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ANNALES AGRICULTURAE FENNIAE, VOL. 16: 167–171 (1977)
Seria ANIMALIA NOCENTIA N. 96 – Sarja TUHOELÄIMET n:o 96

ADULT ANGOUMOIS GRAIN MOTHS SITOTROGA CEREALELLA OLIV. AS A FOOD SOURCE FOR LARVAE OF THE GREEN LACEWING CHRYSOPA CARNEA STEPH. IN MASS REARING

UNTO TULISALO, TUOMO TUOVINEN and SIRPA KURPPA

TULISALO, U., TUOVINEN, T. & KURPPA, S. 1977. **Adult Angoumois grain moths Sitotroga cerealella Oliv. as a food source for larvae of the green lacewing Chrysopa carnea Steph. in mass rearing** Ann. Agric. Fenn. 16: 167–171. (Agric. Res. Centre, Inst. Pest Inv., SF-01300 Vantaa 30, Finland.)

Larvae of the green lacewing (*Chrysopa carnea* Steph.) were fed with adult *Sitotroga cerealella* Oliv. The average number of eggs per one green lacewing female was about 900 and hatching percentage was about 84. In mass rearing 12 mg of food was used per larva daily, that is, three times the quantity required in individual rearing. Daily anaesthetizing with CO_2 reduced the number of green lacewing eggs and also led to a situation in which some of the eggs did not become attached to the roof of the rearing cabinet.

Index words: *Chrysopa carnea*, *Sitotroga cerealella*, mass rearing.

INTRODUCTION

The use of the green lacewing in biological pest control has given such promising results (LINDGREN et al. 1968, RIDGWAY and JONES 1968, 1969, SCOPES 1969, BEGLYAROV et al. 1970, SHANDS et al. 1972, ADASHKEVICH and KUZINA 1974, BEGLYAROV and USHCHEKOV 1974 and TULISALO and TUOVINEN 1975) that mass rearing of the species for practical control may be considered worthwhile. The problems involved in mass rearing of this species have already been solved to quite a large extent (e.g. FINNEY 1950, VANDERZANT 1969, HAGEN and TASSAN 1970 and RIDGWAY et al. 1970). There are, however, still obstacles to be overcome before a mechanized and economically profitable mass rearing system has been created. Some minor improvements and suggestions concerning mass rearing of the green lacewing have been presented during past years (TULISALO and KORPELA 1973, VANDERZANT 1973, BARNES 1975, HASSAN 1975 and MORRISON et al. 1975), but at present there seems to be no method of really extensive and cheap mass production.

At the present time eggs of *Sitotroga cerealella* are used primarily as food for the larvae (MORRISON et al. 1975). Apart from aphidious food, larvae of the cabbage butterfly (HASSAN 1975) and the potato tuber moth (FINNEY 1948) have been used experimentally as food for larvae of the green lacewing. A type of artificial food has also been developed for the larvae (VANDERZANT 1969), but it is not yet suitable for use in mass rearing.

The aim of the present study was to assess the possibility of using adults of *Sitotroga cerealella* as food for green lacewing larvae.

MATERIAL AND METHODS

Green lacewing was reared using a method according to which the larvae were not kept in separate cells (TULISALO and KORPELA 1973). The suitability of grain moth adults as food for these larvae was studied on the basis of two lacewing strains, one of which (groups a and b) was collected in the field in spring 1976 the other (groups c and d) being a laboratory strain. The adults of the latter strain had been fed with artificial food since 1972 (HAGEN and TASSAN 1969) and the larvae with adults of *Sitotroga cerealella* and during the first years with aphids, too. Within each of the two strains two groups were formed for the comparison. In the first case (a and c) the larvae were fed with deepfrozen adults of the Angoumois grain moth and in the second case (b and d) with living peach aphids. The adults which had developed from these comparison groups were fed with Food Wheast^R yeast hydrolysate mixed with water and sugar.

Within the comparison groups studies were carried out on the numbers of eggs laid by the females and their productive lifetime as well as the hatching percentage of the eggs. Moreover, the amounts of food required by the larvae and their rationing were assessed as well as the effect on egg laying of anaesthetizing with CO_2.

RESULTS

Fig. 1. shows a life-fecundity table for the four comparison groups. No significant differences were observed between the groups in respect to the numbers of eggs laid, Table 1. Likewise, the productive lifetime of females was more or less the same in all groups Fig. 2. Table 2 shows the hatching percentage of eggs. There were no significant differences between the comparison groups and the hatching percentages were rather high. Daily anaesthetizing of adults with carbon dioxide led to a situation in which a part of the eggs did not become fastened to the roof of the rearing cabinet, but fell down (Table 3). The egg numbers were also slightly lower in the cases where CO_2 anaesthetizing had been used. Table 4 shows the amounts of food that were used in feeding the larvae. In mass rearing, a satisfactory pupation percentage was reached using three *Sitotroga* adults per larva and day.

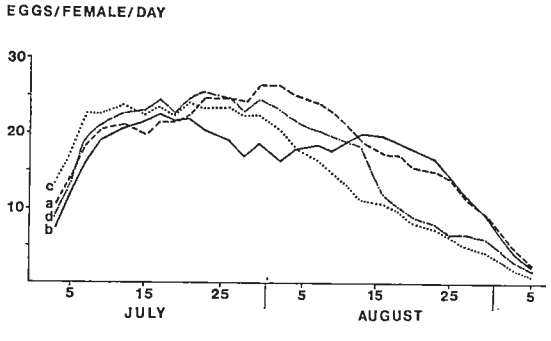

Fig. 1. The life-fecundity tables for comparison groups.

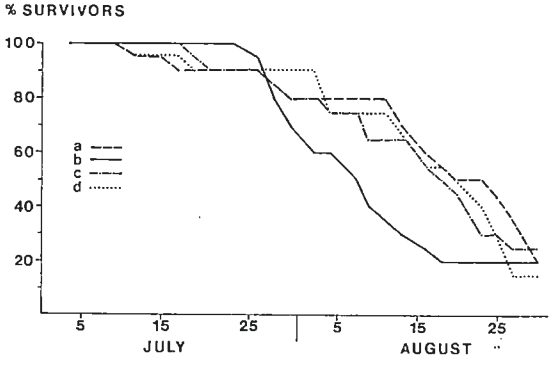

Fig. 2. The survival of females in four comparison groups.

The required amount of food was three times that used in individual rearing in test tubes, and this means that about 12 mg of food was needed per larva daily.

Table 1. Total number of eggs layed by females in four comparison groups.

	total no. of eggs/female (N = 20)	eggs/female/day
a	966,8	15,8
b	710,9	11,7
c	860,0	14,1
d	895,4	14,6

Table 2. The hatching percentage of eggs.

a	80,5 ± 2,2
b	86,3 ± 4,1
c	88,8 ± 1,6
d	86,2 ± 3,0

F = 1,47

Table 3. The impact of daily CO_2-anaesthetizing on the egg laying by females and on the percentage of unfastened eggs.

	eggs/10 female	% of fallen eggs
CO_2anaesthetizing	6 168	38,2
control	7 074	15,4

F = 5,23

Table 4. The effect of the area of the larval rearing unit and the amount of food used on larval development and the net product of cocoons. N = 700.

Chrysopa eggs/50 cm²	*Sitotroga* adults/ *Chrysopa* larva/ day	% of cocoons from hatched eggs	survival of eggs %
5	1.	73,3	36,4
5	3.	86,7	69,2
5	9.	80,0	66,7
20	1.	61,0	30,6
20	3.	61,4	37,1
20	9.	63,6	62,2
50	1.	52,0	27,0
50	3.	61,0	47,8
50	9.	64,0	48,7
150	1.	57,8	20,3
150	3.	53,0	42,5
150	9.	59,7	41,9

DISCUSSION

Up to the present time either aphids or eggs of the Angoumois grain moth have been used primarily as food for the larvae in mass rearings of the green lacewing. Irrespective of which of these methods is used, however, mass production is both laborious and rather expensive. Other alternatives have also been tried on an experimental basis, for instance larvae of the cabbage butterfly (HASSAN 1975) and the potato tuber moth (FINNEY 1948). Up to the present, artificial food has not proved suitable for use in mass rearing. Eggs of *Sitotroga* are, as such, usable as food for the larvae, but their production requires more work than the production of adults alone. For this reason experiments on the use of adult *Sitotroga* as food for green lacewing larvae were set up.

According to the results obtained, this food is, as such, suitable. Egg laying and hatching percentages reach values equal in quality with those obtained with aphidious food.

In these experiments the scale cover of the adult moths was not yet removed, which seemed to cause 1st instar larvae some difficulties in using the type of food concerned. If an improvement can be achieved in this respect in the future, the results obtained from rearing will also be further improved.

Because of inadequacy in the apparatus used in *Sitotroga* rearing, it was not possible

to estimate the price per gram of mass produced *Sitotroga*. However, it seems to compete with other food sources for larvae.

For mass rearing of the green lacewing the food problem may be considered satisfactorily solved in many respects. The question of planning and constructing of equipment for mechanical mass rearing still remains. The results of this study, however, show that there is reason to avoid the use of CO_2 anaesthetizing in planning the mass rearing equipment.

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SELOSTUS

Viljakoin käyttö harsokorennon ravintona massakasvatuksissa

UNTO TULISALO

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TUOMO TUOVINEN ja SIRPA KURPPA

Helsingin yliopisto

Viime vuosien aikana on tehty lukuisia tutkimuksia, joissa on todettu, että harsokorento on varsin käyttökelpoinen eliö mm. kirvojen, perhostoukkien ja koloradokuoriaisen biologisessa torjunnassa. Käytännön sovellutusten esteenä on ollut toistaiseksi taloudellisen ja yksinkertaisen massakasvatusmenetelmän puuttuminen. Harsokorennon massakasvatus on nyt jo varsin pitkälle kehitelty ja varsinaisia heikkouksia on enää sopivan toukkaravinnon puuttuminen.

Näissä kokeissa käytettiin pakastettuja viljakoiaikuisia yksinomaisena toukkaravintona. Vertailuryhmänä oli harsokorennon luontaisella toukkaravinnolla eli kirvoilla kasvatettu harsokorentoryhmä. Aikuisten harsokorentojen eliniässä tai munintamäärissä ei todettu eroja koeryhmän ja vertailuryhmän välillä. Munien kuoriutuminen oli myös normaalia. Täten voitiin todeta, että viljakoiravinto oli toukkaravintona kirvaravinnon veroista. Harsokorentoa on tähän mennessä kasvatettu jo kahdeksan sukupolvea viljakoiravinnolla eikä haitallisia muutoksia ole ilmennyt.

Harsokorennot käyttivät ravintoa 12 mg/toukka/vrk. Viljakoiravinnon tuotantokustannuksia ei voitu luotettavasti laskea, mutta tämän ravinnon tuottaminen on kuitenkin huomattavasti helpompaa ja taloudellisempaa kuin kirvojen tuottaminen.

Seuraavana vaiheena on enää jäljellä tuotannon mekanisointi.

ANNALES AGRICULTURAE FENNIAE, VOL. 16: 172—176 (1977)
Seria AGROGEOLOGIA ET -CHIMICA N. 78 — Sarja MAA JA LANNOITUS n:o 78

LEAD CONTENTS OF CROP PLANTS GROWING IN THE VICINITY OF A LEAD SMELTERY

RAIMO ERVIÖ

ERVIÖ, R. 1977. **Lead contents of crop plants growing in the vicinity of a lead smeltery.** Ann. Agric. Fenn. 16: 172—176. (Agric. Res. Centre, Inst. Soil Sci., SF-01300 Vantaa 30, Finland.)

Lead contents were determined on crop samples collected in late summer in the year 1970 from 104 sites in the vicinity of a lead smeltery in South Finland, and from 36 sites in the surrounding countryside representing the control area.

Plants growing in the vicinity of the smeltery (at a distance of 150—3600 m) contained considerably more lead than did plants from the control area. The lead contents of the leaves of broadleaved species, such as sugarbeet and turnip-rape, growing within the area of lead emission, appeared to deviate more from the contents of the corresponding plants in the control area than was the case with clover or narrow-leaved timothy. The relative difference in lead contents between the two areas was least for the grain of cereals.

The highest single Pb content, 63 ppm of dry matter, was found in a sample of ryegrass growing 300 metres from the smeltery, and the highest mean content for any species, 45 ppm of dry matter, in sugarbeet tops. In contrast, sugarbeet roots and potato tubers from the polluted area contained relatively little lead, about 1 ppm.

Index words: lead in crop plants, environmental pollution.

INTRODUCTION

Preliminary studies have been made on lead pollution in the vicinity of the lead smeltery in Tikkurila, near Helsinki, in relation to the vegetation (LAKANEN and ERVIÖ 1971), and in relation to the soil (ERVIÖ and LAKANEN 1973). In the first mentioned study, the immediate vicinity of the smeltery as sampling area, the lead contents of plants were found to be exceptionally high. The present study deals with the lead contents of plant samples collected at the same time and from the same sites as the soil samples above.

MATERIAL AND METHODS

The plant samples were collected from 104 sites in the vicinity of the lead smeltery, mostly from between 150 and 3600 metres to the north and east of it, and by way of comparison from 36 sites in the surrounding countryside 8—33 km from Tikkurila. The samples were taken between August 25th and October 9th. Cereals were sampled towards the beginning of this period, herbage and root crops towards the end of it. Samples were collected from the following crops: oats, barley, spring and winter wheat, winter rye, potato, sugar-beet (roots and tops), winter turnip-rape (tops), red clover, timothy, meadow fescue, cocksfoot and ryegrass. For cereals the grain was analyzed, while the sample for herbage crops composed the aftermath. The soil type of the sampling sites were clay (93), fine sand (28) and organogenic (15 sites). Lead was determined with a Techtron AA-4 atomic absorption spectrophotometer or with a spectrograph (LAKANEN and ERVIÖ 1971).

RESULTS AND DISCUSSION

The mean lead contents of the »polluted» area in Tikkurila and of the control area are shown together with the variation in contents of individual samples in Table 1.

The tops of broad-leaved species like sugar-beet or turnip-rape have collected very large amounts of lead, the former averaging 45 ppm and the latter 27 ppm in the dry matter, which contents are many times higher than for the corresponding samples from the control area (6,8 and 6,2 ppm respectively). In contrast, even in Tikkurila the lead contents of underground plants parts, such as sugar-beet roots or potato tubers, were low and in either case averaged only about 1 ppm, while the lead content of these two root crops in the control area was 0,5 pp. For herbage plants, the highest content (63 ppm) was found in ryegrass growing 300 m from the smeltery. Both timothy and red clover samples from the polluted area contained on average about 2,5 times as much lead as samples from the control area.

The lead contents of cereal grain from the vicinity of the smeltery were generally around 1 ppm, and on average were not even quite

Table 1. Average lead contents of plant samples (mean and range of variation).

Plant	Lead polluted area at Tikkurila			Area of comparison		
	No. of samples	Pb ppm in dry matter		No. of samples	Pb ppm in dry matter	
Sugar peat, tops	4	45,2	(17—54)	2	6,8	(5,4—8,1)
Sugar peat, roots	4	1,1	(0,7—1,8)	2	0,5	(0,5—0,5)
Potato, tubers	6	0,9	(0,5—1,7)	—	—	
Turnip- rape, tops	5	26,7	(7,1—60,4)	2	6,2	(3,9—8,5)
Red clover, aftermath	16	14,3	(4,9—35,0)	8	5,3	(4,3—6,1)
Ryegrass, aftermath	3	28,9	(11,2—63,4)	—	—	
Meadow fescue, aftermath	11	13,5	(4,4—28,0)	—	—	
Timothy, aftermath	14	11,6	(3,1—21,9)	6	4,5	(1,5—7,0)
Cocksfoot	6	9,2	(4,0—23,0)	1	0,50	
Barley, grain	19	1,23	(0,6—3,5)	4	0,78	(0,5—1,2)
Oats, grain	16	1,02	(0,6—3,8)	10	0,60	(0,5—0,9)
Spring wheat, grain	13	0,75	(0,3—1,8)	7	0,59	(0,5—0,9)
Winter wheat, grain	4	0,55	(0,5—0,6)	—	—	
Winter rye, grain	3	0,41	(0,3—0,5)	1	0,50	

double those of the control samples. In only a few grain samples did the lead content exceed 3 ppm.

The lead precipitation in the Tikkurila area during the autumn of sampling was found to be 1—20 g/100 m²/month, whilst in the Helsinki area it averaged only 0,4 g (LAAMANEN and RYHÄNEN 1971). Within 500 metres of the smeltery, the plough layer at the sampling sites contained on average 378, and at a distance of 500—2000 metres 81 mg lead/litre of soil (ERVIÖ and LAKANEN 1973) while the mean lead content of Finnish soils is about 16 mg/litre. The lead in plants from the area studied is contributed both by precipitation from the air and uptake from the soil, and while the relative importance of these sources could not be determined, it is assumed that lead conveyed via the air plays the more important role.

Of the plant species analyzed in the present study, timothy and cereals grown in Finland have been used for lead investigations. The mean content of 11,6 ppm for timothy samples taken in autumn from the aftermath in the Tikkurila area, and the mean of 4,5 for samples from the surrounding countryside, are clearly in excess of LAKANEN's (1969) mean value of 1,1 ppm for timothy at hay-making time in South Finland. BRUNILA (1975) has studied lead content in cereals growing near roadsides in various parts of Finland. She found that the effect of motor traffic on the lead content of cereal grains was definite, although the level of lead contents was relatively low. In 80 % of the kernel samples there was less than 0,3 ppm lead and in only two cases of samples taken 10 metres from a road did contents exceed 1 ppm. The lead contents of hulled oats and naked barley were somewhat higher than that of wheat. These findings are in agreement with the trends found among different cereals in the present study. Newertheless, the average lead contents of grain samples from both Tikkurila and the surrounding area were higher than in BRUNILA's (1975) material.

At present, there are very few data on the lead contents of crop plants grown in Finland. Nonetheless, in recent years lead content determinations have been made on vegetables grown near trunk-roads. RAJAMA (1973) has published results for lettuce, parsley and dill, whose Pb contents have ranged from 2—14 ppm and HÅRDH (1975) for vegetables in which the highest contents of 22, 53 and 11 ppm were found in lettuce grown near the Tikkurila smeltery, and the lowest of 0,6, 0,5 and 0,3 ppm in lettuce, spinach and carrots grown in Salla, North Finland. LAKANEN (1969) found the mean lead content of 214 timothy samples collected from various parts of Finland to be 1,4 ppm. In addition, this material revealed that the samples collected from Lapland contained on average only 0,6 ppm, whereas those from South Finland contained 1,6 ppm lead. In the pot experiment set up outside within the lead polluted area in Tikkurila, KÄHÄRI (1973) found that the leaves of ryegrass grown in Sphagnum peat accumulated 6—44 ppm lead, and when soluble lead was added to the growing medium 8—55 ppm.

The lead content of plants depends upon several factors, including plant species, the amount of lead deposited from the air onto the plants, the growing season of the plant, the rinsing effect of rain on the leaves, the amount of available lead in the soil etc. In this study, no reliable comparisons between different crop species can be made, since the species sampled were not growing at the same distance or in the same direction from the smeltery. Newertheless, it appears that the leaves of broad-leaved species like sugarbeet and turnip-rape have collected more lead than grasses, and that underground organs such as sugarbeet roots or potato tubers accumulate relatively little lead, in spite of the lead polluted soil they grow in or the lead deposited onto the aerial parts. A similar conclusion was reached by LEH (1966) in a study of crop plants grown within 50 metres of a motorway, as he found 13—20 ppm in

grasses, 11—28 ppm in sugarbeet tops but in the roots only 1,3—3,7 ppm, and in potato tubers 1,5—2,6 ppm lead.

In Finland, maximum levels permitted for the lead contents of human or animal foodstuffs have not been specified, except for tinned fruit products for which the maximum is 1 mg/kg. In certain countries, maximum permissible lead contents for foodstuffs have been specified, e.g. Sweden 3 mg/kg, Switzerland 2,5 mg/kg and England 2 mg/kg of the actual product. The grain samples collected in Tikkurila contained at least 1 mg Pb/kg in 22 instances and more than 2 mg Pb/kg of dry matter in only 3 instances. An animal feed commission acting for the Food Inspection Department of the European Economic Community has set, as the maximum permitted lead content of plant material intended for fodder, a value of 10 mg/kg of dry matter (KLOKE and LEH 1969). For the herbage samples collected in Tikkurila, this value was exceeded in 17 cases out of 54.

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SELOSTUS

Viljelykasvien saastuminen lyijyä käsittelevän sulattamon ympäristössä

RAIMO ERVIÖ

Maatalouden tutkimuskeskus

Lyijysulattamon ympäristöstä Vantaan Tikkurilasta syyskesällä 1970 koottujen viljelykasvien lyijypitoisuuksia on verrattu naapurikunnista otettujen kasvinäytteiden pitoisuuksiin. ERVIÖ ja LAKANEN ovat aikaisemmin julkaisseet vastaavien näytekohtien maaperän lyijypitoisuudet (Annales Agriculturae Fenniae 12: 200—206.)

Tikkurilassa kasvaneet viljelykasvit sisälsivät suurempia lyijymääriä kuin vertailualueen. Sulattamon ympäristössä kasvaneiden leveälehtisten kasvilajien, sokerijuurikkaan ja syysrypsin, lyijypitoisuudet näyttivät poikkeavan suhteellisesti enemmän vertailualueen vastaavista pitoisuuksista kuin pienilehtisten apilan tai timotein pitoisuudet. Sokerijuurikkaan lehtien lyijypitoisuus oli 6,6-, syysrypsin lehtien 4,3-, puna-apilan 2,7- ja timotein 2,6-kertainen. Viljalajien jyvissä suhteellinen ero oli kaikista vähäisin.

Korkein yksittäinen lyijypitoisuus, 63 mg/kg kuiva-ainetta, todettiin 300 metrin etäisyydellä sulattamosta kasvaneessa raiheinässä, mutta lajikohtaisesti korkein keskimääräinen arvo 45 mg/kg sokerijuurikkaan naateista. Sen sijaan sokerijuurikkaan juuret ja perunan mukulat sisälsivät sulattamon vaikutusalueellakin lyijyä suhteellisen vähän, vain noin yhden mg/kg kuiva-ainetta. Rehuksi käytettävien viljelykasvien näytteet sisälsivät 17 tapauksessa 54:stä lyijyä yli 10 mg/kg kuiva-ainetta, mitä määrää kansainvälisesti suositellaan ylimmäksi sallituksi pitoisuudeksi karjan rehussa.

ANNALES AGRICULTURAE FENNIAE, VOL. 16: 177—183 (1977)
Seria AGROGEOLOGIA ET -CHIMICA N. 79 — Sarja MAA JA LANNOITUS n:o 79

EFFECTS OF NITROGEN FERTILIZATION ON THE Ca/P RATIO OF GRASS HERBAGE

SIRKKA-LIISA RINNE, MIKKO SILLANPÄÄ, SIRKKA-LIISA HIIVOLA and ERKKI HUOKUNA

RINNE, S.-L., SILLANPÄÄ, M., HIIVOLA, S.-L. & HUOKUNA, E. 1977. **Effects of nitrogen fertilization on the Ca/P ratio of grass herbage.** Ann. Agric. Fenn. 16: 177—183. (Agric. Res. Centre, Inst. Soil. Sci., SF-01300 Vantaa 30, Finland.)

The effects of fertilization rates (0—600 kg N/ha/year) on the Ca/P ratio of meadow fescue (*Festuca pratensis*) and cocksfoot (*Dactylis glomerata*), harvested for silage three times during the growing season were studied for three years at 18 experimental sites.

In the first year the effect of N fertilization on the Ca/P ratio was negligible. Towards the end of the experimental period, the ratio increased significantly with increasing N fertilization. This phenomenon was most pronounced in crops grown on coarse mineral soils. In the whole material the Ca/P ratio increased from 1,51±0,58 to 1,94±0,81.

Nitrogen fertilization, potassium content of the grass, species, cutting time (season), age of the lay and dry matter yield accounted for 51,7 per cent of the total variation of the Ca/P ratio.

Index words: Nitrogen fertilization, Ca/P ratio of herbage, *Dactylis glomerata*, *Festuca pratensis*.

INTRODUCTION

In three year field experiments, nitrogen fertilization (13 per cent NO_3-N + 13 per cent NH_4-N + 6 per cent Ca) decreased significantly the soil pH, soluble phosphorus and exchangeable calcium in the soil (SILLANPÄÄ and RINNE 1975). The P content of the grass also decreased with increasing nitrogen fertilization except in the first cut in the spring (RINNE et al. 1974 a). Despite the decrease in soil exchangeable calcium, the Ca content of the grass increased with increasing nitrogen fertilization.

Ruminants have been shown to tolerate a wide range of Ca/P ratios. It has been recommended that the Ca/P ratio be as close as possible to the biologically optimal range of 1,5—2,0, and extremely low (<1) ratios be avoided (ANON. 1975). The present paper reports the results of the effects of N fertilization on the Ca/P ratio of the grass of different cuts, soils and years.

MATERIALS AND METHODS

Experimental sites and plant species

Three-year field trials were carried out by the Agricultural Research Centre at 18 sites in Southern and Central Finland (lat. 60—64°). The soils ranged from coarse mineral soil (seven trials) to fine mineral soil (nine) and organogenic soil (two). The experimental plants were meadow fescue and cocksfoot. Full details of the plan of the experiment were given in the preceding number of this series (HUOKUNA and HIIVOLA 1974).

Fertilization

Five nitrogen treatments were used 0, 150, 300, 450 and 600 kg N/ha/year. The nitrogen was applied annually in three equal dressings. All plots received potassium fertilizer at the rate of 100 kg K/year, as well as 500 kg of superphosphate (44 kg P)/ha/year. PK fertilizer was given in one dressing at the beginning of the growing season.

Sampling

The crop was harvested three times during the growing season. The methods for preparing samples for chemical analysis and the results of the analysis were described in detail in the preceding number (HIIVOLA et al. 1974, RINNE et al. 1974 a and b).

RESULTS

In the three year field experiments, when N fertilization was increased from 0 to 300 kg N/ha, the dry matter yield of herbage increased from 2,8 to 9,3 tons/hectare during the first year. With larger quantities of nitrogen, only an insignificant increase was obtained. The effect of nitrogen fertilization declined towards the end of the experimental period.

In the whole study, the average Ca/P ratio at the zero N level was 1,51 $\pm$ 0,58. The results of least squares analyses show that each of several variables is associated highly significantly with the Ca/P ratio (Table 1). The regression variables were potassium content of the grass and dry matter yield, while the class variables were nitrogen fertilization, plant species, season (cut), soil type and age of the ley. The whole model accounted for 51,7 per cent of the total variation in the Ca/P ratio.

Table 1. Least squares analysis of the relationships between the potassium content of the grass, the dry matter yield (regression variables), nitrogen fertilization, species, cutting time, age of the ley and soil type (class variables) and the Ca/P ratio of the grass.

	b	F	▲ R^2, %
Potassium (K) content of the grass	−0,41	462,0***	14,3
Nitrogen fertilization		85,3***	10,6
Plant species		157,1***	4,9
Cutting time		65,7***	4,1
Age of the ley		36,9***	2,3
Dry matter yield	−0,0001	67,5***	2,1
Soil type		20,6***	1,3
Total effect		128,5***	51,7

Effects of nitrogen fertilization

The average phosphorus content of the grass at the zero N level was 0,38 ± 0,11 per cent and the calcium content 0,55 ± 0,17 per cent. Nitrogen fertilization decreased the P content (except in the first cut) and increased the Ca content of the grass. The relationships were curvilinear and highly significant.

Nitrogen fertilization, kg/ha/yr	0	150	300	450	600
Ca content, %/DM	0,55	0,51	0,54	0,57	0,58
P content, %/DM	0,38	0,33	0,33	0,32	0,33

Nitrogen fertilization increased the Ca/P ratio of the grass linearly, on average from 1,51 to 1,94 (Table 2, Figs. 1—2). N fertilization accounted for 10,6 per cent of the variation in the Ca/P ratio. At the beginning of the experiment and in some yields of the first cut the increase was not significant. In the first cut of cocksfoot grown on fine mineral soil and fertilized with 100 kg/ha or less of nitrogen, the Ca/P ratio was under 1 (the health risk limit for bovines).

Plant species

The species did not differ from each other in their average P content, but the Ca content of meadow fescue was a third higher than that of cocksfoot. Thus the Ca/P ratio of meadow fescue was significantly higher (Table 2, Figs. 1—2).

Cutting time

The effect of cutting time (season) on the Ca/P ratio was highly significant (Table 1). The Ca content of the dry matter increased towards the autumn, while the P content was at its lowest in the middle of the growing season. Accordingly, the Ca/P ratio was significantly higher in the second than in the other cuts (Table 2, Figs. 1—2).

Age of the ley

While the average Ca content of the grass increased as the age of the ley increased, the

Table 2. Relationships between nitrogen fertilization, cutting time (season), age of the ley, soil type and plant species, and the Ca/P ratio of the grass. Values followed by the same letter do not differ significantly ($P < 0,05$) from each other. The Tukey test.

N fertilization	kg N/ha/cut	0	50	100	150	200
	Ca/P	1,51[a]	1,62[a]	1,77[b]	1,88[bc]	1,94[c]
	± s	±0,58	±0,63	±0,70	±0,77	±0,81
Cut no.		1.		2.		3.
	Ca/P	1,38[a]		2,01[c]		1,84[b]
Age of the ley	years	1		2		3
	Ca/P	1,67[a]		1,78[b]		1,78[b]
Soils		Coarse mineral		Fine mineral		Organogenic
	Ca/P	1,91[b]		1,62[a]		1,72[a]
Species		Meadow fescue				Cocksfoot
	Ca/P	1,98[b]				1,51[a]
	Ca/P	1,74				
Whole material	± s	±0,72				

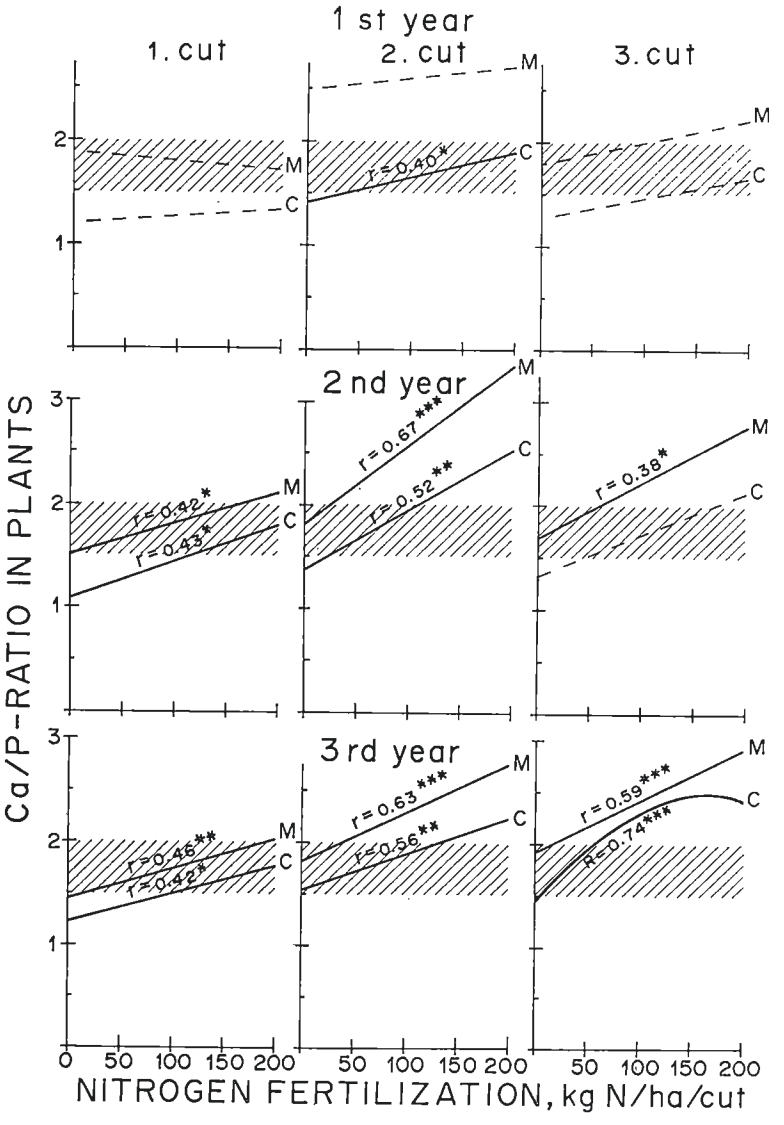

Fig. 1. Regressions of the Ca/P ratio on nitrogen fertilization for coarse mineral soils (seven experimental sites). C = cocksfoot, M = meadow fescue. Diagonal lines indicate the optimal dietary Ca/P ratio for ruminants (ANON. 1975).

age had no significant effect on the P content. Therefore from the first year the Ca/P ratio increased significantly with the age of the ley (Table 2).

Soils

The Ca/P ratio of the grass grown on the coarse mineral soil was significantly higher, on average 1,91, than on other soils. This was because of the high Ca content of the grass. Only 1,3 per cent of the variation in the Ca/P ratio was due to soil type. The potassium content accounted for the greatest proportion (14,3 %) of the variation, which fact reflects the effect of soil type on the Ca/P ratio.

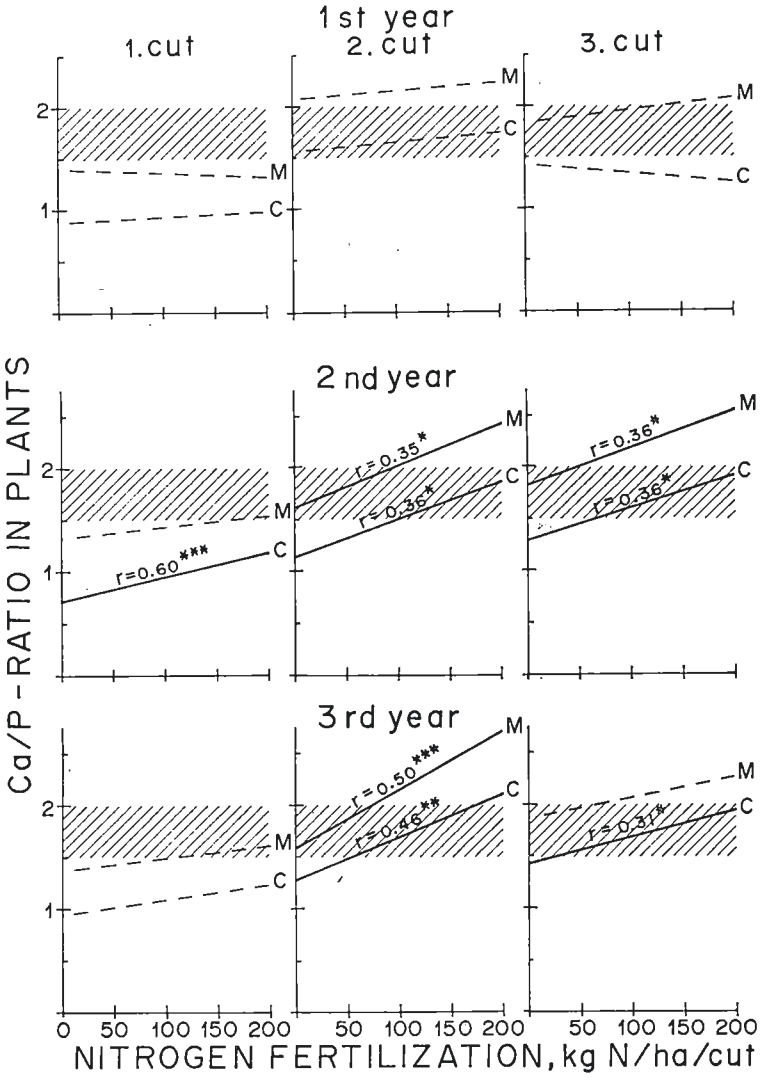

Fig. 2. Regressions of the Ca/P ratio on nitrogen fertilization for fine mineral soils (nine experimental sites). C = cocksfoot, M = meadow fescue. Diagonal lines indicate the optimal dietary Ca/P ratio for ruminants (ANON. 1975).

DISCUSSION

It is obvious that there were several factors contributing to the increase in the Ca/P ratio with increasing nitrogen fertilization. 1) The most important was the potassium content of the grass. Nitrogen fertilization increased strongly the potassium content of the grass and the uptake of potassium. Potassium fertilization replaced only a small part of the enhanced potassium uptake, which led to depletion of the soil potassium (SILLANPÄÄ and RINNE 1975). Thus, towards the end of the experiment, the K content of the grass

decreased with increasing N fertilization and, because of antagonism between calcium and potassium, the Ca content of the grass increased. This was reflected strongly in the increase of the Ca/P ratio with increasing N fertilization. The large amount of variation in the Ca/P ratio (14,3 per cent) accounted for the potassium content, was indirectly due to the soil because the content of plant available potassium depends on soil type. For this reason, nitrogen fertilization did not increase the Ca/P ratio of the grass grown on fine mineral soil so strongly as that on coarse mineral soil. 2) Another factor affecting the Ca/P ratio of the grass was the decrease of soil pH as the N level increased (SILLANPÄÄ and RINNE 1975). This decreased the plant available phosphorus in soil and, consequently, its content in the grass.

In the grass of the first cut, nitrogen fertilization did not increase significantly the Ca/P ratio because both the Ca and the P contents of the grass increased with increasing N fertilization. The increasing P content found in the grass of the first cut is apparently due to the phosphorus being more available shortly after its single dose spring application than during the later stages of the growing season.

Provided there were sufficient plant available potassium and phosphorus in the soil, nitrogen fertilization did not affect significantly the Ca/P ratio. This accords with results found elsewhere that N fertilization does not affect the Ca/P ratio of the grass (BEHAEGHE and CARLIER 1974). It seems that the Ca/P ratio depends rather on plant species, soil type and cutting time than on the level of nitrogen fertilization. Nevertheless, a Ca/P ratio above the optimal dietary range is often the result of unbalanced fertilization and decrease of soil pH. When the Ca/P ratio is too low (<1) for ruminants, the effect of N fertilization is often favourable.

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SELOSTUS

Typpilannoituksen vaikutus nurminadan ja koiranheinän Ca/P-suhteeseen

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Maatalouden tutkimuskeskus

Maatalouden tutkimuskeskus järjesti 18 koepaikalla kolmivuotisia säilörehunurmen typpilannoituskokeita, joissa typpimäärä nousi portaittain 0—600 kg puhdasta typpeä hehtaarille vuodessa ja se annettiin kolmena eränä kasvukaudella. Keväällä annettu peruslannoitus sisälsi 44 kg fosforia ja 100 kg kaliumia hehtaarille.

Typpilannoitus kohotti ruohon kalsium-fosforisuhdetta (Ca/P) erittäin merkitsevästi, keskimäärin 1,51 ± 0,58:sta 1,94 ± 0,81:een. Typpilannoituksen vaikutus ei ollut merkitsevä ensimmäisenä vuotena eikä kaikissa ensimmäisen niittokerran sadoissa.

Typpilannoituksen ohella kasvilaji, niittokerta, nurmen ikä, maalaji, kuiva-ainesadon määrä sekä sadon kaliumpitoisuus vaikuttivat kukin erittäin merkitsevästi ruohon Ca/P-suhteen vaihteluihin. Ne selittivät yhdessä 51,7 % vaihteluista.

Kokeen aikana tapahtuneet muutokset osoittivat, että silloin kun kaliumia ja fosforia oli runsaasti kasvien saatavilla kuten esimerkiksi ensimmäisille sadoille, typpilannoitus ei muuttanut ruohon Ca/P-suhdetta. Myös runsaasti kaliumia sisältävillä savimailla typen vaikutus ruohon Ca/P-suhteeseen oli heikompi kuin karkeilla kivennäismailla. Maan vaihtuvan kaliumin väheneminen kokeen aikana alensi ruohon kaliumpitoisuutta ja nosti sen kalsiumpitoisuutta. Samaan aikaan tapahtunut pH:n aleneminen vähensi liukoisen fosforin määrää maassa ja sen pitoisuutta sadossa, jolloin Ca/P-suhde nousi nurmen iän kasvaessa.

Nurminadan Ca/P-suhde (1,98) oli erittäin merkitsevästi korkeampi kuin koiranheinän (1,51). Karkeilla kivennäismailla kasvaneessa ruohossa suhde oli korkeampi (1,91) kuin muilla maalajeilla (1,62—1,72).

Nautaeläimille sopiva Ca/P-suhde on 1,5—2,0. Jos tämä luku on pienempi kuin 1, rehu voi aiheuttaa sairautta. Keskimäärin tämä suhde oli koiranheinän kevätsadoissa hienoilla kivennäismailla 100 kg/ha typpilannoitukseen saakka aina mainitun riskirajan alapuolella. Karkeilla kivennäismailla tilanne oli parempi.

Ensimmäisen niittokerran sadoissa Ca/P-suhde oli keskimäärin alhaisin (1,38) ja keskikesällä korkein (2,01). Eräänä todennäköisenä syynä liian alhaiseen Ca/P-suhteeseen keväällä oli kerralla koko kesän tarvetta varten annettu PK-lannoitus. Jos typpilannoitusta, joka nostaa suhdetta, ei muista syistä haluta lisätä, on vaihtoehtona kalin ja fosforin jakaminen useampana eränä. Tämä korjaisi eläinten ravitsemuksen kannalta pahimman epäkohdan, koiranheinän liian alhaisen Ca/P-suhteen kevätsadoissa. Rehun Ca/P-suhde ei näytä muodostuvan vaarallisen korkeaksi runsaitakaan typpimääriä käytettäessä.

ANNALES AGRICULTURAE FENNIAE, VOL. 16: 184–187 (1977)
Seria ANIMALIA NOCENTIA N. 97 – Sarja TUHOELÄIMET n:o 97

STORING DORMANT COCCINELLA SEPTEMPUNCTATA AND ADALIA BIPUNCTATA (COL., COCCINELLIDAE) ADULTS IN THE LABORATORY

MATTI HÄMÄLÄINEN

HÄMÄLÄINEN, M. 1977. **Storing dormant Coccinella septempunctata and Adalia bipunctata (Col., Coccinellidae) adults in the laboratory.** Ann. Agric. Fenn. 16: 184–187. (Agric. Res. Centre, Inst. Pest Inv., SF-01300, Vantaa 30, Finland.)

Adult beetles collected in August or September were placed in an artificial laboratory hibernacula at +6 ± 1°C and at 70–90 % R. H. Survival was poor in *Coccinella septempunctata*; the last beetles died in January. More than 70 % of *Adalia bipunctata* survived till March and 50 % until May.

A considerably greater percentage of *A. bipunctata* than *C. septempunctata* started to reproduce when taken from storage to conditions suitable for breeding. In *A. bipunctata* dormancy is chiefly controlled by environmental factors.

Index words: *Coccinella septempunctata, Adalia bipunctata,* laboratory hibernacula, dormancy, cool storage, survival.

If ladybeetles are used for the biological control of aphids in greenhouses (see HÄMÄLÄINEN 1977) they may be required earlier in spring than they are available from nature. A breeding ladybeetle population can be maintained all year around in the laboratory (HÄMÄLÄINEN 1976). It would, however, be simpler if the beetles could be kept dormant in an artificial hibernacula, and taken to conditions suitable for reproduction when required (cf. HODEK et al. 1973).

The aim of the present study was to find out the rate of survival of adults of *Coccinella septempunctata* L. and *Adalia bipunctata* (L.) collected from the field in a simple laboratory hibernacula, and of reproduction after cessation of storage.

MATERIAL AND METHODS

Adults of *C. septempunctata* were collected from nature in Helsinki area:

a) in Mid-August (1975) from fields and gardens, 1—3 weeks after the beetles emerged
b) in late September (1976) from rocky spots where the beetles had arrived for hibernation.

Adults of *A. bipunctata* gathered for hibernation on walls of buildings were collected from different localities in South-Finland in Mid-September (1975 and 1976).

The beetles were placed in plastic cages (diameter 4,5 cm, height 22 cm, see MARKKULA and RAUTAPÄÄ 1963) stuffed with cleanex paper; about 50 beetles were placed in each cage. The cages were placed in a store room at a temperature of $+6° \pm 1°C$ and at a relative humidity of 70—90 % (constant darkness).

Samples of beetles (200—400 in each) were taken from the storage temperature to room temperature at intervals of one month, and the percentage of live beetles was counted.

Each month 40 viable beetles of both species were reared in the laboratory for one month on pea aphids *Acyrthosiphon pisum* (Harris) and green peach aphids *Myzus persicae* (Sulz.). Twenty beetles were placed together in plastic jars (diameter 16 cm, height 9 cm). The survival and fecundity of the beetles was recorded. Average weekly temperatures in the laboratory varied from 22° to 25°C. The photoperiod was LD 18: 6.

RESULTS AND DISCUSSION

Survival in storage

A. bipunctata survived storage well: the mortality rate was less than 30 % over a period of six months. On the other hand, in *C. septempunctata* the mortality rate was high after only 1—2 month's storage, and none of the beetles survived beyond January (Fig. 1). Death occurred more rapidly in beetles collected in September, which had accumulated food reserves in their body for hibernation, than in beetles collected soon after emergence and with limited reserves.

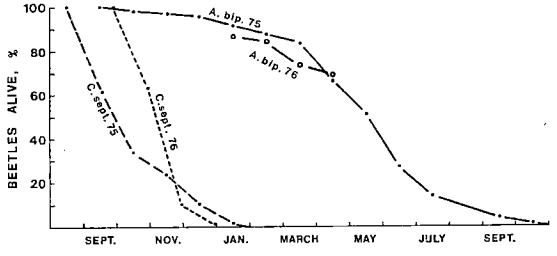

Fig. 1. Survival of field collected *Coccinella septempuntata* and *Adalia bipunctata* in an artificial hibernacula at $+6° \pm 1°C$ and at 70—90 % R.H. C. sept. 75 = *C. septempunctata* collected from fields in August 1975 1—3 weeks after emergence; C. sept. 76 = collected from hibernation sites at the end of September 1976; A. bip. 75 and 76 = *A. bipunctata* collected from hibernation sites in Mid-September 1975 and 1976 respectively.

The lack of reserves was therefore not the reason for the rapid death rate in *C. septempunctata*. It was most probably caused by unsuitable microclimatic conditions. The hibernacula was too dry and perhaps too warm for *C. septempunctata*. In nature, the species hibernates in a sheltered environment covered by snow: in litter, under tussocs, shrubs or stones. On the other hand *A. bipunctata* hibernates in the cracks and crevices of tree trunks and of building structures. According to HARIRI (1966) *A. bipunctata* lose less water during hibernation than *C. septempunctata*. NOVÁK and GRENAROVÁ (1967) kept ladybeetles over the winter under the roof of an open hut and in tree tops and noted that *A. bipunctata* survived

considerably better than *C. septempunctata*. There were, however, no differences in the mortality rate when the beetles were stored in a protected grass environment. Also HARIRI (1966), SHANDS et al. (1972) and ANON. (1972) obtained better survival in *C. septempunctata* than was recorded in the present study by keeping the beetles in outdoor cages in a more natural microclimate.

It might also be possible to improve survival in *C. septempunctata* in the laboratory hibernacula by supplying them periodically with water or aphids during storage. BORODKIN (1973) briefly reports that adults of *C. septempunctata* and *Adonia variegata* (Goeze) can be stored in the laboratory at 5° and at 80 % R.H. up to 8 months by feeding them periodically with aphids and other food.

Mortality and fecundity after storage

A higher percentage of *C. septempunctata* than *A. bipunctata* died out during one month in rearings. The higher mortality rate in *C. septempunctata* was partly caused by parasitism by *Perilitus coccinellae* (Schrank) (Table 1).

The percentage of *A. bipunctata* females starting to reproduce ranged from 32 to 87 % and that of *C. septempunctata* from 0 to 33 % in different samples. The average number of eggs laid by *A. bipunctata* females was also greater than that of *C. septempunctata*. There was no correlation between the percentage of fecund females and the duration of storage, or between the number of eggs laid and the duration, except in *C. septempunctata* collected in late September (Table 1).

The results indicate that in *A. bipunctata* dormancy is directly controlled by environmental factors, since a high percentage of females soon starts to reproduce after transfer to conditions suited for reproduction. In *C. septempunctata* dormancy is known to be more complex (see HODEK 1973).

Results indicate that *A. bipunctata* is more suited to simple laboratory storage than *C. septempunctata*. Methods for storing the latter species for practical application should still be developed. The present experiments were carried out with beetles collected from nature. The possibility of storing laboratory produced beetles in artificial hibernacula should be tested further (cf. IPERTI and HODEK 1974).

This study is part of a project supported financially by the National Research Council for Agriculture and Forestry (Academy of Finland).

Table 1. Mortality and fecundity in *Coccinella septempunctata* and *Adalia bipunctata* in the laboratory after artificial cool storage of different length. Symbols: C.s.Aug. = *C. septempunctata* collected from fields in Mid-August (1975), C.s. Sept. = *C. septempunctata* collected from hibernation sites in late September (1976), A.b. = *A. bipunctata* collected from hibernation sites in Mid-September (1975). The beetles were dissected, and females with developed ovaries were considered fecund. — means no record.

Duration of storage, months	Mortality during one month[1]) %			*Perilitus coccinellae* pupae emerged from % of beetles			Nr of fecund females			% of fecund females			Shortest preoviposition period, days			Eggs/ all females[2])		
	C.s. Aug.	C.s. Sept.	A.b.	C.s. Aug.	C.s. Sept.	A.b.	C.s. Aug.	C.s. Sept.	A.b.	C.s. Aug.	C.s. Sept.	A.b.	C.s. Aug.	C.s. Sept.	A.b.	C.s. Aug.	C.s. Sept.	A.b.
0	—	43	—	—	3	—	1	10	15	2	59	88	—	8	—	—	151	—
1	—	65	8	—	0	0	—	4	16	—	33	76	—	11	13	—	91	264
2	53	90	18	25	0	0	2	0	26	11	0	87	18	—	9	49	0	177
3	48		10	15		0	1		10	8		83	24		10	2		162
4	55		20	20		0	5		12	33		67	19		7	44		138
5	55		45	0		0	2		9	20		32	13		8	62		107
6			10			0			26			84			6			133
7			45			0			11			39			4			217

[1]) Mortality caused by *Perilitus* included

[2]) Total number of eggs laid divided by number of live females after 10 days.

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SELOSTUS

Seitsenpiste- ja kaksipistepirkkojen varastointi kylmässä

MATTI HÄMÄLÄINEN

Maatalouden tutkimuskeskus

Jos leppäpirkkoja käytetään kirvojen torjuntaan kasvihuoneissa, niitä tarvitaan kevätkaudella jo niin aikaisin, ettei niitä ole kerättävissä luonnosta. Yksinkertaisin keino olisi säilyttää leppäpirkkoja kylmähorroksessa laboratoriossa kulloistakin tarvetta varten.

Luonnosta elo—syyskuussa kerättyjä aikuisia seitsenpiste- ja kaksipistepirkkoja säilytettiin muovilieriöissä +6° ±1°:n lämpötilassa ja 70—90 %:n kosteudessa. Seitsenpistepirkot eivät kestäneet säilytystä, vaan kuolivat viimeistään tammikuussa. Sen sijaan kaksipistepirkoista oli 70—80 % elossa maaliskuussa ja vielä 50 % toukokuussa.

Suurin osa kylmähorroksesta huoneen lämpötilaan otetuista kaksipistepirkoista alkoi munia, seitsenpistepirkoista sen sijaan vain pieni osa.

Tulokset osoittivat, että aikuisten kaksipistepirkkojen varastointi kylmässä on helppo järjestää. Varastointimenetelmiä on edelleen kehitettävä, erityisesti seitsenpistepirkkoa varten.

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Serie ANIMALIA NOCENTIA N. 98 — Sarja TUHOELÄIMET n:o 98

PESTS OF CULTIVATED PLANTS IN FINLAND IN 1976

MARTTI MARKKULA

MARKKULA, M. 1977. **Pests of cultivated plants in Finland in 1976.** Ann. Agric. Fenn. 16: 188—191. (Agric. Res. Centre, Inst. Pest Inv., SF-01300 Vantaa 30, Finland.)

In 1976 pests were less abundant than usual. This was probably due to the chilliness of the growing season. Responses to inquiries showed that average abundance in all pests, in terms of the 0—5 value scale, was 1,8. It was 2,8 the previous year and 2,6 in the ten-year period 1965—1974. Only *Lepus europaeus* and *Arvicola terrestris* caused more damage than normally. *Cydia pomonella* and *Argyresthia conjugella* damaged less apples than ever before during the years recorded. A new pest to Finland, *Kessleria rufella*, was identified. It caused considerable local damage in black currant cultivations.

Index words: plant pests, Finland, year 1976, severity of damage, frequency of damage.

Like the previous ones (e.g. MARKKULA 1976), the present survey is based on replies to inquiries sent to the advisers at Agricultural Centres. During the growing season four inquiries were sent to 199 advisers, and replies were received as follows:

	Replies	%	Communes	%
Spring inquiry	147	74	151	32
First summer inquiry	146	73	143	30
Second summer inquiry	153	77	142	30
Autumn inquiry	115	58	139	29

A general estimate of pest abundance during the whole growing season was given by 115 advisers from 133 communes. This estimate was based on the 0—5 value scale (MARKKULA 1969). In 1976 the country was divided into 390 rural communes, 22 country towns, and 63 cities, a total of 475 communes.

The growing season got under way late. Ground frost thawed as late as early May, even in South Finland. Since May was warmer than normal, sowing was only slightly delayed. A cool period set in in June, and the whole season was rather chilly. The temperature in May—August was 0,4°C below the long term average. Rainfall was close to normal in the early summer, but rainfall for the whole season was less than normal.

Table 1. Results of questionnaires. Severity of damage estimated according to a scale of 0—10. Frequency of damage calculated as the percentage of crops in which damage was observed.

	Number of 1976	Severity of damage 1976	Severity of damage 1965—74	Frequency of damage 1976	Frequency of damage 1965—74
CEREALS					
Oscinella frit (L.)	154	0,6	1,0	4	13
Macrosiphum avenae (F.)	75	0,6	1,4	14	22
Elateridae	89	0,4	1,1	5	15
Phyllotreta vittula (Redtb.)	114	0,4	1,0	12	18
Rhopalosiphum padi (L.)	97	0,4	1,2	4	18
FORAGE PLANTS					
Amaurosoma spp.	88	1,2	1,5	23	28
Apion spp.	59	0,5	1,0	9	16
ROOT CROPS AND VEGETABLES					
Delia brassicae (Wied.) and *D. floralis* (Fall.)	155	1,5	2,9	22	28
Trioza apicalis (Först.)	94	1,3	1,3	4	21
Phyllotreta spp. on crucifers	98	1,2	2,0	21	38
Plutella xylostella (L.)	78	1,1	1,6	17	21
Pieris brassicae (L.) etc.	66	1,1	1,7	20	29
Hylemya antiqua (Meig.)	74	1,0	1,9	15	21
Phaedon cochleariae (F.)	64	0,6	1,1	10	19
Mamestra brassicae (L.)	45	0,5	1,1	6	21
Psila rosae (F.)	62	0,4	0,8	9	10
Brevicoryne brassicae (L.)	45	0,2	0,8	1	14
TURNIP RAPE					
Meligethes aeneus (F.)	55	1,0	1,8	28	40
SUGAR BEET					
Pegomya betae (Curt.)	136	1,3	1,8	32	48
Lygus rugulipennis Popp.	60	1,2	1,9	33	43
Chaetocnema concinna (Marsh.)	93	1,1	1,7	36	40
Silpha opaca L.	57	0,6	1,4	19	33
PEAS					
Cydia nigricana (F.)	56	1,3	1,9	29	37
APPLES					
Lepus europaeus Pallas and *L. timidus* L.	97	1,9	1,6	19	15
Cydia pomonella (L.)	67	1,1	2,5	15	42
Aphis pomi (Deg.)	63	0,9	1,5	14	24
Panonychus ulmi (Koch.)	100	0,7	1,3	11	21
Yponomeuta padellus malinellus Zell.	65	0,7	1,6	8	23
Argyresthia conjugella Zell.	63	0,7	3,4	13	46
Psylla mali (Schmidbg.)	66	0,6	0,9	9	13
Microtus agrestis (L.)	73	0,6	1,1	6	8
Arvicola terrestris L.)	69	0,6	0,5	4	4
Xyleborus dispar (F.)	60	0,3	0,5	3	4
BERRIES					
Cecidophyopsis ribis (Wettw.)	116	2,1	2,2	21	30
Tarsonemus pallidus Bks.	95	1,5	2,0	29	28
Incurvaria capittella Cl.	102	1,3	1,9	15	22
Aphdidae, on Ribes species	80	1,0	1,8	11	26
Anthonomus rubi (Hbst.)	68	1,0	1,6	20	26
Zophodia convolutella (Hbn.)	61	0,9	0,9	8	12
Byturus urbanus (Lndb.)	65	0,9	1,7	19	29
Tetranychus urticae (Koch.)	58	0,7	1,3	12	21
Pachynematus pumilio Knw.	75	0,4	1,3	12	21
Nematus ribesii (Scop.) and *Pristiphora pallipes* Lep.	82	0,1	1,7	10	16
PESTS ON SEVERAL PLANTS					
Hydraecia micacea (Esp.)	63	0,7	1,2	13	21
Deroceras agreste (L.) etc.	67	0,5	1,3	8	24

RESULTS AND DISCUSSION

Delay at the beginning of the growing season and the lack of warm periods prevented an increase in pest abundance, and probably was the main reason for the scarcity of pests and little damage.

The average abundance of pests in terms of the 0—5 scale was 1,8. In the previous year it was 2,8. The 10-year average for 1965—1974 was 2,6 (MARKKULA 1976). Since 1965 same method has been used in gathering data. In no year has pest abundance been so low as in 1976.

Only damages caused by *Lepus europaeus* and *Arvicola terrestris* were a little more severe than usual (Table 1). Damages caused by *Cecidophyopsis ribis* and *Zophodia convolutella* reached the normal levels, but the values indicating the severity of damage by all other pests were below normal.

Rhopalosiphum padi, *Argyresthia conjugella*, *Pachynematus pumilio*, *Nematus ribesii* and *Pristiphora pallipes* were especially scarce (Table 1). The values showing the severity of damage by them were at most one third of the average during 1965—1974.

The apple crop was exceptionally rich in 1976, whereas in the previous year it was almost a complete failure due to frost during flowering. Even poorly cultivated or totally neglected home gardens gave records yields of apples in 1976.

Egg-laying by *Cydia pomonella* and *Argyresthia conjugella* was scanty, due to the cool weather during their flight periods. As apple yields were also plentiful, the percentage of damaged apples remained very low. It was lower than ever before during the years recorded.

	1976	1975	1965 – 1974	Replies 1976
Argyresthia conjugella	8	24	31	40
Cydia pomonella	8	20	22	41

Damage by *Cydia nigricana* was also slighter than usual. According to estimates by the advisers, 9 % of pea pods were damaged. The corresponding percentage for the previous year, and also for the 10-year period 1965—1974, was 14 %.

During the year of the survey a new pest to Finland, *Kessleria rufella* (Tgstr.) was identified. Its larva injures black currant buds (*Ribes nigrum*). A survey showed that *K. rufella* is distributed over the whole black currant cultivation area up to Lapland. The pest caused considerable damage locally by destroying as much as half the black currant buds (O. HEIKINHEIMO, oral communication).

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SELOSTUS

Viljelykasvien tuhoeläimet 1976

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Maatalouden tutkimuskeskus

Tuhoeläinten aiheuttamat vahingot olivat kasvukautena 1976 varsin vähäisiä, mikä johtui ensisijaisesti kasvukauden koleudesta. Maatalouskeskusten piiriagrologien arvioiden perusteella laskettu tuholaisten runsausluku oli 1,8. Edellisenä kasvukautena se oli 2,8 ja kymmenvuotiskautena 1965—1974 2,6.

Ainoastaan jänisten ja vesimyyrän vioitukset olivat keskimääräistä pahempia. Omenakääriäinen ja pihlajanmarjakoi vahingoittivat omenoita huomattavasti vähemmän kuin tilastokauden aikaisempina vuosina.

Katsausvuotena määritettiin uusi tuholainen, herukan silmukoi (*Kessleria rufella*), jonka todettiin esiintyvän koko musteherukan viljelyalueella Lappia myöten.

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Seria AGROGEOLOGIA ET -CHIMICA N. 80 — Sarja MAA JA LANNOITUS n:o 80

THE EFFECT OF NITROGEN FERTILIZATION ON THE COPPER/MOLYBDENUM RATIO OF GRASS HERBAGE

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RINNE, S.-L., SILLANPÄÄ, M., HUOKUNA, E. & HIIVOLA, S.-L. 1977. **The effect of nitrogen fertilization on the copper/molybdenum ratio of grass herbage.** Ann. Agric. Fenn. 16: 192—198. (Agric. Res. Centre, Inst. Soil. Sci., SF-01300 Vantaa 30, Finland.)

In nitrogen fertilization experiments made at the Agricultural Research Centre on grass for silage, Oulu salpetre (calcium ammonium nitrate) increased the copper content of the herbage and reduced its molybdenum content highly significantly. This resulted in a linear and highly significant increase in the ratio between copper and molybdenum ($r = 0{,}49^{***}$). When the nitrogen level was increased from 0 to 600 kg/ha, the Cu/Mo ratio for the whole material rose average from 7,2 to 24,2.

At the beginning of the experiment, the Cu content of the unfertilized herbage was too low from an animal nutritional standpoint (on average 6,2 μg/g) and the Mo content somewhat high (on average 2,4 μg/g). Thus moderate nitrogen fertilization (not exceeding 250 kg N/ha) had a favourable effect on the Cu/Mo ratio of the herbage.

As the ley aged, the Cu content of the herbage increased still further and the Mo content fell, in consequence of which the Cu/Mo ratio nearly trebled (from 9,3 to 25,1).

On organogenic soils, the Cu content of herbage increased more sharply than on other soils in response to nitrogen fertilization and age of the ley. The Cu/Mo ratio rose more rapidly and attained a higher level on organogenic than on coarse or fine mineral soils.

Index words: Nitrogen fertilization, Cu/Mo ratio of herbage, *Dactylis glomerata*, *Festuca pratensis*.

INTRODUCTION

In animal nutrition, the interrelations between various trace elements are exceedingly complex. It has been demonstrated that for instance, the amount of molybdenum consumed affects the copper metabolism, and that this relationship is influed by sulphate. For example, copper has been shown to accumulate in the liver and cause toxicity symptoms in sheep receiving feed containing moderate amounts of copper but very low amounts of molybdenum and sulphate. In contract, a high content of molybdenum and sulphate in the feed increases the risk of copper deficiency (WYNNE and MCCLYMONT 1956).

A working group representing the Association of Nordic Agricultural Scientists (NJF) has specified norms for the copper and molybdenum requirements of animals (ANON. 1975).

It recommends as the copper requirement norms for cattle 10 μg/g of odder, provided that the molybdenum content of the fodder does not exceed 1 μg/g, nor the sulphur content 2000 μg/g. As the molybdenum content increases, so does the copper requirement.

An excess of molybdenum causes imbalances more frequently than does a deficiency, since the toxicity treshold is low, particularly when there is little copper (UNDERWOOD 1971). According to the NRC (1971), the upper limit for the Mo content is 6 μg/g for dairy cattle, and the working group (ANON. 1975) consider 0,1—0,5 μg/g adequate for beef cattle. Nonetheless, extremely low Mo contents have been confirmed in many localities without any sign of imbalance in the animals, thus the overall balance is always the result of many factors interacting.

The trace element content of plants depend upon diverse factors. Soil acidity determines the solubility of trace elements and thus their availability to plants. In general, the solubility increases with increasing acidity. The solubility of molybdenum is especially sensitive to variations in acidity, but in contract to other trace elements, its solubility decreases with rising acidity.

Experiments made at the Agricultural Research Centre reveal that heavy fertilization with Oulu salpetre reduces soil acidity to a highly significant extent (SILLANPÄÄ and RINNE 1975). The fertilization has increased the copper content and reduced the molybdenum content of the herbage highly significantly (RINNE et al. 1974).

In the following, an account will be given of the effects of heavy nitrogen fertilization on changes in the copper/molybdenum ratio on different soils and with varying age of the ley.

MATERIALS AND METHODS

Experimental sites and plants species

At 18 sites comprising experimental stations and farms of the Agricultural Research Centre, three year nitrogen fertilization experiments were made on grass leys for silage. Of the experiments, nine were run on fine mineral soils, seven on coarse mineral soils ond two on organogenic soils. The plant species used in the experiments were meadow fescue and cocksfoot.

Fertilization

The fertilization level was increased stepwise: 0, 150, 300, 450 and 600 kg N/hectare, which levels correspond to 0, 580, 1150, 1730 and 2310 kg of Oulu salpetre. The basic fertilization, with 500 kg of superphosphate and 200 kg of potassium chloride, was annually carried out in spring.

Sampling

The yield was taken in three cuts during the growing season. A sample was taken from each cut for chemical analysis. The copper content of the herbage was determined on each sample. Molybdenum was determined on 90 combined samples only (5 N treatments × 2 species × 3 soil groups × 3 years). In dederminations of the Cu/Mo ratio, the corresponding mean Cu contents were used.

Yields

During the first year, the dry matter yields increased with increasing nitrogen fertilization very strongly. Nevertheless, the yield level fell off as the ley aged. Dry matter yields, averaged for the three years at each of the different nitrogen levels, were as follows:

Nitrogen fertilization kg N/ha/year	0	150	300	450	600
Dry matter yield tn/ha/year	2,0	6,1	7,9	8,4	8,2

Soil pH

The results and their interpretation are substantially affected not only by the increasing yields, but also by soil changes occurring during the course of the experiment. Of these, the most important change influencing trace element relationships was the fall in pH resulting from increased nitrogen fertilization. When the experiment was started, the soil pH for the fine mineral soils averaged 5,90, for the coarse mineral soils 5,86 and for the organogenic soils 5,01. Analyses made at the end of the experiment showed that at the lower nitrogen levels (0—300 N) the pH fell by 0,10—0,15 pH units and at the higher levels (450—600 N) by 0,29—0,41 units. The fall was similar on all the soil types.

The Cu/Mo ratio

At the beginning of the experiment, the Cu/Mo ratio of herbage from leys not receiving nitrogen was very low. This was due to the low Cu content (averaging 6,2 μg/g) and the high molybdenum content (averaging 2,4 μg/g). As the nitrogen fertilization was increased, the Cu content of the herbage rose, while the Mo content diminished. Owing to this the increase of the Cu/Mo ratio was linear and highly significant. The relationship between the Cu/Mo ratio and the nitrogen level is described by the equations:

1st year	$3{,}39 + 0{,}0197$ ($r = 0{,}68^{***}$, df 1,28)	N/ha/yr
2nd year	$4{,}35 + 0{,}0259$ ($r = 0{,}65^{***}$, df 1,28)	»
3rd year	$12{,}79 + 0{,}0409$ ($r = 0{,}60^{***}$, df 1,28)	»
Whole material	$6{,}84 + 0{,}0289$ ($r = 0{,}49^{***}$, df 1,88)	»

Plant species

The Cu/Mo ratio for cocksfoot (18,3 $\pm$ 14,0) was higher than for meadow fescue (12,7 $\pm$ 10,1). This reflects the significantly higher copper content and lower molybdenum content for cocksfoot than for fescue. Nitrogen fertilization increased the Cu/Mo ratio of cocksfoot on average more, from 10,1 to 28,1, than that of fescue, from 4,7 to 20,2 (Table 1). Nonetheless, for cocksfoot the correlation was poorer (Fig. 1 A).

Age of the ley

Since the soil pH at all levels of nitrogen fell during the 3 year period of the experiment, the solubility relations of the trace elements altered accordingly. Thus as the ley aged, the Cu content of the herbage increased and its Mo content decreased. The Cu/Mo ratio of the herbage did, in fact, increase very rapidly as the ley grew older (Fig. 1 B). In the first year, the Cu/Mo averaged 9,3, in the second 12,1 and in the third 25,2.

Soil type

At the beginning of the experiment (1st year), herbage from unfertilized plots on the fine mineral soils contained significantly more molybdenum (3,2 μg/g) than on coarse mineral

Table 1. Effect of nitrogen fertilization on the Cu/Mo ratio of grass herbage with increasing age of ley.

	Nitrogen fertilization, kg N/ha/yr					
	0	150	300	450	600	Aver.
			Meadow fescue			
1st year	2,1	5,0	7,7	9,8	11,2	7,2
2nd »	3,4	6,7	11,6	15,1	16,0	10,6
3rd »	8,5	14,2	19,6	25,7	33,2	20,2
aver.	4,7	8,6	13,0	16,9	20,2	12,7
			Cocksfoot			
1st year	3,5	8,4	13,7	11,6	19,9	11,4
2nd »	5,4	9,5	10,5	21,5	21,5	13,7
3rd »	21,3	20,5	25,7	39,9	42,8	30,0
aver.	10,1	12,8	16,6	24,3	28,1	18,4
			All			
1st year	2,8	6,7	10,7	10,7	15,6	9,3
2nd »	4,4	8,1	11,1	18,3	18,8	12,1
3rd »	14,9	17,4	22,7	32,8	38,1	25,2
aver.	7,4	10,7	14,8	20,6	24,2	15,5

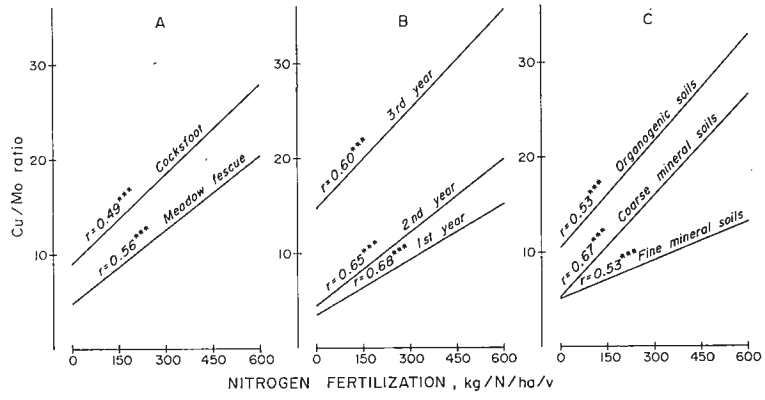

Fig. 1. Effect of nitrogen fertilization on the Cu/Mo ratio of grass herbage (A grass species, B years and C soils).

soils (2,4 μg/g) or on organogenic soils (1,6 μg/g). The Cu content of herbage (0 N) was low on all the soil types. On the fine mineral soils it averaged 6,7, on the coarse mineral soils 7,8 and on the organogenic soils 4,3 μg/g. On all the soils, nitrogen fertilization reduced the Mo content of the herbage to the same extent. In contract, as the ley aged and the nitrogen level increased, the Cu content of the herbage rose more sharply for the organogenic soils than for the other soil types (in the first year the mean Cu content of the herbage was 5 μg/g, in the third 18 μg/g). Owing to this, the Cu/Mo ratio of the herbage increased more sharply on the organogenic than on the other soils (Fig. 1 C).

The effect of the age of the ley was different on the different soil types. The Cu/Mo ratio of the herbage on the organogenic soils rose on average from 10,4 (1st year) to 35,9 (3rd year), on the coarse mineral soils from 10,3 to 25,0 and on the fine mineral soils from 5,6 to 14,3.

The more pronounced increase in the Cu/Mo ratio of the yield on organogenic soils than on the other soils was a result of the sharp response of the copper content to nitrogen and increasing age of the ley. On organogenic soils, nitrogen fertilization can alter the Cu/Mo ratio from one extreme to the other. In herbage which had received no nitrogen, a low Cu content was associated with a high Mo content, a situation which can promote the onset of Cu deficiency. An increase in the nitrogen level and in the age of the ley leads to the converse situation: a high Cu content of the herbage and a low Mo content. Under unfavourable conditions, an interaction of these factors can lead to copper toxicity in sheep.

In order that the significance of the Cu/Mo ratio in animal nutrition be assessed, the amount of sulphur in the feed should be known. However, sulphur was not determined in the present material. According to SALONEN et al. (1965) and KORKMAN (1973), the sulphur content of timothy varies from 1200 to 1400 μg/g. According to data from Viljavuuspalvelu (Soil Testing Service Co.), the sulphur content of silage has varied from about 1600 to 2500 μg/g and that of hay from 900 to 1900 μg/g d.m.

Since data on sulphur contents in this experiment are lacking, and no feeding experiments were made, no difinite conclusions can be drawn. On the basis of the results, one would nevertheless except that the continued application of large quantities of nitrogen would result in low Mo contents in the herbage, as allthough the mean values obtained here are not alarming, they nonetheless indicate a change for the worse. In addition, LAKANEN (1969) has found that a low Mo content in timothy, 0,62 (0,05—5,55 μg/g) indicates poor availability, so that if the pH of an acid soil falls as a result of fertilization, there is a danger that the Mo content of the herbage will fall to an extremely low level.

The results presented here support the use of a moderate amount of nitrogen, at the most 200—250 kg/ha, whereupon fertilization can even have a favourable influence on the Cu/Mo ratio: the excessively low copper content of unfertilized herbage rises and the unnecessarily high molybdenum content falls.

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SELOSTUS

Typpilannoituksen vaikutus ruohon kupari/molybdeeni -suhteeseen

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Maatalouden tutkimuskeskus

Maatalouden tutkimuskeskuksen koeasemilla ja maatiloilla järjestettiin kolmivuotisia säilörehunurmen typpilannoituskokeita 18 koepaikalla. Typpilannoitus nousi portaittain 0—600 kg typpeä hehtaarille (0—2310 kg oulunsalpietaria). Typpilannoitus nosti ruohon kuparipitoisuutta ja alensi molybdeenipitoisuutta erittäin merkitsevästi. Tästä oli seurauksena Cu/Mo-suhteen suoraviivainen ja erittäin merkitsevä kohoaminen, keskimäärin koko aineistossa 7,2:sta 24,2:een ($r = 0{,}49^{***}$).

Typpilannoituksen todettiin lisäävän myös maan happamuutta, mikä edelleen kohotti ruohon Cu/Mo-suhdetta nurmen iän kasvaessa. Eloperäisillä maalajeilla ruohon kuparipitoisuus ja siten myös Cu/Mo-suhde kohosivat jykemmin kuin muilla maalajeilla.

Eläinten ravitsemuksessa molybdeenin määrä rehussa vaikuttaa kupariaineenvaihduntaan. Tämä on riippuvainen sulfaattien määrästä rehussa. Tässä kokeessa lannoittamattoman ruohon Cu-pitoisuus kokeen alkaessa oli keskimäärinkin erittäin alhainen, 6,2 µg/g, ja Mo-pitoisuus korkea, 2,4 µg/g. Saadut tulokset puoltavat kohtuullisten, korkeintaan 200—250 kg/ha typpimäärien käyttöä. Tällöin lannoituksella on jopa edullinen vaikutus rehun Cu/Mo-suh-

teeseen: lannoittamattoman rehun eläinten kannalta liian alhainen rehun Cu-pitoisuus nousee ja korkea Mo-pitoisuus alenee.

Jotta voitaisiin arvioida Cu/Mo-suhteen kohoamisen merkitys eläinten ravitsemuksessa, olisi tiedettävä myös rikin määrä rehussa. Sitä ei kuitenkaan tästä aineistosta määritetty, mutta muiden selvitysten mukaan suomalaisen heinän rikkipitoisuus on melko alhainen, 900—1900 μg/g. Säilörehussa rikkiä on enemmän, 1600—2500 μg/g.

Eloperäisellä maalajilla typpilannoitus muutti ruohon Cu/Mo-suhdetta äärimmäisyydestä toiseen. Sadossa, joka ei saanut typpeä, erittäin alhainen kuparipitoisuus liittyi korkeaan molybdeenipitoisuuteenmikä tilanne saattaa edistää kuparin puutteen syntymistä, jos sulfaatteja on rehussa paljon. Typpitason voimakas nostaminen ja nurmen iän kasvaminen johtivat päinvastaiseen tilanteeseen: korkeaan ruohon kuparipitoisuuteen ja alhaiseen molybdeenipitoisuuteen. Näiden tekijöiden yhteisvaikutus liittyneenä alhaiseen sulfaattipitoisuuteen puolestaan saattaa epäedullisissa olosuhteissa johtaa kuparin kertymiseen eläimen maksaan ja jopa kuparille herkän eläimen, kuten lampaan, kuparimyrkytykseen. Vaikka todetut Mo-pitoisuuksien keskiarvot eivät olekaan hälyttävän alhaisia, ne osoittavat kuitenkin muutosten epäedullisen suunnan. Muissa kokeissa on todettu timotein alhaisten Mo-pitoisuuksien viittaavan sen saannin niukkuuteen Suomessa. Jos lannoituksella vielä lisätään maan happamuutta, saattaa rehun Mo-pitoisuus muodostua alhaiseksi suhteessa kuparin saantiin. Kuitenkin on todettu monin paikoin erittäin alhaisia rehun Mo-pitoisuuksia ilman mitään häiriöitä eläimissä. Aina on siis kysymyksessä monen tekijän yhteisvaikutus.

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EQUIPMENT FOR APPLYING LIQUID FUNGICIDES TO SMALL AMOUNTS OF SEED GRAIN

REIJO VANHANEN

VANHANEN, R. 1977. **Equipment for applying liquid fungicides to small amounts of seed grain.** Ann. Agric. Fenn. 16: 199—206. (Agric. Res. Centre, Inst. Plant Path., SF-01300 Vantaa 30, Finland.)

An attempt has been made to improve the uniformity of the distribution of liquid chemicals in seed dressing by means of a laboratory seed treater. The structure and the principle of the machine are simple. Liquids are sprayed by means of compressed air through a nozzle onto the kernels during the mixing in a rotating seed container. The performance of the seed treating machine was studied by determining the mercury content of the treated kernels and by comparing the effectiveness of the seed treater with that of a method in common use. The uniformity of the distribution of mercury is good. The results of the comparisons of the dressing techniques showed that the seed treater is superior to the current laboratory method.

Index words: seed dressing, seed treater, testing of fungicides.

INTRODUCTION

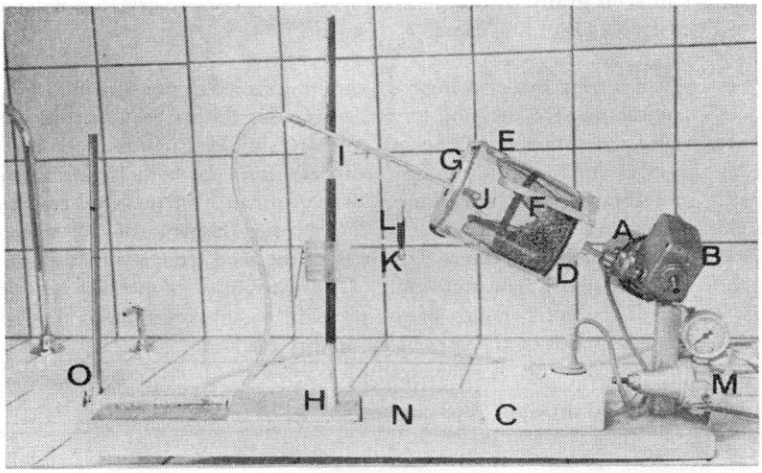
In the earlier wet processes, large volumes of liquid seed dressings had to be used in order to ensure the thorough treatment of the grain. The disadvantage of the procedure was that the seed had to be dried prior to sowing. Nowadays, the amount of fungicide used in a liquid seed treatment is very small, 200—300 ml per 100 kg seed, which is as little as 6—9 ml liquid for about 100 000 kernels.

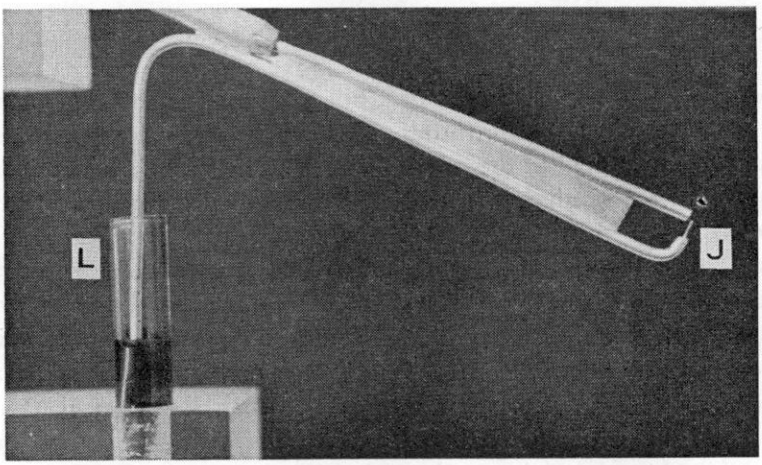
Uniform distribution of the pesticide has been a problem and much criticism has been levelled against the inadequacy of the coating achieved by the existing machinery on commercially dressed cereal seed (e.g. JEFFS et al. 1968, LORD et al. 1971). An even distribution of the active ingredient is especially important in the efficiency tests of seed dressings, in which a predetermined quantity of the compound is mixed with a given weight of seed. An excess of the compound in some kernels can damage them, reduce germinability and give rice to deformed seedlings. Correspondingly, too small a quantity of the active ingredient in other kernels may be insufficient to give adequate disease control, so that a proper idea of the characteristics and efficacy of the compound is not obtained.

The usual laboratory method is to pipette the liquid formulation onto the walls of the bottle containing seeds, after which the container is shaken vigorously by hand or revolved by motor for 4 or 5 minutes. In the case of many formulations the distribution by this method is far from satisfactory. One property of a good seed-dressing is its ability to adhere firmly to the grain. When the seed-dressing is

measured onto the walls of the container, a great deal of the compound is absorbed into the surface of the first few grains with which it happens to come into contact. Consequently the bulk of the grain receives less of the active ingredient than intended, while a proportion receives none at all.

To achieve a more even distribution of the seed-dressing, an apparatus with which the prescribed quantity of fungicide can be sprayed onto the seed in a rotating glass jar was set up at the Institute of Plant Pathology. The uniformity of treatment was studied both by determining the mercury content of seeds and by agar-plate method described by MACHACEK (1950).





Figs. 1 and 2. Construction of the seed treater.

A. Electric motor
B. Continuous speed control
C. Time switch
D. Container frame
E. Glass jar
F. Wire netting blades
G. Lid
H. Stand
I. Nozzle base
J. Nozzle
K. Test tube frame
L. Test tube
M. Pressure regulation valve
N. Mount
O. Mount leg

Construction and operation of the seed treater

The equipment is shown in Figs. 1 and 2. The source of power is a 50 watt electric motor equipped with a time switch and with a continuous speed control from 15 to 200 rpm. The motor rotates the container frame and a 1 liter glass jar serves as the mixing chamber. The axis of the container is about 25° from vertical. To ensure thorough mixing of the seeds there are two sheet-iron blades inside the jar. The blades are tinned spring-steel so that they can be removed for cleaning. The jar is closed by a lid with a hole in the middle for the nozzle. The seed-dressing is measured with a 2 ml disposable syringe into a 2 ml test tube. The up-and-down mobile test tube frame and the nozzle base are fastened to the movable stand. Compressed air is led through the pressure regulation valve to the nozzle. The device is fastened to a chipwood mount. The angle of the container can be regulated according to the volume of seed by means of an adjustable mount leg.

For the treatment of cereal seeds, a 1000 ml glass jar is a suitable container in which to dress the 150—200 g lot of seed required for the 10 m² plot used in efficiency tests. The jar is revolved for 5 minutes at 75 rpm. The airstream sucks the fungicide from the test tube and blows it in the form of a fine mist onto the surface of the kernels rotating in the container. The nozzles, which vary in size from 0,3 to 0,5 mm in diameter, are chosen according to the viscosity of the formulations so that the spraying time for all formulations is about 50 seconds and the air pressure 78 kPa.

MATERIALS AND METHODS

Assays of mercury on seeds

In order to asses the performance of the seed treater, experiments were done to investigate

a) the proportion of active ingredient remaining in the test tube and the nozzle, on the walls of the glass jar, the lid and the blades
b) the proportion of active ingredient in the grain and
c) how evenly the active ingredient in the grain is distributed between the kernels.

Wheat seeds were chosen for this study because wheat is the most important crop as regards seed treatment, and it has been found that other grain seeds act in much the same way as wheat (LINDSTRÖM 1958). The fungicide used was Täyssato-liquid, used at the rate of 200 ml/100 kg of seed, and with an active ingredient content of 18,4 g methoxyethylmercuriacetate per litre of formulation. In the experiment, 200 g of wheat, moisture content 12 %, thousand kernel weight 40 g, free from mechanical damages and of equal size, were dressed with 0,4 ml of Täyssato-liquid. The spraying time with a 0,3 mm nozzle was 50 seconds, at a pressure of 78 kPa, and the rotation time 5 minutes. Immediately after the dressing, determinations of the mercury content of the Täyssato-liquid used, the amounts of mercury remaining in the equipment, and the amount of mercury in the grain were made by the flameless atomic absorption method on a Techtron Selective mercury analyzer Resonile 202 in the laboratory of the Kemira Oy Research Centre.

Assays of the average mercury content of the grain were carried out on ten samples of 10 seeds, and on 100 single seeds. The mercury loading is expressed as parts of active ingredient per million parts of grain by weight (ppm).

Uniformity of the mercury distribution is described by two statistical characteristics, standard deviation and variation coefficient. According to LINDSTRÖM (1961), a good

estimate of the uniformity of the distribution can be obtained by means of a sample of 30 kernels, and a sample of 100 kernels is large enough to give a good idea of kernels with noticeable deviations from the average fungicide loading.

Comparison of the new system with the old one

Seeds dressed in this new treater (»new method») were compared with seeds treated in a bottle (»old method»).

In the new method, seed treatments were done in the same way as in the assays of mercury except that the fungicide was Lignasan (BMC 5 %), used at the rate of 0,5 ml/200 g of seed, and that the blades inside the seed container were made of wire netting, because much of the fungicide stuck to sheet-iron blades. In the old method the liquid was applied evenly to the walls of a bottle with a measuring pipette while the bottle was rolled. A 200 g lot of seeds was placed in the bottle and rotated for 5 minutes. The amount of Lignasan was 0,5 ml except in the tenth experiment when it was 0,7 ml/200 g of seed. Immediately after dressing, the seeds were divided into 18 kernel samples with a mechanical seed divider. Then they were placed on 23 × 23 cm Pyrex-glass dishes of inoculated oat-agar at 3,5 cm intervals in six rows, each sown with six seeds, three rows being of seeds treated by the new and three by the old method. Spores of *Aspergillus niger* van Tiegh. were sprayed from Petri dish cultures of the fungus onto agar with a high pressure atomizer. The seeds were covered by glass sheets and kept at room temperature for 3—5 days. During this time a dense, black fungus growth covered the agar, with the exception of clear zones of inhibition around the seeds. The radius of these zones was measured and the variability in radius of the inhibition zones (indicating dispersion and uniformity of treatment) was determined by the formula

$$\text{Variability} = \Sigma x^2 - T^2/N$$

where Σx^2 is the sum of the squares of individual measurements and T^2/N is the squared total of measurements divided by their number (MACHACEK 1950). Comparison of the methods was done by means of t-test. Ten separate treatments were done with both dressing methods and 18 + 18 kernels from each treatment were placed on six dishes, so the total number of treated seeds investigated was 2160.

RESULTS

Mercury analyses

In the chemical analyse it was found that the mercury content of the formulation used was 11,6 g Hg/l, so in 0,4 ml there were 4,64 mg of Hg, which were distributed as follows:

a) amount of Hg in the seed container
(jar, lid, blades) 1,7 mg
in the nozzle 0,007 mg
in the test tube 0,016 mg
making a total of 1,723 mg in the seed dressing equipment, which is 37,1 % of the quantity of the Hg used.

b) amount of Hg in the 200 g lot of treated seed was 2,96 mg or 62,9 % of the total Hg.

c) uniformity of distribution of the 2,96 mg Hg determined on the grain proved good. The mean of mercury contents of ten batches of 10 kernels was 14,8 ppm, which is the same as the mercury content of the entire dressed lot (Table 1).

In individual seed assays the distribution of active ingredient was also good (Fig. 3), since the mean mercury content of 100 single kernels was the same 14,8 ppm as for the batches of 10 kernels and the whole treated seed lot. The lowest Hg concentration in a single seed analysis was 7,5 ppm ~ 0,3 μg

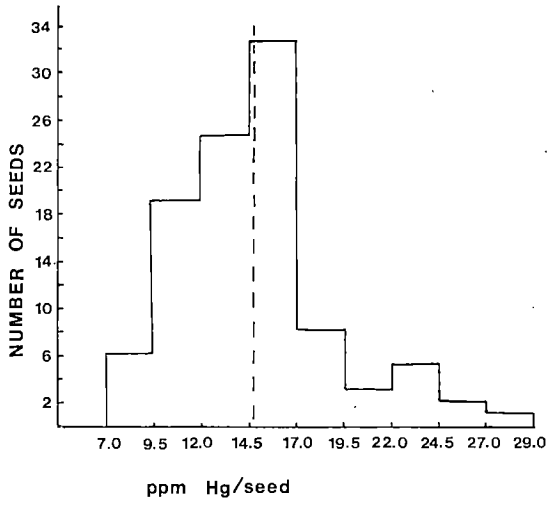


Fig. 3. Distribution of mercury on single seeds.

Hg/kernel, and the highest 28,4 ppm ~ 1,138 µg Hg/kernel. Nearly half (47 %) of the kernels contained 12,8—16,8 ppm of mercury ~ 0,512 —0,672 µg Hg/kernel, while the theoretical amount was 14,8 ppm ~ 0,592 µg Hg/kernel.

Comparison of the dressing methods

Results of comparisons of the old (A) and the new (B) dressing techniques are given in Table 2. The uniformity of treatment was clearly better with the seed treater than using the usual laboratory method (see also A and B in Fig. 4). The mean radius of zones of inhibition in the seeds treated with the usual laboratory method is about 2 mm shorter than with the seed treater. This is due to the unequal distribution, because of which very few seeds carried multiple amounts and a great many had very little or none of the active ingredient that would have been on the seeds if all the fungicide had been distributed evenly. When the amount of fungicide in the old method was increased up to 350 ml/100 kg of seed in the tenth treatment, the mean radius of the zones was nearly as large as in the new method, but the variability was no better than in the other treatments. The mean radius of the zones differed between the various treatments due to the timing of the measurements, 3—5 days from inoculation.

Table I. Mercury loadings (ppm) on groups of 10 seeds.

	Samples										
	1	2	3	4	5	6	7	8	9	10	X
ppm	12,7	13,8	14,4	14,4	14,8	14,9	15,1	15,3	16,0	16,5	14,8

stand. dev. 1,08
coeff. of var. 0,073

Table 2. Radius and variability of zones of inhibition of treated seeds. A, old dressing technique; B, new dressing technique.

Treatments	Mean radius of zones of inhibition mm		Variability of zones of inhibition	
	A	B	A	B
I	2,9	5,2	396	126
II	6,7	9,0	893	253
III	5,3	7,5	899	263
IV	3,4	5,6	774	469
V	5,4	8,0	763	238
VI	5,3	6,7	721	217
VII	3,5	5,5	843	542
VIII	4,0	6,0	601	295
IX	3,3	5,1	670	443
X	5,7[1])	5,8	567	299

$t = 7{,}6^{***} > t_{0,1\,\%} = 4{,}78$

[1]) A, 350 ml/100 kg of seed

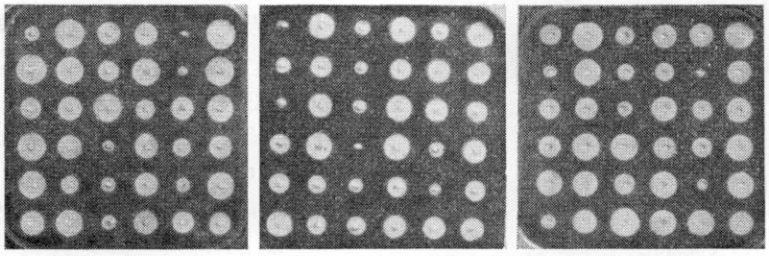


Fig. 4. Zones of inhibition around treated wheat seeds on three dishes. Seeds treated
A, with the usual laboratory method
B, with the seed treater

DISCUSSION

The purpose of the work described here was to develop a laboratory seed treater giving a uniform distribution of liquid pesticides in efficiency tests, and to determine the practicability of the machine with investigations of treated seeds.

The amount of Hg remaining in the seed treater and determined on the grain was 0,04 mg more than the amount of Hg contained in 0,4 ml of liquid. The difference is probably due to a lack of accuracy in allocating the Täys-sato-liquid to the test tube and/or in the Hg analyses.

The amount of Hg remaining in the seed dressing apparatus was slightly larger than expected. The iron sheet blades, particulary, were the part to which much fungicide adhered. In consequence of this the material was changed to wire netting.

In order that the amount of active ingredient in the grain will meet the recommendations, a quarter more of the fungicide than the calculated amount must be measured into the test tube. Determined by visual examinations, the amount of seed dressing remaining in the seed treatment equipment is nearly the same for all liquid formulations. The container should be cleaned between the treatment of successive grain lots so that the content of active ingredient in each lot will be the same.

According to the mercury assay, no blow-back of spray mist occurs through the lid hole if the air pressure is 78 kPa or less. Because of differences between the volatility of various fungicides, it is safest to place the seed treater in a space provided with a ventilator shaft to eliminate undue hazards.

The uniformity of mercury distribution between the kernels can be considered good on the ten seed samples and on single seeds, with a variation coefficient of 0,073 and 0,27 respectively. According to LINDSTRÖM's (1959) estimates the distribution is good with a variation coefficient of the order of 0,2 to 0,3. Consideration must be given to the fact that LINDSTRÖM divided the seeds into N-kernels (the population of normal kernels) and R-kernels (the population of excessively treated kernels). The borderline between N- and R-kernels was set at twice the average loading of the N-kernel population. Only the first mentioned was characterized by a variation coefficient. In the mercury assay of the present study not a single kernel exceeded this borderline, and even the lowest Hg concentration was larger than half of the average. It must also be remembered that the formulations of mercurial fungicides used in the Panogen process were volatile (vapour concentration about 270 $\mu g/m^3$ at 20°C), and the

action of vapour considerably improves the poor initial distribution (LINDSTRÖM 1958, 1960), whereas the vapour concentration (2 $\mu g/m^3$ at 20°C, ULFVARSON, 1969) for methoxyethylmercuryacetate used in this work is below the limit for efficient vapour action. Nowadays it is not possible to rely on vapour action as a remedy for a poor initial distribution, because many fungicides are nonvolatile.

To exclude the important role played by volatility in achieving an even distribution, nonvolatile Lignasan was used in comparisons of the seed dressing methods. Though the agar-plate method has some weaknesses in testing the amount of fungicide on the kernels — the inhibition zones indicate only the amount, which diffuses along the agar surface, and various fungicides have different diffusions and effectiveness on the growth of mycelium — it is very useful in comparing one seed dressing method with another. The results indicate that nonvolatile fungicides can also be distributed evenly by the seed treater and that it is superior to the usual laboratory method.

There are not many detailed data on the distribution achieved by commercial machines. In comparison with »Rotostat», which is considered by ELSWORTH and HARRIS (1973) to approach the requirements of the ideal seed treater more closely than any system in current use, our laboratory treater gives a more uniform treatment of seed, with a variation coefficient of 27 %, while, in spite of the high rate (4000 p.p.m.w.a.i.) of Ethirimol seed dressing, in an analysis of 100 single seeds it was 44,5 % for the »Rotostat» (MIDDLETON 1973). With the »Rotostat» it may be possible to get better loadings of the fungicides than with this seed treater, but the correct quantity of dressing to a definite weight of seed is not nearly as important as the uniformity of treatment. To explain the matter with a theoretical example: Suppose we have a fungicide which, at a certain rate of application, is 100 % effective against some disease, and the infection level of the seeds we are going to treat with this fungicide is 100 %. A 5 % deduction, for example, of the amount of the fungicide is of so little significance that it very likely has no effect at all on the disease control. The results of many years' official seed treatment trials prove that the reduction of a dosage by 50 %, or in some cases by 75 %, from the prescribed amount has caused only a minor decrease in disease control (e.g. HANSEN 1975). But if we have an unequal distribution of the fungicide leaving 5 % of the seeds without any dressing, the control is only 95 %. Seed treatment trials are usually carried out on seed lots with a very high degree of natural or induced infection and for that reason the uniformity of the distribution is particularly important in fungicide testing, much more important than in actual agricultural practice.

The laboratory seed treater described in this work has proved useful in the chemical treatment of small lots of seeds. In fungicide testing if offers a considerable improvement over the unequal distribution achieved by the laboratory method in common use. The seed treater is inexpensive and simple to construct, and the size of the dressing equipment can easily be modified as desired, to suit the volume of the seed lots.

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SELOSTUS

Nestepeittauslaite pienten jyväerien käsittelyyn

REIJO VANHANEN

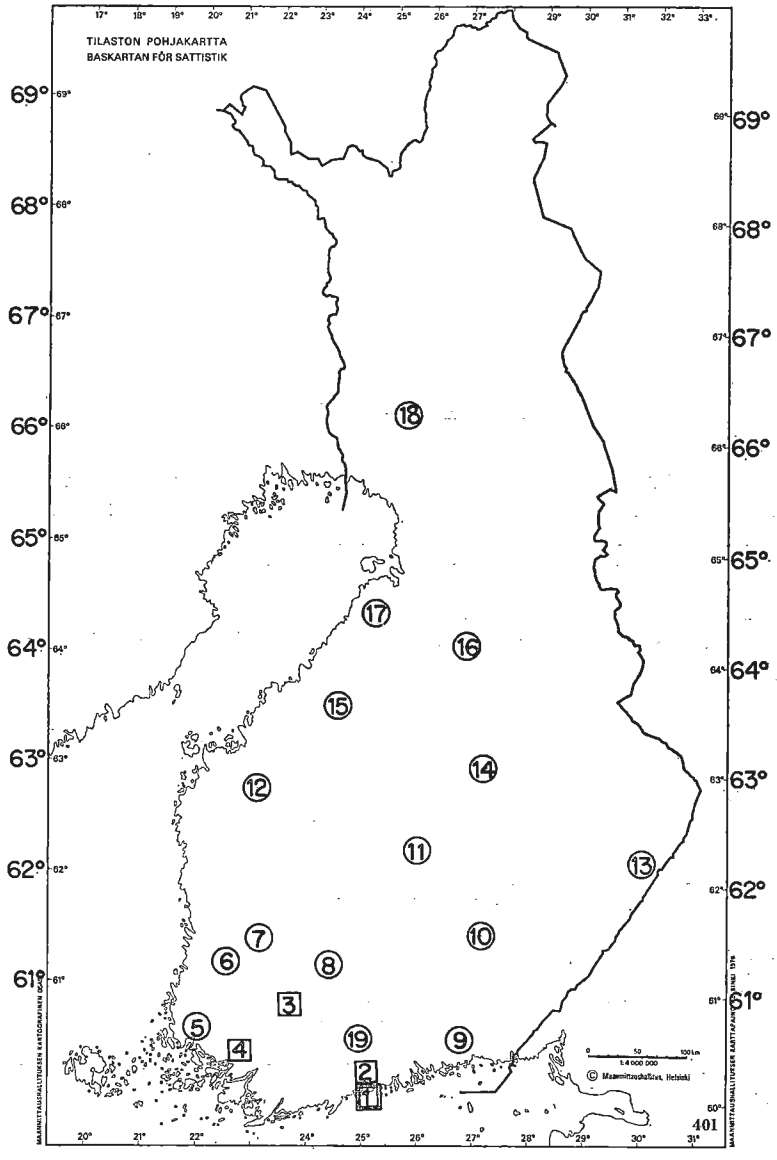
Maatalouden tutkimuskeskus

Nestepeittauksessa käytettävät torjunta-ainemäärät ovat hyvin pieniä, vain 2—3 millilitraa 25000—40000 jyvää kohti. Näin vähäisten nestemäärien tasainen levittäminen yksittäisten siementen pinnalle on osoittautunut vaikeaksi, varsinkin peittausaineiden tehotarkastuskokeissa, joissa käsitellään pieniä siemeneriä. Laboratorioissa yleisesti käytetyssä peittausmenetelmässä tehoaineen jakautuminen siementen kesken on epätyydyttävä. Siinä nestemäinen valmiste tiputetaan jyviä sisältävän astian seinämille ja sekoittaminen tapahtuu astiaa ravistelemalla tai pyörittämällä. Paremman peittaustuloksen saavuttamiseksi rakennettiin kasvitautien tutkimuslaitoksella laite, jossa peittausneste suihkutetaan paineilman avulla hienona sumuna pyörivässä lasipurkissa sekoittuvien jyvien joukkoon.

Laitteen käyttökelpoisuutta tutkittiin määrittämällä peitattujen jyvien elohopeapitoisuus kymmenen siemenen eristä ja 100 yksittäisestä siemenestä. Lisäksi peittauksen tasaisuutta tutkittiin sijoittamalla koneella ja tavallisella laboratoriomenetelmällä peitattuja jyviä *Aspergillus niger*-sienellä saastutetulle agarille.

Peittauslaitteistoon jäänyt elohopeamäärä oli hieman odotettua suurempi, mutta tehoaine oli jakautunut tasaisesti jyvien kesken. Peittausmenetelmiä verrattaessa konepeittauksella saatiin selvästi tasaisempi peittaustulos kuin tavallisella laboratoriomenetelmällä.

Laitteisto osoittautui käyttökelpoiseksi pienten jyväerien käsittelyyn. Se on halpa, helppo rakentaa ja muuntaa erikokoisten siemenerien nestepeittaukseen ja tarjoaa merkittävän parannuksen laboratorioissa yleisesti käytettyyn peittausmenetelmään.



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