 980	1 760	2 580
—62 Peruna Amyla — *Potato* ..	kl, vl	2 730	2 350	2 730	2 790	2 670	2 870	2 900	2 450	2 810	2 930	3 180	3 410
—63 Ohra Paavo — *Barley*	vl	3 970	230	—190	—1 340	—150	540	4 460	580	190	—840	80	660
—64 1. v:n nurmi — *1st year ley*		2 000	290	—120	— 690	—200	220	2 300	440	340	—530	40	300
—65 2. » » — *2nd* » »		2 200	610	730	—1 020	850	1 180	2 480	970	760	640	970	1 170
—66 3. » » — *3rd* » »		2 300	—100	300	—1 220	400	470	2 760	—320	50	—200	—220	—210
—67 Syysvehnä Elo — *Winter wheat*	vl	320	540	2 590	1 220	2 730	4 420	1 260	1 150	1 660	2 510	3 110	3 660

[1]) Lantaa annettu — *Farmyard manure applied*
[2]) Väkilannoiteyhdistelmät annettu — *Fertilizer comb. applied*

Taulukko 2. Eri lannoitusten vaikutukset eri viljelyskasveilla ja kaikilla kasveilla keskim. vuodessa ry/ha
Table 2. Effects of different fertilizings on different crops and averages for all crops fu/ha a year

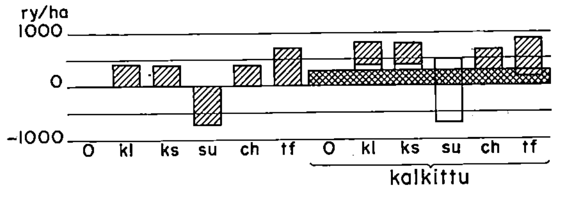
	Sato ilman lann. *Yield*	Sadonlisäys *Yield increase*					Sadonlisäysten välisten erojen merkitsevyydet, F-testi *Significances of diff. between yield increases*		Yhdistelmävaikutukset *Interactions*		
	0	kl	ks	su	ch	tf	lann. *fert.*	kalk. *liming*	vuodet-lann. *years-fert.*	vuodet-kalk. *years-liming*	lann.-kalk. *fert.-liming*
Syysvehnä, 3 satoa — *Winter wheat, 3 yields*											
Ilman kalkitusta — *No lime*	957	1 007	2 027	893	2 053	3 273	ei laskettu — *not calc.*				
Kalkittuna — *Limed*	1 597	1 420	2 070	1 983	2 283	2 757					
Yhdistelmävaikutus — *Interaction*		413	43	1 090	230	–516					
Ohra, 2 satoa — *Barley, 2 yields*											
Ilman kalkitusta — *No lime*	3 150	255	135	–585	110	555	»	»	»	»	
Kalkittuna — *Limed*	3 420	555	370	–150	300	585					
Yhdistelmävaikutus — *Interaction*		300	235	435	190	30					
Peruna, 2 satoa — *Potato, 2 yields*											
Ilman kalkitusta — *No lime*	3 330	2 165	2 270	2 250	2 295	2 415	»	»	»	»	
Kalkittuna — *Limed*	3 355	2 305	2 405	2 465	2 660	2 775					
Yhdistelmävaikutus — *Interaction*		140	135	215	365	360					
Nurmi, 6 satoa — *Ley, 6 yields*											
Ilman kalkitusta — *No lime*	2 390	407	398	–737	390	718					
Kalkittuna — *Limed*	2 670	540	520	215	392	607	***	***			***
Yhdistelmä — *Interaction*		133	122	952	2	–111					
Kaikki kasvit keskim., 13 satoa — *All crops, 13 yields*											
Ilman kalkitusta — *No lime*	2 321	792	1 022	122	1 024	1 544					
Kalkittuna — *Limed*	2 643	1 017	1 145	913	1 163	1 433	***	***	***		***
Yhdistelmävaikutus — *Interaction*		225	123	791	139	–111					

Kussakin koekäsittelyssä annettuja ravinteiden määriä esittävässä numeroasetelmassa ilmenevä lannan liian pieni käyttö riittää selitykseksi siihen, että sen vaikutus tämän jakson aikana näyttää jäävän huonommaksi kuin parhaimpien väkilannoiteyhdistelmien vaikutus, mikä poikkeaa aikaisemmista tuloksista (SALONEN ja HONKAVAARA 1954, s. 13). Jos lasketaan lantatonnin satoa lisäävä vaikutus, saadaan ilman kalkitusta 137 ry/tn ja kalkituksen ohella 176 ry/tn. Aikana 1931—52 saatiin vastaavaksi luvuksi 85.8 ry/tn. Tämän mukaan lannan teho on aikana 1955—67 ollut parempi kuin aikaisemmin. Väkilannoiteyhdistelmä su on ollut selvästi huonoin. Silmään pistävää on sen erittäin huono vaikutus kalkitsemattomalla maalla, piirre, joka on vain tehostunut ajan mukana. Ohralle ja nurmelle on tämä lannoiteyhdistelmä ollut suorastaan vahingollinen etenkin kalkitsemattomalla maalla. Väkilannoiteyhdistelmät ks ja ch ovat antaneet paremmat ja keskenään samat tulokset. Kauttaaltaan selvästi parhaaksi tulee väkilannoiteyhdistelmä tf.

Taulukon 2 lukujen mukaan kalkitus sinänsä on parantanut satoja, mutta sen lisäksi eri lannoitusten vaikutus on voinut olla erilainen kalkituilla ja kalkitsemattomilla koejäsenillä. Niinpä taulukkoon 2 on merkitty myös nämä erot, ns. yhdistelmävaikutukset. Niiden mukaan on antamalla sekä kalkitus että lannoitus yleensä saatu suurempia sadonlisäyksiä kuin on kummankin erikseen antamisella saatujen sadonlisäysten summa. Vain lannoiteyhdistelmä tf muodostaa poikkeuksen. Erityisen korkea on kalkituksen ja lannoituksen positiivinen yhdistelmävaikutus lannoiteyhdistelmän su kohdalla. Kumpikin äärimmäisyys on helposti selitettävissä: tomasfosfaatilla on maata kalkitseva, ammoniumsulfaatilla taas päinvastainen, happamuutta lisäävä vaikutus. Kiintoisa on tosin hieman epävarmaksi jäävä tieto, että kalkitus parantaisi lannankin vaikutusta. — Kuvissa 1 ja 2 esitetään eri käsittelyjen vaikutuksia havainnollisesti pylväinä.

Apila nurmissa. Taulukoissa 1 ja 2 esitettyihin nurmisatoihin sisältyvät sekä apila että timotei, joiden määräsuhteet on kaikkina vuosina selvitetty lajittelemalla ja punnitsemalla ilmakuivana. Molempina nurmikausina saatiin toisen vuoden nurmesta runsaimmat kokonaissadot. Apilan määrät sekä prosentteina että kiloina olivat suurimmat nurmikautena 1958—60 toisen ja nurmikautena 1964—66 kolmannen vuoden nurmessa. Tässä tarkastellaan vain kaikkien vuosien keskiarvoja. Taulukossa 3 esitetään apilan osuus prosentteina koko sadosta ja kg/ha. Kalkitus ja eri lannoiteyhdistelmät, lukuun ottamatta yhdistelmää su, ovat lisänneet apilaa sekä prosentteina että kiloina ilmaistuna.

Perunasatojen laatua osoittavia tietoja ovat vain tärkkelysprosentit, jotka yhdessä tärkkelyssatojen kanssa esitetään taulukossa 4. Kaikki koekäsittelyt ovat selvästi alentaneet tärkkelysprosentteja, mutta kun satomäärät ovat nousseet, ei tärkkelyssatoihin ole tullut vähennyksiä.

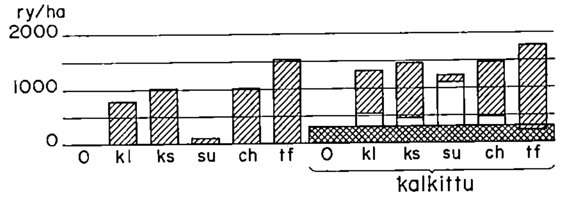


Kuva 1. Eri koelannoitusten ilman kalkitusta ja kalkituksen ohella antamat sadonlisäykset nurmilla ry/ha keskim. 6 sadosta. Koekäsittelyt on merkitty:

0 = ilman lannoitusta
kl = karjanlantaa
ks = väkilannoiteyhdistelmä, jossa kalkkisalpietaria
su = » » ammoniumsulfaattia
ch = » » chilensalpietaria
tf = » » kalkkisalp. ja tomasfosfaattia

Fig. 1. Yield increases obtained with different fertilizings, with and without liming, on ley fu/ha, averages for six yields. Treatments indicated:

0 = *without fertilizing*
kl = *farmyard manure*
ks = *fert. comb. with nitrate of lime*
su = » » » *ammonium sulphate*
ch = » » » *Chilean saltpetre*
tf = » » » *nitrate of lime and basic slag*
kalkittu = *limed*



Kuva 2. Eri koelannoitusten ilman kalkitusta ja kalkituksen ohella antamat sadonlisäykset kaikilla kasveilla, keskim. 13 sadosta. Selitykset ks. kuvaa 1.

Fig. 2. Yield increase obtained with different fertilizings, with and without liming, on all crops fu/ha, averages for 13 yield. For explanations see Fig. 1.

Taulukko 3. Heinäsatojen apilamäärät % ja kg/ha
Table 3. Clover contents of ley yields, % and kg/ha

		Ilman lann. 0	Lannoituksen aiheuttama muutos *Diff. caused by treatments*				
			kl	ks	su	ch	tf
Ilman kalkitusta — *No lime*	%	40	3	13	— 4	16	14
Kalkittu — *Limed*	»	47	4	11	9	15	9
Ilman kalkitusta — *No lime*	kg/ha	2 272	510	1 341	—639	1 488	1 528
Kalkittu — *Limed*	»	2 940	1 720	1 187	960	1 403	1 187

Taulukko 4. Perunan tärkkelys-% ja -sadot kg/ha
Table 4. Starch contents of potato, % and kg/ha

		Ilman lann. 0	Lannoituksen aiheuttama muutos *Diff. caused by treatments*				
			kl	ks	su	ch	tf
Ilman kalkitusta — *No lime*	%	15.8	—1.7	—1.3	—1.7	—1.5	—1.5
Kalkittu — *Limed*	»	15.5	—1.6	—1.2	—1.5	—1.7	—1.8
Ilman kalkitusta — *No lime*	kg/ha	2 602	1 244	1 439	1 330	1 399	1 488
Kalkittu — *Limed*	»	2 582	1 324	1 522	1 478	1 553	1 606

Lannoituksen ja kalkituksen vaikutukset maassa

Keväällä 1968 otettujen ruuduittaisten maanäytteiden analysoinnissa saatuihin lukuihin esitetään katsaus taulukossa 5. Ravinnemääritykset on tehty happamasta ammoniumasetaattiuutteesta ns. viljavuusmenetelmällä.

Maan humuspitoisuutta osoittavissa hiilimäärissä sen enempää kuin kokonaistyppimäärissäkään ei etupäässä eri kerranteiden välisten suurten vaihtelujen vuoksi voida minkäänlaisella varmuudella sanoa olevan koekäsittelyistä johtuvia eroja. Mikään lannoitus ei kuitenkaan näytä ainakaan vähentäneen maan humuspitoisuutta. Tuskinpa sitä on tehnyt kalkituskaan, vaikka 0-käsittelyssä saadut arvot näyttävät viittaavan sellaiseen. Eri lannoituksilla ja kalkituksella on ollut hyvin selvät ja varmat vaikutukset maan happamuuteen ja vaihtuvan kalkin pitoisuuteen. Nämä seikat ovat kiintoisia erityisesti koejäsenen su, ammoniumsulfaatti, kohdalla. Kuten luvuista nähdään, annettu 4 tn/ha kalkkikivijauhetta ei ole riittänyt kokeen käynnissä olon aikana, v:sta 1931 alkaen, kaikkiaan käytetyn ammoniumsulfaatin, yht. 3 050 kg/ha, maan happamuutta lisäävän ja kalkkia kuluttavan vaikutuksen kumoamiseen (teoreettisesti, ekvivalenteissa laskien pitäisi jo 2 500 kg/ha kalkkikivijauhetta olla riittävä).

Varsinaisten kasvinravinteiden, kalin, magnesiumin ja fosforin analyysilukuihin on vain lannoituksella ollut vaikutusta. Tämä vaikutus on ollut positiivinen kaikkiin muihin paitsi magnesiumiin, mikä johtuu siitä, että väkilannoitteet eivät ole sisältäneet magnesiumia, mutta ne ovat satoja nostaessaan kuitenkin lisänneet magnesiumin kulutusta.

Verrattaessa v:n 1968 maanäytteistä saatuja analyysiarvoja aikaisempiin, v:n 1950 vastaaviin (Salonen ja Honkavaara 1954, s. 22—31) ei hiili- ja kokonaistyppimäärissä nähdä eroja. Maan happamuus on kuluneena aikana hieman lisääntynyt kalkitsemattomilla koejäsenillä, lukuunottamatta koejäsentä tf, tomasfosfaatti, mutta kalkitus on pitänyt pH-luvun suunnilleen muuttumattomana. Vaihtuvan kalkin (sinänsä alhaisten) määrien mukaan näyttää epäsuotuisa kehitys nopeammalta, sillä kalkituillakin koejäsenillä pyrkivät luvut olemaan alle 1950:n tason. Kalilukujakin voidaan kaiken kaikkiaan pitää alhaisina, ja niissä on tarkasteltavana aikana tapahtunut vielä laskua. Siitä päätellen annettu kalilannoitus ei näytä täysin riittäneen. Magnesiummääritykset

Taulukko 5. Maa-analyysissä saatuja lukuja koekentästä v:lta 1968

Table 5. Soil analysis values of the trial field, 1968

	Ilman lannoitusta 0	Koelannoitusten aiheuttamat erot *Diff. caused by treatments*					Erojen väliset merkitsevyydet, F-testi *Significances of diff.*		
		kl	ks	su	ch	tf	lann. *fert.*	kalk. *lime*	yhd. vaik. *interact.*
Orgaaninen hiili — *Organic carbon*, C %									
ilman kalk. — *no lime*	3.11	0.37	0.39	0.27	0.03	0.13			
kalkittu — *limed*	3.00	0.47	0.42	0.33	0.31	0.18			
Kokonaistyppi — *Total N* ‰									
ilman kalk. — *no lime*	2.80	—0.04	0.04	—0.02	0.10	—0.04			
kalkittu — *limed*	2.68	0.24	0.17	0.26	0.29	0.22			
pH vedessä — *pH in water*									
ilman kalk. — *no lime*	5.14	0.02	—0.01	—0.20	0.10	0.38			
kalkittu — *limed*	5.46	—0.04	—0.06	—0.40	—0.07	0.28	*	*	
Kalsium, Ca, mg/l maata — *soil*									
ilman kalk. — *no lime*	763	37	56	—125	12	231			
kalkittu — *limed*	925	75	38	—187	19	288	***		
Kalium, K, mg/l maata — *soil*									
ilman kalk. — *no lime*	56	5	57	109	59	42			
kalkittu — *limed*	60	3	58	83	65	40	***		
Magnesium, Mg, mg/l maata — *soil*									
ilman kalk. — *no lime*	146	9	— 42	— 64	— 32	— 30			
kalkittu — *limed*	169	14	— 67	— 95	— 57	— 42	***		
Fosfori, P, mg/l maata — *soil*									
ilman kalk. — *no lime*	3.6	0.9	2.1	2.9	2.0	1.9			
kalkittu — *limed*	3.5	0.5	2.2	2.8	2.0	2.1	***		

on näinä eri aikoina tehty eri menetelmillä (1950:n näytteistä typpihapolla, 1968:n näytteistä happamalla ammoniumasetaatilla), joten vertailu ei ole mahdollinen. Eri tavoin saatujen tietojen mukaan magnesiumlukuja on pidettävä alhaisina. Fosforiluvuissa on poikkeuksena muista ollut pientä nousua, mutta niitä voidaan yhä pitää alhaisina.

Tiivistelmä

Vuodesta 1931 käynnissä olleessa lannan ja eri väkilannoiteyhdistelmien vaikutusta vertailevassa kokeessa on kalkituksen jälkeen vuosina 1955—67 saatu seuraavanlaisia tuloksia:

Kalkitus on kautta linjan suuresti parantanut satoja, eniten happamasti (ammoniumsulfaatti) ja vähiten emäksisesti vaikuttavan lannoituksen (tomasfosfaatti) ohella käytettynä. Kalkkimäärä, 4 tn/ha 50-%:sta kalkkikivijauhetta, ei ole riittänyt poistamaan ammoniumsulfaatin hapanta vaikutusta.

Karjanlannan teho on ollut erittäin hyvä, mutta sen vaikutusta ei voida suoranaisesti verrata väkilannoiteyhdistelmien vaikutukseen, sillä lantaa on annettu liian vähän verrattuna väkilannoiteyhdistelmissä annettuihin kasvinravinnemääriin.

Kaikissa tapauksissa on tomasfosfaattia sisältänyt yhdistelmä ollut paras väkilannoiteyhdistelmä. Sen jälkeen tulevat samanarvoisina typen kalkkisalpietarina ja chilensalpietarina sisältäneet yhdistelmät. Huonoimmaksi jää ammoniumsulfaattiyhdistelmä, joka ohralla ja nurmella on aiheuttanut suoranaista sadonvähennystä.

KIRJALLISUUTTA

SALONEN, M. ja HONKAVAARA, T. 1954. Karjanlannan ja väkilannoitteiden vaikutuksen vertailua. Summary: Results of a long-term field experiment for the comparison of farmyard manure and different fertilizer combinations. Valt. Maatal.koetoim. Julk. 142.

SUMMARY

The effects of farmyard manure and mineral fertilizers II

Different fertilizer combinations and liming

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In an earlier paper, SALONEN and HONKAVAARA 1954, a report was given on the results of a long-term field trial involving acid, muddy clay soil, in which the yield-increasing effects of farmyard manure and various fertilizer combinations were compared. Later, in 1954, the experimental plots were divided, with one half of each plot receiving 4 ton/ha of ground limestone and the other half left unlimed. In the ensuing years, it has become evident that the rate of application of the limestone was underestimated; accordingly, it was deemed necessary to repeat the measure in 1968. Thus, the years 1955—1967 represent a clearly defined experimental period, and the results obtained during this time are reported here.

The experimental measures and the rates of application of the plant nutrients in the period of 1955—1967 are set forth on page 337. It will be noted that the farmyard manure used during this period contained plant nutrients in far smaller amounts than the different fertilizer combinations did. Hence it is not possible to compare the effects of the manure and the various fertilizer combinations.

The yields and yield increases obtained by different treatments in the 1955—1967 period are presented in Scandinavian fodder units in Table 1. Table 2 gives the average yields of various crops. It also shows calculations of the interactions of lime and different fertilizer combinations. Figures 1 and 2 contain diagrams representing the results obtained for leys and the averages for all the crops. Table 3 contains the results of botanical analyses of ley yields, and Table 4 the starch contents of the potato yields.

Table 5 presents the results of the analyses of the soil samples taken in 1968 before the renewed liming. The

Ca, K, Mg and P values have been determined by the ammonium acetate method.

The following conclusions may be drawn from the results obtained during this experimental period:

Liming greatly increased the yields — most when the fertilizer combination was acid (amm.-sulph.), and least when the fertilizer combination had a neutralizing effect (basic slag). Liming with 4 ton/ha ground limestone did not suffice to neutralize the acidifying effect of the ammonium sulphate (used throughout the experimental period of 1931—1967, totalling 3 050 kg/ha).

The yield-increasing effect of farmyard manure proved exceedingly good, 137 ry/ton.

The best fertilizing in this acid soil proved to be the combination containing nitrate of lime + basic slag + potassium chloride. The next best were the combinations in which the nitrogen is in nitrate of lime or in Chilean saltpetre and phosphorus in superphosphate and potassium in potassium chloride. Inferior results were given by the combination of ammonium sulphate + superphosphate + potassium chloride, which caused a decrease in the yields of barley and ley.

ANNALES AGRICULTURAE FENNIAE, VOL. 9: 343—344 (1970)
Seria ANIMALIA NOCENTIA N. 48 — Sarja TUHOELÄIMET n:o 48

RESIDUES OF DIAZINON AND TRICHLORONATE IN CARROTS

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Diazinon, when applied to the soil to control carrot rust fly, persists in plants for a long time (MOSEBACH and STEINER 1960, KLEE and STEINER 1961, TIITTANEN and VARIS 1965). No previous data exists on the persistance of residues of granulated diazinon and trichloronate in plants grown under Finnish conditions. The present study was carried out to clarify the extent to which granulated diazinon and granulated trichloronate, and trichloronate emulsion persist in carrots when applied to plant rows.

Material and methods

The studies were made at the Department of Pest Investigation, Tikkurila, in 1967, by bioassay method using Drosophila as a test organism (VARIS and TIITTANEN 1963). The carrots (var. Nantaise Markthalle) were grown in medium fine sand soil. The residues were first determined in the growing season, when the first carrots were ready for lifting, and were continued throughout the growing season, and some determinations were made during storage. The carrots were kept in cold storage at +2 — +5°C.

Results and discussion

Substantial residues of diazinon strewn on carrot seed rows were found in carrots as late as 70—80 days after application (Table 1). The quantities of diazinon residues found were roughly the same as those applied as diluted emulsion to plant rows (cf. TIITTANEN and VARIS 1965). Also, LASKA (1966) found that granulated diazinon strewn on seed rows persists for quite a long time in carrots.

Table 1. Residues of diazinon and trichloronate in carrots. Carrot variety used was Nantaise Markthalle and soil was medium fine sand. 2 g of granulated insecticide were strewn on seed rows and 0.5 l of diluted emulsion was applied per metre of row

Insecticide and date of application	Active ingredient %	Active ingredient g per metre of row	Number of days between application and bioassay	Residue p.p.m. washed carrots	Residue p.p.m. scraped carrots
Granules on seed rows					
Diazinon	10	0.2	67	> 2	1
(Basudin 10)	—	—	81	1	0
11 May	—	—	88	0.7	0
	—	—	95	> 0	0
	—	—	102	0.1	0
	—	—	109	0.5	0
	—	—	123	0.1	0
	—	—	136	0.4	0
	—	—	179	0	0
Trichloronate	2.5	0.05	75	0.1	0
(Agritox)	—	—	82	0	0
11 May	—	—	89	0	0
	—	—	96	0	0
	—	—	103	0	0
	—	—	110	0	0
	—	—	124	0	0
	—	—	138	0	0
	—	—	180	0	0
Emulsion to plant rows					
Trichloronate	50	0.25	27	0.6	0
(Agritox liquid)	—	—	34	0	0
28 June	—	—	41	0	0
	—	—	48	0.5	0
	—	—	55	0.2	0
	—	—	62	0	0
	—	—	76	0	0
	—	—	90	0	0
	—	—	132	0	0
Trichloronate	50	0.25	1	2.4	0
(Agritox liquid)	—	—	8	4.6	0.1
24 July	—	—	15	2.7	0.5
	—	—	22	> 2	0.1
	—	—	29	> 2	0.2
	—	—	36	0.5	0
	—	—	50	0.5	0
	—	—	64	∼1	0
	—	—	106	1.1	0
	—	—	198	∼1	0

In his investigations the residue after harvest amounted, on average, to 0.60 p.p.m. for 2 years when active ingredient was applied in a quantity of 6 kg/ha, which is a somewhat larger quantity than that applied in the present study. When 3 kg/ha of active ingredient were applied, the corresponding amount of residue was 0.18 p.p.m.

Granulated trichloronate strewn on seed rows had disappeared from the carrots by the time they were ready for consumption.

Trichloronate residues which could be removed by peeling were found in carrots almost two months after the application of trichloronate emulsion to plant rows to control the first generation of carrot rust fly. When plant rows were treated in this way at the time the first carrots were ready for consumption, residues were found in the carrots throughout the remainder of the growing season and even after 1 ½ — 4 months of cold storage. The residues were located chiefly in the skin, and the last residues in scraped carrots were detected 6 months after the application.

Summary

In 1967, an investigation was made at Tikkurila of the persistence in carrots of granulated diazinon and trichloronate strewn on seed rows and of emulsified trichloronate applied on plant rows. The carrot variety used was Nantaise Markthalle, and the soil was medium fine sand.

Diazinon residues amounting to c. 1 p.p.m. were detected as late as 70—80 days after application. In contrast, the granulated trichloronate strewn on the seed rows had disappeared from the carrots by the time they were large enough for consumption. Residues from application to plant rows of trichloronate emulsion carried out when the carrots were large enough for consumption were found throughout the remainder of the growing season and even after 1 ½ — 4 months of cold storage.

The trichloronate residues were located chiefly in the skin; most of these residues could be removed by scraping the carrots.

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SELOSTUS

Diatsinoni- ja trikloronaattijäämät porkkanoissa

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Kylvöriveihin siroteltujen diatsinoni- ja trikloronaattirakeiden sekä kasteluaineena käytetyn trikloronaatin säilymistä porkkanoissa tutkittiin Tikkurilassa v. 1967. Porkkanalajike oli Nantes Markthalle ja maalaji hieno hiekka. Määritykset tehtiin biologista menetelmää käyttäen. Koeeläimenä oli banaanikärpänen.

Tulokset on esitetty taulukossa 1. Diatsinonista todettiin vielä 70—80 vrk:n kuluttua käsittelystä noin 1 p.p.m:n suuruisia jäämiä. Sen sijaan trikloronaatti hävisi porkkanoista siihen mennessä kun ne olivat tarpeeksi suuria käytettäviksi.

Ensimmäisen porkkanakärpässukupolven toukkien torjumiseksi suoritetusta trikloronaattikastelusta voitiin kuorimattomissa porkkanoissa todeta jäämiä lähes kahden kuukauden ajan. Trikloronaattikastelusta, joka tehtiin ensimmäisten porkkanoiden ollessa kooltaan käyttökelpoisia, oli jäämiä koko jäljellä olevan kasvukauden ajan ja vielä 1.5—4 kk kestäneen kellarisäilytyksen jälkeen.

Trikloronaattijäämät sijaitsivat pääasiassa porkkanoiden pintakerroksessa, ja enin osa niistä saatiin poistetuksi raaputtamalla porkkanat.

ANNALES AGRICULTURAE FENNIAE, VOL. 9: 345—346 (1970)

Seria PHYTOPATHOLOGIA N. 30 — Sarja KASVITAUDIT n:o 30

WINTERING OF FIELD CROPS IN FINLAND, 1968—1969

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Received February 10, 1970

In spring 1969, information on damage to field crops during the winter of 1968—69 was requested from agricultural experimental stations and advisers in different parts of Finland (Fig. 1). In the enquiry carried out, damage caused by biotic and abiotic factors to winter cereals, clover and the most common species of grasses was estimated by visual analyses according to a scale of 0—3, as follows: 0 = no winter damage, 1 = 1—10 %, 2 = 10—40 % and 3 = 40—100 % damage to the stands. The results are presented in Table 1. It should be mentioned that due to recovery during the growing season economic losses will have been lower than the values given. The various factors contributing to winter damage are, however, most easily distinguished early in the spring.

In 1968—69, wintering of field crops varied greatly in different parts of the country. In southern Finland, apart from clover, the results can be considered satisfactory, in central Finland poorer than usual, and in northern Finland, especially in Lapland, very poor. Throughout the whole country, clover was attacked heavily by clover rot (*Sclerotinia trifoliorum*).

In southern Finland the abiotic factors caused more damage to winter cereals and grasses than the biotic ones. Of the former factors, frost and heaving were the most important. *Fusarium nivale* was the most common winter-killing fungi found. Exceptionally, *S. borealis* appeared in several localities.

The importance of winter-killing fungi increased in central Finland, and cereals, especially,

Fig. 1. Observation areas (black) in (I) southern, (II) central and (III) northern Finland covered by the enquiry made in spring 1969 concerning the wintering of field crops. Personal observations on the hatched area.

Kuva 1. Havaintoalueet (mustat) (I) Etelä-, (II) Keski- ja (III) Pohjois-Suomessa keväällä 1969 suoritetussa peltokasvien talvehtimista koskevassa tiedustelussa. Viivatulta alueelta omia havaintoja.

Table 1. Damage occurring in winter cereals, clover and grasses in the winter of 1968—69, in (E) southern, (K) central and (P) northern Finland, according to the enquiry made in spring 1969. The figures given are the average values derived from the answers received (explanation in the text). + = sporadic appearance.

Taulukko 1. Talvehtimisvauriot syysviljoissa ja yleisimmissä nurmikasveissa 1968—69 keväällä 1969 suoritetun tiedustelun perusteella (E) Etelä-, (K) Keski- ja (P) Pohjois-Suomessa. Luvut ovat vastausten keskiarvoja (selostus tekstissä). + = satunnaisia esiintymisiä.

Field crop [1]) — *kasvi*

Cause of damage *Tubon aiheuttaja*	Triticum aestivum *Syysvehnä*			Secale cereale *Ruis*			Trifolium spp. *Apila*			Phleum pratense *Timotei*			Festuca pratensis *Nurminata*			Dactylis glomerata *Koiranheinä*		
	E	K	P	E	K	P	E	K	P	E	K	P	E	K	P	E	K	P
Biotic factors — *Bioottiset tekijät*																		
Fusarium nivale [2]) — *Lumihome* ..	0.5	1.2	—	0.8	1.5	1.5	0.4	0.4	1.0	+	0.7	1.5	0.3	0.7	1.3	0.3	1.0	1.5
Typhula spp. — *Pahkulahomeet*	0.3	0.9	—	0.2	0.5	0.2	+	+	0.5	+	0.2	0.6	0.1	0.4	0.8	0.1	0.4	0.5
Sclerotinia borealis — *Pohjolan pahkahome*	+	0.2	—	+	0.2	—	—	—	—	+	0.2	0.3	+	0.1	0.2	+	+	0.2
Sclerotinia trifoliorum — *Apilamätä*	—	—	—	—	—	—	1.3	1.4	0.8	—	—	—	—	—	—	—	—	—
	0.8	2.3	—	1.0	2.2	1.7	1.7	1.8	2.3	+	1.1	2.4	0.4	1.2	2.3	0.4	1.4	2.2
Abiotic factors — *Abioottiset tekijät*																		
Water — *Vesi*	0.4	0.2	—	0.3	0.2	0.5	0.3	+	—	0.1	0.2	0.3	0.2	0.2	0.3	0.1	0.1	0.3
Heaving — *Rouste*	0.5	0.9	—	0.5	0.7	0.1	0.3	0.3	—	0.2	0.2	0.3	0.3	0.3	+	0.3	0.2	+
Ice — *Jää*	0.2	0.9	—	0.2	0.4	0.3	0.3	0.7	+	0.2	0.4	0.2	0.2	0.5	+	0.2	0.6	+
Frost — *Pakkanen*	0.4	0.6	—	0.4	0.3	—	0.4	0.4	+	0.1	0.1	—	0.4	0.2	+	0.4	0.4	+
	1.5	2.6	—	1.4	1.6	0.9	1.3	1.4	+	0.6	0.9	0.8	1.1	1.2	0.3	1.0	1.3	0.3
Winter damage, total — *Talvehtimisvauriot yhteensä*	2.3	4.9	—	2.4	3.8	2.6	3.0	3.2	2.3	0.6	2.0	3.2	1.5	2.4	2.6	1.4	1.7	2.5

1) On turnip rape, only sparse data available. — *Rypsistä ainoastaan hajatietoja.*

2) On clover *Fusarium* spp. — *Apilassa Fusarium spp.*

were attacked by the pathogens. *F. nivale* was the most common species found, on both cereals and grasses. On cereals, *Typhula* spp. also appeared with high frequency. The damage caused by *S. borealis* was small and local. Ice and heaving were the most harmful abiotic factors in central Finland.

In northern Finland, winter rye appeared to be in good condition in spring 1969. On the other hand, severe injuries caused by attacks of winter-killing fungi were found on the grasses. The greatest damage occurred in young stands, approximately 50 % of which were destroyed. *F. nivale* was most injurious in the southern and eastern parts and in northern Lapland, and *T. ishikariensis* in central Lapland. In some localities *S. borealis* also caused damage. In northern Finland, the damage caused by abiotic factors was small as compared with other parts of the country.

SELOSTUS

Peltokasvien talvehtiminen Suomessa 1968—1969

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Tietoja peltokasvien talvehtimisesta 1968—69 saatiin keväällä 1969 eri puolilta Suomea (kuva 1). Suoritetussa tiedustelussa käytettiin talvehtimisvaurioiden arvioinnissa asteikkoa 0—3 seuraavasti: 0 = ei vaurioita, 1 = 10 %, 2 = 10—40 % ja 3 = 40—100 % lehtimassasta tuhoutunut. Kyselyyn saapuneet vastaukset (taul. 1) osoittavat, että maan eteläosissa talvehtiminen oli tyydyttävä, keskiosissa keskimääräistä huonompi sekä pohjoisosissa, varsinkin Lapissa, erittäin huono. Koko maassa apila kärsi pahasti apilamädän runsaasta esiintymisestä.

ANNALES AGRICULTURAE FENNIAE, VOL. 9: 347—356 (1970)
Seria ANIMALIA DOMESTICA N. 34 — Sarja KOTIELÄIMET n:o 34

MAJOR MINERAL ELEMENTS IN THE BOVINE RUMEN FLUID I

Concentrations and their changes between feedings

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Received March 9, 1970

One of the most significant aspects of the mineral elements in bovine rumen fluid is their neutralizing and buffering effect on the acids in the rumen. Interest attaches to the extent to which the different dietary, and possibly other, factors affect the concentration of certain mineral elements in the rumen and the internal circulation of minerals in the animal. It has been shown that the addition of some mineral elements to the rumen have improved the buffering capacity of the rumen fluid (HAWKINS and LITTLE 1968), favoured the digestion in the rumen (CHAPPEL et al. 1952) and affected the flow rate (POUTIAINEN 1968).

There is abundant information in the literature concerning the concentration of different mineral elements in the rumen fluid of animals on a variety of feeds. Systematic studies on the effect of certain dietary or other factors are, however, rare. LAMPILA (1965) and LAMPILA and POUTIAINEN (1966) showed that the time of sampling after feeding and the location of the sampling point in the rumen had a significant effect on the concentration of sodium and potassium in the rumen. FENNER et al. (1969) observed that dry matter intake influenced the concentration of dissolved mineral elements in the rumen fluid of animals fed on hay and they also give equations for the patterns of change in concentration with the time of sampling after feeding. If the pattern of change in concentration of a certain mineral element in the rumen could be expressed in the form of a general equation, this would make it easier to compare the results of different experiments.

The purpose of this study was to investigate the effect of certain dietary factors on (1) the mean concentrations of some major mineral elements in the rumen fluid, (2) the pattern of change in concentration between two feedings, and (3) the possible differences in concentration between different parts of the rumen. The dietary factors in question were: (1) the level of feed intake, (2) the dosage of sodium chloride, and (3) the proportion of long hay in the ration.

Experimental

Animals and diets

Two Ayrshire cows fitted with rumen fistulas (STODDARD et al. 1951) were used as experimental animals. The experiments were conducted during two indoor feeding periods in 1965—66. The rations were fed twice daily at 05.00 hrs. and 17.00 hrs. in two equal portions. Water was accessible to the animals at all times.

The composition of the experimental diets and the feeding schedules have been described in detail in an earlier publication (POUTIAINEN 1968). Briefly, 50 % of the rations consisted of hay (long or ground) and 50 % of concentrates with the exception of the diets concicting solely of long hay. The effect of dry matter intake on the mineral elements in the rumen was investigated by feeding 3, 6, 9, 11—12 and 14 kg DM/day. Sodium was supplied as NaCl in doses of 0, 50 and 100 g/day at the DM levels of 6 to 14 kg/day. The effect of the physical character of the ration on the minerals in the rumen was investigated by adjusting the proportion of long hay in the diet to 100, 50, 25 and 10 % of DM. This was done by giving part of the hay in finely ground form (1.5 mm screen). With all the diets 100 g dicalcium phosphate, was given per day.

Sampling and preparation of samples

Before sampling was begun the animals were kept on each of the experimental diets for periods averaging 16 days. The samples from the rumen were taken at 3 hour intervals from 05.00 hrs. to 17.00 hrs., the first samples being taken just before the 05.00 hr. feed. Each time samples were taken from four different parts of the rumen: upper, central, lower and lower fore parts. The description of the sampling device used and the location of the points of sampling have been given in an earlier paper (LAMPILA and POUTIAINEN 1966).

The sampling procedure was repeated three times for each diet, with a 24-hour non-sampling interval between each period of sampling. The samples of three days were put together so that four bulk samples, relating to the four parts of the rumen, were obtained for each of the five daily sampling times.

The samples were centrifuged for 20 minutes at 4 000 r.p.m. in order to separate the plant material, and the supernatant fluid was used for the analyses of the mineral elements.

Analytical methods

The diluted rumen fluid was used for the sodium, potassium and chloride determinations. 10 ml of the supernatant fluid were wet-ashed with sulphuric acid and hydrogen peroxide (LAKANEN, personal communication) in a micro-Kjeldahl apparatus. The wet-ashed samples, made up to a total volume of 100 ml with distilled water, were used for the determinations of calcium, magnesium and phosphorus. For the feeds, the dry-ashing method described by SALONEN et al. (1960) was applied. The method used for the determinations of the different mineral elements were as follows:

C a l c i u m a n d m a g n e s i u m were determined with the atomic absorption spectrophotometer. Lanthanum oxide (La_3O_2) was used in the solution to avoid disturbances from the other mineral elements, especially phosphorus. Every reading was taken three times and the mean value was taken as the concentration of the Ca and Mg of the sample.

P o t a s s i u m was determined directly from the diluted rumen fluid with a flame photometer.

S o d i u m was determined with Beckman's Na electrode and a Model 76 pH meter with an expanded scale (POUTIAINEN and LAMPILA 1966).

C h l o r i d e was measured by potentiometric titration.

P h o s p h o r u s was measured colorimetrically.

Results and discussion

The mineral contents of the different diets, expressed as grams per kg DM, are shown in Table 1. The daily intakes of K, Ca, Mg and P were almost completely determined by the DM intake, because the concentrations varied rather little. The intakes of Na and Cl were determined by both the DM intake and the dosage of NaCl.

The significance of different factors for the concentration of dissolved mineral elements in the rumen fluid was analysed statistically with the analysis of variance. The results are shown

Table 1. The intake of six mineral elements by two experimental cows, Ina and Irpu, on different diets, expressed as g per kg DM ingested

Diet No	DM intake kg/day	NaCl supplement g/day	Proportion of long hay as % DM	Na		K		Ca		Mg		P		Cl	
				INA	IRPU	INA	IRPU	INA	IRPU	INA	IRPU	INA	IRPU	INA	IRPU
1	14	100	50	4.15	—	16.09	—	5.15	—	1.45	—	4.30	—	11.31	—
2	»	50	»	2.56	—	15.66	—	4.61	—	1.99	—	4.90	—	7.37	—
3	»	0	»	0.63	—	16.04	—	4.49	—	1.63	—	4.48	—	3.85	—
4	12	100	50	4.16	3.67	14.71	13.88	7.04	6.43	2.33	2.31	4.55	4.47	13.75	12.24
5	»	50	»	3.11	3.00	13.34	13.19	6.41	6.19	2.23	2.24	4.57	4.53	8.20	7.92
6	»	0	»	0.74	0.75	13.74	13.80	7.00	8.39	2.37	2.69	5.52	5.80	3.74	3.68
7	9	100	50	5.02	5.83	16.31	14.93	7.24	6.74	1.82	2.26	4.98	5.24	14.62	15.67
8	»	50	»	2.66	3.51	15.05	13.84	8.07	6.47	2.00	1.87	5.25	5.29	9.43	9.24
9	»	0	»	0.44	1.11	13.78	13.09	5.66	5.55	1.82	1.86	5.44	5.14	3.73	3.61
10	9	50	100	2.89	2.76	22.73	24.85	7.53	7.26	1.49	1.39	4.33	4.68	11.96	12.22
11	»	»	25	3.28	3.27	11.72	12.64	6.44	6.16	1.72	1.52	5.47	5.07	10.51	9.89
12	»	»	10	3.51	3.60	12.31	12.74	7.42	6.98	1.98	2.19	5.20	6.02	8.80	10.37
15	6	50	100	4.09	3.93	18.25	22.27	8.44	8.44	1.34	1.33	5.16	5.33	14.78	15.30
13	»	»	50	4.52	3.73	16.32	17.70	7.74	9.23	1.87	2.00	6.58	6.27	11.77	11.93
16	»	»	25	4.60	6.62	12.33	11.83	6.23	7.52	1.77	1.97	6.87	6.48	11.93	14.59
17	»	»	10	4.63	6.73	11.27	11.77	5.33	8.27	1.60	1.47	5.77	6.30	11.57	14.07
18	3	50	100	—	6.63	—	22.25	—	11.69	—	1.38	—	8.13	—	23.00
19	»	»	50	—	6.75	—	13.56	—	10.00	—	1.50	—	8.56	—	19.44
20	»	»	10	—	7.56	—	10.94	—	10.56	—	1.63	—	9.19	—	19.44

Table 2. Significance of effects of various factors on the concentration of certain dissolved mineral elements in the rumen fluid, proportion of long hay in diet being 50 % of DM

Parameters	Na	K	Ca	Mg	P	Cl
Cows	NS	NS	NS	NS	NS	NS
Dry matter	NS	NS	NS	NS	NS	NS
Sodium chloride	*	***	NS	NS	*	NS
Time of sampling	***	***	**	***	NS	***
Part of rumen	*	***	**	**	NS	***

Table 3. Significance of effects of various factors on the concentration of certain dissolved mineral elements in the rumen fluid with NaCl dosage of 50 g/day

Parameters	Na	K	Ca	Mg	P	Cl
Cows	NS	NS	NS	NS	NS	NS
Dry matter	NS	NS	NS	NS	*	NS
Long hay proportion	NS	NS	NS	NS	NS	NS
Time of sampling	***	***	***	***	NS	***
Part of rumen	NS	***	**	***	***	**

Levels of significance: NS Non-significant, * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

in Tables 2 and 3. The factors wich appeared to exert a statistically significant effect on the concentration of certain mineral elements were examined in more detail in an attempt to find a general equation for the patterns of change in concentration. The time of sampling after feeding affected the concentration of all the mineral elements studied except P. The method of orthogonal polynomials was used in fitting the prediction curves for the concentrations as a function of time after feeding.

Sodium (Na)

The concentration of Na in the rumen fluid was not significantly affected by the DM intake or the proportion of long hay in the ration, but it was significantly affected by the dosage of NaCl. However, the Na concentration showed a tendency to decrease when the intake of DM increased. The effects of these factors on the mean concentration are discussed in an earlier publication (Poutiainen 1968).

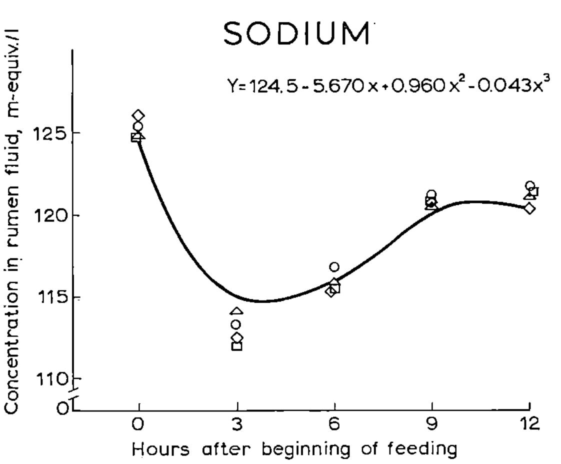

Fig. 1

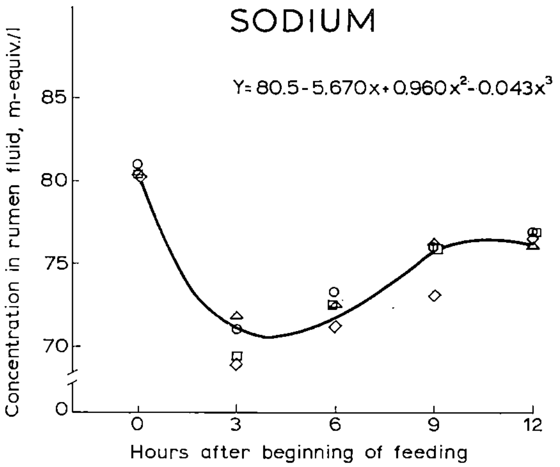

Fig. 2

Fig. 1—2. The changes in the mean concentrations of Na in bovine rumen fluid as a function of time after feeding at NaCl dosage levels of 100 and 50 g (Fig. 1) and 0 g (Fig. 2) per day. Symbols: observed mean values for upper △, central ○, lower □ and lower fore ◇ parts of the rumen.

The time of sampling had a significant effect on the Na concentration. The changes in Na concentration as a function of time at different levels of NaCl dosage, are expressed in Figures 1—2.

The differences in Na concentration between the sampling points could only just be detected in this material (Table 2), but are so small that they cannot be considered to be of any practical importance. This point is discussed in the paper of Lampila and Poutiainen (1966).

The changes in Na concentration as a function of time were best predicted with a polynomial of the third degree. The pattern of change was fairly independent of the level of Na concentration in the rumen fluid and the same prediction equation coefficients are applied for the high (50/100 g/day NaCl) and low (0 g/day NaCl) values of Na concentration. The prediction equation account for 95 and 92 % of squares among the time of sampling on the high and low levels of Na concentration of rumen fluid respectively.

The minimum concentration of Na occurred 3—4 hours after feeding. This is in agreement with the results of Lampila (1964) and Fenner et al. (1969). The last-mentioned authors have calculated the prediction equation for the changes in Na concentration as a function of time and obtained a polynomial of the second degree. The changes in concentration were predicted for a eight-hour period instead of the 12-hour period used in this experiment.

Potassium (K)

The concentration of K was not significantly affected by the DM intake, or the proportion of long hay, but the effect of the dosage of NaCl was found to be significant.

The time of sampling and the part of the rumen from which the samples were taken had a significant influence on the K concentration. The changes in K concentration as a function of time are presented in Figures 3 and 4.

The values for the NaCl dosage levels of 100 and 50 g/day are combined because the K concentration of the rumen fluid was the same at both levels (Fig. 3). The concentration of K was markedly higher at the 0 level of NaCl dosage. The reasons for this phenomenon have been discussed in detail in an earlier paper (Poutiainen 1968). Apart from the difference in the level of K between the 0 and 50/100 g NaCl supplement levels, there was also a difference in the pattern of change in concentration as a function of time. The prediction equations are polynomials of the third degree in both cases, but the

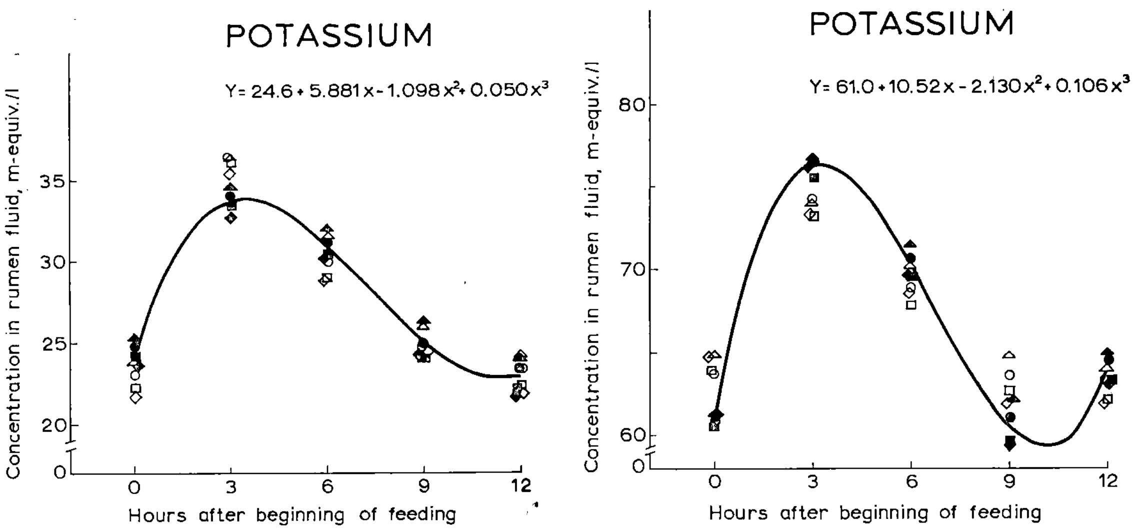

Fig. 3—4. The changes in the mean concentrations of K in bovine rumen fluid as a function of time after feeding at NaCl dosage levels of 100 and 50 g (Fig. 3) and 0 g (Fig. 4) per day. Symbols: observed (open) and predicted (closed) values for upper △ ▲, central ○ ●, lower □ ■ and lower fore ◇ ◆ parts of the rumen.

increase in K concentration after feeding was considerably sharper when NaCl was not given (Fig. 4). The high concentration of potassium in the saliva (cf. POUTIAINEN 1968) together with the ample amount of K in the feeds raised the concentration. The prediction equations for the K concentration accounted for 95 % (Fig. 3) and 90 % (Fig. 4) of the squares among the time of sampling. The maximum concentrations were attained 3—4 hours after feeding i.e. as soon as the whole ration had been consumed. Changes of the same type have been observed by LAMPILA (1965) and FENNER et al. (1969).

The differences in the concentration of K between the parts of the rumen are greater than those in Na concentration. This has already been observed in the investigation of LAMPILA and POUTIAINEN (1966), where the reasons for this phenomenon and its significance are discussed.

Calcium (Ca)

None of the dietary factors studied affected the concentration of Ca in the rumen fluid. The input of Ca into the rumen is almost completely regulated by the dietary Ca, and the flow of soluble Ca was fairly constant per kg DM eaten (POUTIAINEN 1970). In the experiments reported by FENNER et al. (1969) the DM intake influenced the concentration of Ca in hay feeding. The prediction equation for the concentration of dissolved Ca was polynomial of the second degree.

The time of sampling after feeding and the location of the sampling point had significant effects on the concentration of dissolved Ca in the rumen fluid. The curves and equations for the changes in Ca concentration are given in Figure 5. The prediction equation fitted to the average Ca concentrations accounted for 97 % of the sums of squares among the time of sampling.

The maximum concentration was observed 3—4 hours after feeding and it was nearly 50 % higher than the concentration just before feeding, when it was at a minimum. The differences in the concentration of Ca between the different parts of the rumen are marked, but the patterns of change as a function of time are much the same. The range of concentration is the same as those reported by LAMPILA (1964) and FENNER et al. (1969).

The effect of time on the concentration of dissolved Ca can be explained by the fact that its concentration is closely dependent on the dietary Ca. Ca is evidently released slowly into

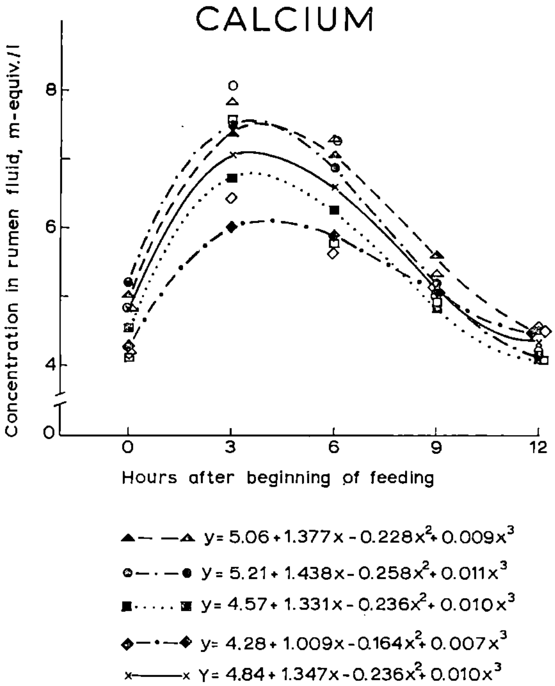

Fig. 5. The changes in the mean concentrations of dissolved Ca in bovine rumen fluid in different parts of the rumen as a function of time after feeding. Symbols: observed (open) and predicted (closed) values for upper △ ▲, central ○ ●, lower □ ■ and lower fore ◇ ◆ parts of the rumen.

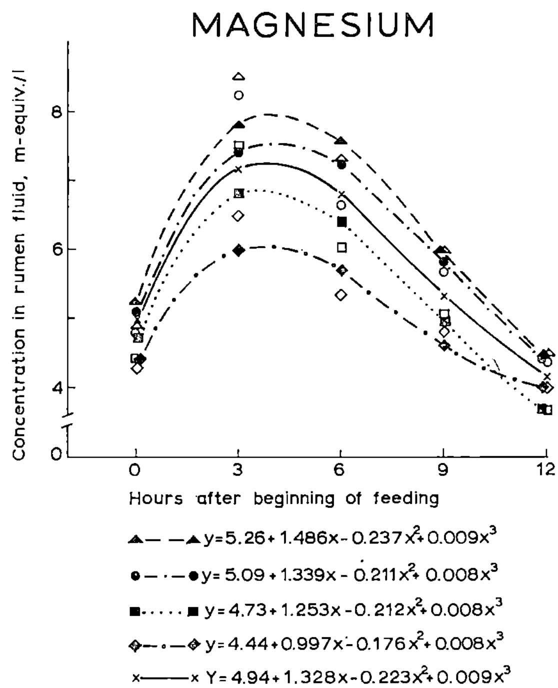

Fig. 6. The changes in the mean concentrations of dissolved Mg in bovine rumen fluid in different parts of the rumen as a function of time after feeding. Symbols: observed (open) and predicted (closed) values for upper △ ▲, central ○ ●, lower □ ■ and lower fore ◇ ◆ parts of the rumen.

the fluid from the ingested feed and, since it is not absorbed through the rumen wall in any significant amount, it accumulates in the rumen as the animal feeds. The difference in concentration between the parts of the rumen is partly explained by the above-mentioned factors. In addition, since saliva contains very little Ca and it reaches the bottom layers of the rumen first, it evidently reduces the calcium concentration there. The diluting effect of the drinking water must also be considered. The differences in Ca concentration on due to the time of sampling after feeding and the location of the sampling point are great enough to be taken into account in sampling procedure.

Magnesium (Mg)

None of the dietary factors studied had a significant effect on the concentration of Mg in the rumen fluid. Dietary Mg was the main source of Mg, as the saliva supplied only about 4 % of the total input (cf. Poutiainen 1970), and since the amount of Mg and the flow of fluid per kg DM eaten were fairly constant, the concentration was not greatly influenced by the dietary factors. In the experiments of Fenner et al. (1969) an increase in the level of the feed intake increased Mg concentration significantly when the diet consisted solely of hay. With such a diet the flow of fluid evidently did not increase in the same proportion as the input of Mg.

The time of sampling after feeding and the sampling point in the rumen had a significant effect on the concentration of Mg. The curves and their equations are presented in Figure 6. The prediction equation fitted to the average Mg concentrations accounted for 94 % of the sum of squares among the time of sampling.

The maximum concentrations were reached 3—4 hours after feeding. Mg accumulates in the rumen with the ingested feed. The pattern of change in Mg concentration is almost identical with that of Ca (Fig. 5). The concentration changes can be predicted with polynomials of the third degree. There are marked differences between the upper and lower parts of the rumen in both the level of concentration and the pattern of change as a function of time. The reasons are evidently the same as those suggested in the discussion of Ca. Since the pattern of change in Mg concentration due to the sampling time is fairly regular, it may be possible to predict the Mg concentration at some other time after feeding than that when the sample is taken. However, when making such predictions, it should be taken into account that the length of the feeding interval may influence the pattern of change (cf. FENNER et al. 1969).

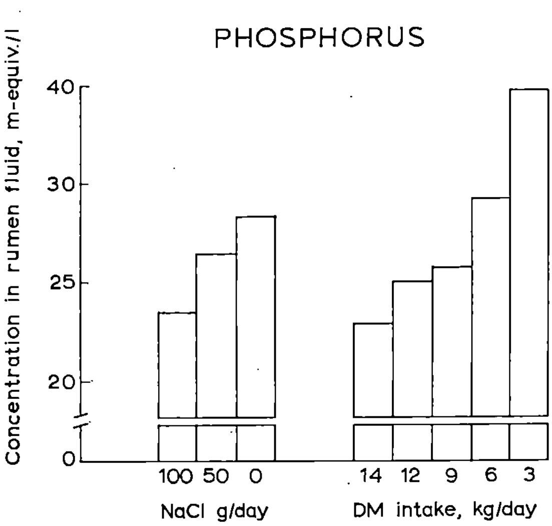

Fig. 7. The effect of the level of NaCl dosage and the level of DM intake on the mean concentrations of dissolved P in bovine rumen fluid.

Phosphorus (P)

Of the dietary factors studied, the level of DM intake and the dosage of NaCl had an influence on the concentration of dissolved P in the rumen fluid. Contrary to the position with all the other major mineral elements in the rumen fluid, the concentration of P was independent of the time of sampling after feeding. Therefore prediction equations were not calculated for P.

A fairly constant concentration of P was also observed by LAMPILA (1964) in animals on diets containing about the same amount of P as in the present investigation. When the P concentration of the diet was very high (wheat bran included), the P content of the rumen fluid tended to be higher immediately after feeding especially in the upper part of the rumen, than at other times during the feeding interval. The remarkably uniform concentration of dissolved P in the rumen fluid is maintained by the ample and constant flow of salivary P (POUTIAINEN 1970). The low solubility of phosphorus compounds in the feeds also partly explains the constancy of the P concentration in the rumen.

The differences in P concentration between the different parts of the rumen were significant in one sequence of results (Table 3), but not in the other one (Table 2). Since the differences in the concentration of P between the sampling points were not very regular and not of great importance, the values of P are not presented separately for each part of the rumen.

The effects of DM and NaCl on the P concentration are shown in Figure 7. The concentration P increased with decreasing NaCl dosage, each 50 g decrease in the dosage producing an increase in concentration of about 10 %. Since there were no distinct differences in the intake of P at the different NaCl dosage levels (cf. Table 1), it would seem that these changes should be attributed to variations in the salivary supply of P, which, on the average, accounted for 60 % of the total amount of dissolved P entering the rumen (POUTIAINEN 1970). The P concentration in the saliva decreased with increases in the dosage of NaCl (unpublished data) probably as a result of an observed increase in the flow rate of the saliva. It has been shown that the concentration of phosphate in the saliva is reduced when the rate of secretion increases (COATS and WRIGHT 1957). The increase in the P concentration of the rumen fluid with decreasing DM intake is also connected with the salivary P. The inflow of salivary P per kg DM eaten had a tendency to increase when the level of DM was decreased.

Chloride (Cl)

None of the dietary factors studied affected the concentration of Cl in the rumen fluid. This was even the case with the dosage of NaCl, which naturally increased the amount of Cl reaching the rumen fluid. The overdose of Cl was easily absorped through the rumen wall and thus the concentration remained within the same limits irrespective of the diet (cf. POUTIAINEN 1970).

The interval between feeding and sampling and the part of the rumen had a significant influence on the concentration of Cl in the rumen fluid. The patterns of change are presented in Figure 8. The changes in the concentration of Cl as a function of time can be predicted with a polynomial of the third degree. The prediction equation accounted for 88 % of the sum of squares among the time of sampling.

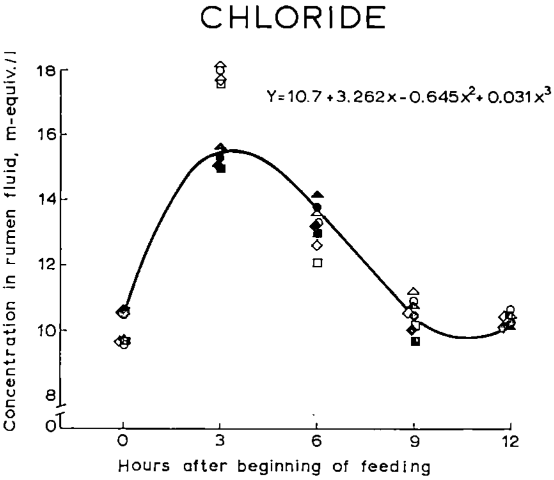

Fig. 8. The changes in the mean concentrations of Cl in bovine rumen fluid as a function of time after feeding. Symbols: observed (open) and predicted (closed) values for upper △ ▲, central ○ ●, lower □ ■ and lower fore ◇ ◆ parts of the rumen.

Interest attaches to the differences in the behaviour of the two anions Cl and P and the factors responsible for the changes in their concentration. The proportions of the total input introduced by the saliva into the rumen are of about the same magnitude for both anions (POUTIAINEN 1970, Table 5). The explanation for their differing concentrations evidently lies in the difference between the solubilities of phosphates and chlorides. The phosphates have a low solubility and therefore remain longer in the feeds while the chlorides are more quickly and easily released into the rumen fluid. The concentration of the latter then increases to a certain level before absorption starts to take place. The subsequent decrease in concentration is mainly the results of the outflow of Cl through the reticulo-omasal orifice. The Cl content of the saliva is lower than that of the rumen fluid (BAILEY 1961).

Summary

This paper is a report of studies made on the effect of some dietary factors on the concentrations and on the pattern of concentration changes of sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), phosphorus (P) and chloride (Cl) in the rumen fluid during a 12-hour feeding interval. The dietary factors in question were: 1) the level of feed intake (3—14 kg DM/day), 2) the dosage of sodium chloride 0, 50 and 100 g/day), and 3) the proportion of long hay in the ration (100, 50, 25 and 10 % of DM). Two cows equipped with rumen fistulas were used as experimental animals.

The cows were fed twice daily at 05.00 hrs and 17.00 hrs. With each diet samples of the rumen fluid were taken at regular 3-hour intervals and each time from four different points in the rumen: upper, central, lower and lower fore parts. The fluid samples were analysed for Na, K, Ca, Mg, P and Cl.

The findings made in these studies were as follows:

(1) The concentrations of Na and K in the rumen fluid were not significantly affected by the DM intake or proportion of long hay but they were significantly afected by the dosage of NaCl.

(2) The concentrations of Na and K were significantly affected by the time of sampling after feeding. The Na concentration decreased while the K concentration increased during the first 3 hours after feeding, after which the concentrations returned to the prefeeding levels. The increase in K concentration after feeding was more marked when the diet was not supplemented with NaCl than when 50 or 100 g of NaCl were given. The differences in Na and K concentrations between the four sampling points in the rumen were statistically significant but small in absolute terms.

(3) None of the dietary factors studied had a significant effect on the concentrations of dissolved Ca and Mg in the rumen fluid.

(4) The concentrations of Ca and Mg were significantly affected by the time of sampling after feeding and the sampling point. The patterns of changes in concentration as a function of time were almost identical for Ca and Mg. The maximum concentrations were reached 3—4 hours after the beginning of feeding, after which the concentrations sank to the prefeeding level. There were marked differences between the different parts of the rumen both as regards the level of concentration and the patterns of change as a function of time.

(5) The concentration of dissolved P in the rumen fluid increased significantly with decreasing NaCl dosage and with decreasing DM intake.

(6) The concentration of dissolved P in the rumen fluid remained fairly constant throughout the feeding interval and was not significantly affected by the time of sampling. The differences between the different parts of the rumen were not great, but attained significance in one sequence of samples.

(7) None of the dietary factors studied affected the concentration of Cl in the rumen fluid.

(8) The time of sampling and the part of the rumen had a significant influence on the Cl concentration of the rumen fluid. The pattern of change in concentration as a function of time was basically the same as those of Ca and Mg, the maximum values being obtained 3—4 hours after feeding.

(9) The possible reasons for these patterns of concentration change are discussed, and prediction equation are presented for changes in the concentration of different mineral elements as a function of time after feeding.

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SELOSTUS

Lehmän pötsinesteen tärkeimmät kivennäisaineet I

Konsentraatiot ja niiden muutokset ruokintojen välillä

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Kirjoituksessa on selostettu tutkimuksia, joissa selvitettiin eräiden ruokinnallisten tekijäin vaikutusta natriumin (Na), kaliumin (K), kalsiumin (Ca), magnesiumin (Mg), fosforin (P) ja kloorin (Cl) konsentraatioihin pötsinesteessä ja niiden muutoksiin ruokintavälin aikana. Kyseessä olevat ruokinnalliset tekijät olivat 1) syödyn kuiva-aineen määrä (3—14 kg/p), 2) ruokasuolan annostus (0, 50 ja 100 g/p), ja 3) pitkän heinän osuus kuiva-aineesta (100, 50, 25 ja 10 %). Koe-eläiminä käytettiin kahta pötsifistelillä varustettua lehmää.

Lehmät ruokittiin kahdesti päivässä, klo 05.00 ja 17.00. Kullakin dieetillä otettiin pötsinesteestä näytteitä säännöllisesti kolmen tunnin välein ja joka kerta neljästä eri pötsin osasta: ylä-, keski-, ala- ja etualaosasta. Pötsinestenäytteistä analysoitiin Na, K, Ca, Mg, P ja Cl.

Tutkimuksissa saatiin seuraavia tuloksia:

(1) Syödyn kuiva-aineen määrä ja pitkän heinän osuus kuiva-aineesta eivät merkittävästi vaikuttaneet Na:n ja K:n konsentraatioihin pötsinesteessä. Sen sijaan ruokasuolan annostuksen vaikutus sanottujen kivennäisten konsentraatioihin oli tilastollisesti merkitsevä.

(2) Näytteenottoajankohta vaikutti Na:n ja K:n konsentraatioihin pötsinesteessä erittäin merkitsevästi. Na-konsentraatio aleni K-konsentraation vastaavasti noustessa kolmen ruokinnanjälkeisen tunnin aikana, minkä jälkeen konsentraatiot palasivat ruokintaa edeltäneille tasoille. K-konsentraation nousu ruokinnan seurauksena oli selvempi dieeteillä, joilla ruokasuolalisäystä ei annettu, kuin dieeteillä, joissa oli 50 tai 100 g:n NaCl -lisäys. Na:n ja K:n konsentraatioerot pötsin osien välillä olivat tilastollisesti merkitsevät, mutta absoluuttisesti pienet.

(3) Mitkään tutkituista ruokinnallisista tekijöistä eivät vaikuttaneet tilastollisesti merkitsevästi pötsinesteen liukoisen Ca:n ja Mg:n konsentraatioihin.

(4) Näytteenottoajankohta ja näytteenottopaikka pötsin sisällössä vaikuttivat erittäin merkitsevästi liukoisen Ca:n ja Mg:n konsentraatioihin. Ajan funktiona esitetty konsentraation muutos pötsinesteessä ruokintavälin aikana oli Ca:lla ja Mg:lla jokseenkin samanlainen. Korkeimmat konsentraatioarvot saavutettiin molemmilla kivennäisillä 3—4 tuntia ruokinnan jälkeen, ja sitten ne alenivat ruokintaa edeltäneille tasoille. Pötsin osien välillä oli huomattavat erot sekä konsentraatiossa että niiden muutoksissa ajan funktiona.

(5) Liukoisen P:n konsentraatio pötsinesteessä nousi merkitsevästi ruokasuolan annostuksen pienentyessä sekä syödyn kuiva-ainemäärän pienentyessä.

(6) Liukoisen P:n konsentraatio pötsinesteessä pysyi jokseenkin vakiona ruokintavälin aikana, eikä näytteenottoajankohta vaikuttanut siihen tilastollisesti merkitsevästi. Pötsin osien väliset erot P-konsentraatiossa eivät olleet suuret, mutta ne olivat yhdessä näyteryhmässä tilastollisesti merkitsevät.

(7) Mitkään tutkituista ruokinnallisista tekijöistä eivät vaikuttaneet pötsinesteen Cl-konsentraatioon.

(8) Näytteenottoajankohta ja pötsin osa vaikuttivat merkitsevästi Cl-konsentraatioon pötsinesteessä. Ajan funktiona esitetty Cl-konsentraation muutos ruokintavälin aikana noudatti periaatteessa samaa kaavaa kuin Ca:n ja Mg:n, konsentraation ollessa maksimiarvoissa 3—4 tuntia ruokinnan jälkeen.

(9) On tarkasteltu mahdollisia syitä havaittuihin konsentraatiomuutoksiin ruokintavälin aikana ja esitetty yhtälöt eri kivennäisalkuaineiden konsentraatiomuutoksille ruokinnasta luetun ajan funktiona.

ANNALES AGRICULTURAE FENNIAE, VOL. 9: 357—360 (1970)
Seria HORTICULTURA N. 15 — Sarja PUUTARHANVILJELY n:o 15

EFFECT OF UREA-FOLIAR SPRAYS IN SATISFYING THE NITROGEN NEED OF APPLE TREES

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Received March 14, 1970

Urea sprays have been used since the early 1950s to supplement the nitrogen supply of fruit trees, particularly apple trees. It has been shown that the nitrogen requirement of the tree is rapidly satisfied if the foliage is sprayed with urea solution (HAMILTON et al. 1943, FISHER 1952, BLASBERG 1953, BOYNTON et al. 1953). The urea is rapidly absorbed through the undersides of the leaves, whence it is carried into the other parts of the plant. However, the effect of nitrogen fertilization administered through the leaves is of brief duration. Urea sprays have been found to cause an increase in yield, growth and leaf-size of apple trees. The manner in which yield increment is achieved varies in different varieties. For example, in the McIntosh variety the increase is due to the fact that trees sprayed with urea develop a large number of spurs that form two apples, whereas the spurs of this variety normally form only one apple each. It has been found that one of the disadvantages of urea spraying is a decline during storage in the firmness and the keeping quality of apples (RASMUSSEN 1966). This fault appears, however, only if the apples are stored for a long time. In Sweden (JOHANSSON and ROOTSI 1954) and Finland (SÄKÖ 1956) an increase in apple size has been produced with urea sprays. It has also been shown that urea sprays are of considerable importance in ensuring a nitrogen supply for the apple trees, especially during drought (SÄKÖ 1959). In Finland, during a severe drought in the growing season of 1955, the amount of nitrogen in the leaves declined by 0.3—0.8 percent units (12—28 %) in different varieties. The nitrogen content of the leaves could be raised by 0.62—1.19 percent units (26—58 %) above that of the control trees by means of four urea sprayings.

Investigations were also made into the effects of urea sprayings carried upon apple trees out in autumn. In Norway, OLAND (1966) found that urea sprays administered to the foliage in September—October caused an increase in the yield of the Gravenstein variety. However, in experiments performed elsewhere, it has not been possible to confirm this result.

The urea spraying of apple trees has been considered of significance only as an additional means of nitrogen fertilization, not as a substitute for nitrogen fertilization applied through the substrate. To clarify this question, a long-term test was set up at the Department of Horticulture to investigate the administration of nitrogen exclusively through urea spraying of the foliage of the trees.

Materials and methods

30 'Huvitus' apple trees, grafted on Antonovka seedling rootstock, were planted for the experiment in 1955. Huvitus is a suitable variety for an experiment of this type, since it has a relatively

weak growth and readily reacts to changes in growing conditions, for instance in respect of apple size. Further, because of its winter hardiness Huvitus is suitable for an experiment covering a period of several years. Sandy clay soil was used. The fertilization experiment was commenced two years after the trees were planted. The qualities of fertilizer used are shown in Table 1. Calcium nitrate was applied to the substrates of the trees in spring, at the turn of May —June. Urea fertilizer was applied to the foliage in five sprayings, using an ordinary pine sprayer. The urea content of the spray mixture was 0.75 per cent. The sprayings were applied at intervals of roughly one week from the first week of June onwards.

Other fertilization comprised 200—300 kg/ha of potassium sulphate and 100—200 kg/ha of superphosphate annually. The nutrient content of the substrate was determined at depths of 0—10 and 20—30 cm in 1964—65, and that of the leaves was determined in the growing season of 1964. Growth of the trees was measured in 1960 and in 1965; yield was classified annually. At the termination of the experiments, the weights of the trunks and the crowns of all the trees were determined.

Results and discussion

The trees treated with urea sprays were given substantially more nitrogen per areal unit than were the trees fertilized with calcium nitrate (Table 1). The nitrogen administered to the foliage in the form of urea in 1961—65 was the equivalent of 555 kg of calcium nitrate per hectare. This

Table 1. The amount of nitrogen used annually in the experiment

Taulukko 1. Kokeessa vuosittain käytetyt typpimäärät

Years *Vuosina*	A Nitrogen given in soil as Calcium nitrate *Typpeä puiden kasvualustaan kalkkisalpietarina*		B Nitrogen as foliar sprays with urea *Typpeä puiden lehdistöön ureana*	
	N kg/ha	$CaNO_3$	N kg/ha	urea
1957—58	31	(200 kg/ha)	58	(125 kg/ha)
1959—60	39	(250 »)	58	(125 »)
1961—65	47	(300 »)	87	(188 »)

Table 2. The results of soil analyses in the experiment

Taulukko 2. Tulokset kokeesta otetuista maa-analyyseista

Treatment *Käsittely*	Depth of sample *Näytteen syvyys* cm	Nitrogen *Typpi* 1964 %	Nitrogen *Typpi* 1965 %	pH	$CaCO_3$ ton/ha *tn/ha*	Potassium *Kali* 40 % Nuriate of Potash *40 % Kalisuola* kg/ha	Phosphorus *Fosfori* Superphosphate *Superfosf.* kg/ha	Humus %
Calcium nitrate — *Kalkkisalpietari*	0—10	0.109	0.140	6.24	7.2	2 435	324	2.3
	20—30	0.081	0.170	5.61	3.7	570	58	1.7
Urea	0—10	0.115	0.170	6.03	6.5	2 520	290	2.4
	20—30	0.088	0.170	5.61	4.1	625	57	1.9

high level of nitrogen fertilization cannot be recommended for the substrates of apple trees, and especially not for young apple trees, in the climatic conditions of Finland, since abundant nitrogen fertilization will delay the maturing of the shoots and will lower the winter hardiness of the trees. But urea sprays administered to the foliage in early summer have not been found to have any harmful effect in this respect, even when the amount of nitrogen per areal unit is quite high. Urea sprays may bring about a fairly high nitrogen content in the leaves. After spraying is stopped, the amount of nitrogen in the leaves will decline, so that by the autumn it will be at the same level as that in untreated trees, and the shoots of trees will ripen normally (Säkö 1959).

Analyses of soil samples taken from under the trees show slight differences only (Table 2). The amount of nitrogen under the trees receiving urea through the foliage was slightly higher (0.006—0.03 percent units) than that of the trees receiving calcium nitrate. The difference is slight compared with the nitrogen quantities applied. In 1961—65 the urea plots received 88 per cent more nitrogen than the calcium nitrate plots. Some of the urea nitrogen ran down into the soil and thus became available to the root system.

Leaf samples taken in 1964 after the discontinuation of urea spraying in mid-July showed that the nitrogen content of leaves from urea-sprayed trees was substantially higher than that of leaves from trees whose substrates had been dressed with calcium nitrate in the spring (Table 3). The growth was slightly weaker in the trees sprayed with urea than in those receiving calcium nitrate fertilization through the soil (Table 4). This was most clearly apparent from the weights of the trunk and crown. The trees treated with urea produced a yield more than 9 per cent higher (Table 5). Thus the ratio tree weight/total yield was clearly smaller, indicating greater productivity in the ureatreated trees than in trees fertilized through the soil.

The most distinct and important difference, however, was in apple size (Table 5). Huvitus is a variety yielding fruits of small size. It is characteristic of Huvitus for the apple size to remain small as the tree ages. Most of the apples yielded by trees 10 years of age or above are below 50 mm in diameter. A significantly larger size of apple was now obtained using urea sprays than with calcium nitrogen fertilization administered to the substrate in spring.

Table 3. Results of the leaf analyses. Samples taken 16. 7. 1964 after the fifth urea-spray

Taulukko 3. Lehtianalyysin tulokset. Näytteet otettiin 16. 7. 1964 viidennen urearuiskutuksen jälkeen

Treatment *Käsittely*	Per cent in dry matter *Prosenttia kuiva-aineessa* N	P	K	Ca
Calcium nitrate in soil — *Kalkkisalp. maahan* ..	2.55	0.20	1.92	1.14
Urea as foliar spray — *Urearuiskutus lehdistöön*	2.96	0.20	1.77	1.12

Table 4. The average growth of trees. Trees planted in 1955

Taulukko 4. Puiden keskimääräinen kasvu. Puut istutettu v. 1955

Treatment *Käsittely*	Number of trees *Puita kpl*	Trunk diameter *Rungon läpimitta* mm 1960	1965	Trunk girth *Rungon ympärysmitta* mm 1960	1965	Tree spread *Latvuksen leveys* m 1960	1965	Weight of tree (Crown and trunk) *Puun paino (latvus ja runko)* kg 1965	Ratio Tree weight/total yield *Suhde puun paino/kokonaissato* 1965
Calcium nitrate in soil *Kalkkisalp. maahan*	15	67	147	264	486	3.7	4.4	88.3	0.448
Urea as foliar spray — *Urea ruiskutus lehdistöön*	15	66	143	260	473	3.8	4.5	85.2	0.396

Note: The trunk diameter and girth measured at a height of 30 cm above the soil surface. The trees were cut at the same point for weighing.

Huom. Rungon läpimitta ja ympärys mitattiin 30 cm korkeudelta maasta. Kokeen päätyttyä puut katkaistiin samalta korkeudelta punnitsemista varten.

Table 5. The cumulative yields per tree and the sorting results in the nitrogen fertilization experiment in 1957—65 with Huvitus apple variety.

A = Calcium nitrate in soil
B = Urea foliar spray (5 sprays administered at the beginning of growing season) Trees planted in 1955. Experiment started in 1957

Taulukko 5. Vuosittain yhteenlasketut sadot puuta kohti sekä lajittelutulokset Huvitus-omenapuiden typpilannoituskokeesta vv. 1957—65.

A = kalkkisalpietari maahan
B = urearuiskutus lehdistöön (5 ruiskutusta kasvukauden alkupuolella) Puut istutettu v. 1955. Koe aloitettiin v. 1957

Year *Vuosi*	Cumulative yields per tree *Vuosittain yhteenlasketut sadot puuta kohti* kg A	B	Diameter of apples in per cent of total yields *Omenien läpimitta % kokonaissadosta*: Under *Alle* 50 mm A	B	50—55 mm A	B	over *yli* 55 mm A	B
1960	18.6	21.7	37	37	25	25	39	38
1961	40.4	45.1	31	28	34	32	35	40
1962	74.5	87.5	38	31	36	37	26	32
1963	92.1	104.7	36	28	36	35	28	37
1964	187.5	197.5	64	57	23	23	14	20
1965	197.0	215.4	62	54	23	23	15	22
L.S.D. — *Merk. ero* 5 %							3.57	

F = 16.95***

The above results of the 9-year experiment show that it is possible to satisfy the nitrogen requirement of apple trees by using urea foliar sprays, and that the sprays may actually lead to more favourable results than those achieved with a nitrogen fertilizer administered to the soil. On the southwestern coast and in the southwestern archipelago of Finland, the main apple orchard areas, urea sprays are of great importance owing to the fact that the drought which occurs there in early summer makes it difficult for the trees to obtain nitrogen from the soil. Also, the nitrogen requirements of apple trees are at their greatest early in the summer, when the green fruit forms and grows. As the price of one kilo of nitrogen applied in the form of urea is at present a mere 56 per cent of the price of a kilo of nitrogen in the form of calcium nitrate, the nitrogen amounts (Nks 47 and N urea 87 kg/ha) here employed are roughly equal in price. Neither does the application of urea sprays cause any noteworthy additional costs, for the sprays can be combined with the necessary plant protection sprays.

Summary

A nitrogen fertilization experiment on apple trees was carried out at the Department of Horticulture over the period 1957—65 to compare the effects upon the growth and yield of Huvitus apple trees of soil-administered calcium nitrate and urea-foliar sprays. The urea was administered in five sprayings with a 0.75 per cent mixture at intervals of roughly one week in the early part of the growing season. The trees receiving nitrogen fertilization in the form of calcium nitrate applied to the soil grew more vigorously. The trees sprayed with urea produced a higher yield and a better sized apple.

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SELOSTUS

Omenapuun typentarpeen tyydyttäminen urearuiskutuksilla

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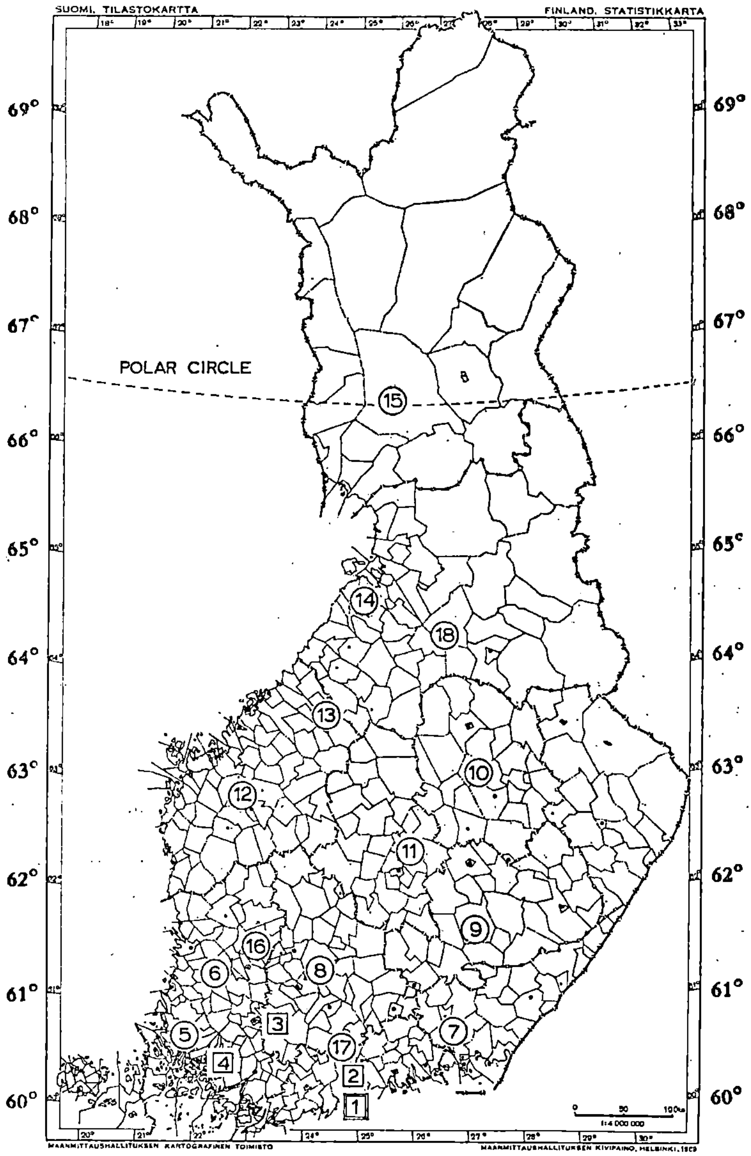
Tässä tutkimuksessa selvitetään omenapuun typentarpeen tyydyttämistä puun lehdistöön annetuilla urearuiskutuksilla. Vertailukohteena on typpilannoitus kalkkisalpietarina puiden kasvualustalle. Tutkimus oli käynnissä vuosina 1957—65. Urea annettiin vuosittain viitenä ruiskutuksena n. viikon väliajoin kesäkuun alkupuolelta lähtien. Ruiskutusnesteen väkevyys oli 0.75 %. Koeaineistona oli 30 Huvitus-omenapuuta, jotka oli varrennettu Antonovka-siemenperusrunkoon. Käytetyt lannoitemäärät sekä tulokset maa- ja lehtianalyyseista esitetään taulukoissa 1—3.

Puut, joille typpi annettiin urearuiskutuksina lehdistöön, jäivät kasvultaan heikommiksi kuin kasvualustaan lannoitetut puut (taul. 4). Urealla ruiskutetut puut tuottivat kuitenkin suuremman kokonaissadon. Niiden omenien koko oli myös suurempi kuin salpietarilannoituksen maahan saaneilla vertailupuilla.

Yhdeksän vuotta kestäneen kokeen tulokset osoittavat, että omenapuun typentarve voidaan tyydyttää puun lehdistöön annetuilla urearuiskutuksilla. Urean etuna on myös, että typpikilon hinta tulee siinä huomattavasti halvemmaksi kuin kalkkisalpietarissa. Viiden urearuiskutuksen suorittaminen ei myöskään aiheuta sanottavia lisäkustannuksia, koska ruiskutukset voidaan yhdistää välttämättömiin kasvinsuojeluruiskutuksiin.



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