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PREFERENCE OF CEREAL APHIDS FOR VARIOUS CEREAL VARIETIES AND SPECIES OF GRAMINEAE, JUNCACEAE, AND CYPERACEAE

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A great deal of information, based both on field observations and on experimental work, has been reported on the host plants of the English grain aphid, *Macrosiphum avenae* (F.), and the oat bird-cherry aphid, *Rhopalosiphum padi* L. In his extensive study, PATCH (1938) listed several dozen plant species on which aphid specimens or colonies had been found. Later, HARPAZ (1953), ITO (1960), RICHARDS (1960), ORLOB (1961 a and b), ORLOB and MEDLER (1961), HSU (1963), and ROBINSON and HSU (1963) have supplemented the list as regards either one or both species. The suitability of a variety of plant species and cereal varieties as host plants of cereal aphids has been elucidated by testing the fecundity and longevity of aphids on the plants (COON 1959, ITO 1960, ORLOB 1961 a, HSU and ROBINSON 1962, 1963, HSU 1963, ADAMS and DREW 1964, VILLANUEVA and STRONG 1964, JESSEP 1967). The effect of the age and of the part of the host plant on the fecundity of cereal aphids has been clarified by ITO (1963) and by BELVETT et al. (1965).

Relatively few studies have been made on the choice of host plant by *M. avenae* and *R. padi*. In studies on the behaviour of alate females of *R. padi*, it was found (ORLOB 1961 b) that the aphids settled on some plants in greater numbers and for longer periods than on others, and were most prolific on the plants most preferred. ITO (1960) obtained similar results when he compared the numbers of *M. granarium* Kirby (= *M. avenae*) and *R. prunifoliae* Fitch (= *R. padi*) settling on various species of cereal. APABLAZA and ROBINSON (1967) also studied the preferences shown by alate and apterous *M. avenae* for wheat, oats, and two barley varieties in host selection tests in greenhouses, but did not observe any differences between the plants.

In the present work an endeavour has been made to ascertain the preferences of alate females of *M. avenae* and *R. padi* for cereal shoots and for young plants of Gramineae, Cyperaceae, and Juncaceae species, and also any changes in preference as the host plant ages.

Material

The aphids belonged to strains maintained parthenogenetically for several years in the greenhouse. One of the strains was descended from a *M. avenae* female and the other from a *R. padi* female. The host plants, Sisu oats, were grown in cages (30 × 30 × 60 cm) on peat with suitable additions of fertilizer for cereals.

Continuous light was supplied in the cages at an intensity of 7 000 to 12 000 lux under the glass ceiling. The source was mercury lamps (Osram

HQL 400 W) placed about 50 cm above the cages. The relative humidity of the air in the cages above the plants varied between 50 and 80 per cent, and the temperature varied from +19 to +28°C.

The alate aphids were collected from the ceilings or walls of the cages at most 15 minutes before the start of the experiments.

The test plants were grown from seed on fertilized peat. The light intensity at the surface of the growth substrate varied between 4 000 and 10 0000 lux and the temperature varied between about 20 and 28°C. Liquid fertilizer was added to the irrigation water once a week.

The seed of the cereal varieties tested had been procured from Finland, Sweden, Canada, and the U.S.A. Some of the varieties have been designated with numbers and letters indicating their origin. The following abbreviations will be used in the text:

Jo	Agricultural Research Centre, Dept. of Plant Breeding, Jokioinen, Finland
Ta b, Ta c	Plant Breeding Institute of Hankkija Experimental Farm, Helsingin pitäjä, Finland
Sv	Svalöv Plant Breeding Institute, Sweden
Weib	Weibullsholm Plant Breeding Institute, Landskrona, Sweden
C. I.	»Cereal Investigations», abbreviation used in North America
C. B.	Cebeco, Rotterdam, The Netherlands
MGH	Dr. R. L. Mansholt's Veredelings Bedrijf, N.V. Ulrum, The Netherlands

The first seed lots were procured when the tests were started in 1963 and the last in 1965.

Some of the seed of Gramineae species and all that of Juncaceae and Cyperaceae species was acquired from the seed collection of Finnish plants of the University of Helsinki Botanical Gardens in 1964 and 1967. In the following, the origin of these plants has been designated with H (see e.g. Fig. 1). The same garden arranged to procure seed of *Avena*, *Hordeum* and *Triticum* species from other European countries. The rest of the Gramineae seeds (denoted by S in Fig. 1) were acquired from Germany through the courtesy of Siemen Oy, Helsinki, Finland.

Methods

In studying the preferences for cereal varieties, two methods were used: (A) varieties were compared four at a time or (B) varieties were compared two at a time. As a preliminary step, the aphids' choice of host plant was tested by simultaneously offering four varieties chosen at random (method A). After some of these tests, the two varieties on which the greatest and the least number of aphids had settled were chosen for further experiments by method B.

The preference for wild species was also studied by two methods: (C) three species and Sisu oats were compared at one time or (D) only two species were compared with each other.

The influence of the age of the plant on its susceptibility to *M. avenae* was studied (1) by weekly comparisons of the preference for the same batch of plants compared with the preference for Sisu oats about 10 cm tall sown anew for each experiment and (2) by studying the numbers of aphids settling on Sisu oats 1-, 2-, 3-, and 4- week-old as calculated from the time of shooting.

All the cereals were about one week old, as calculated from the shooting, and about 10 cm tall at the start of the tests. The order in which the seed of the non-cereals was sown was based on rate of shooting, the Juncaceae species being four weeks old, the other plants three weeks old at the start of the tests.

For each experiment the seed was sown in four pots (Ø 25 cm) in a ring near the edge of the pot. The substrate was peat with added fertilizer. When four varieties or species were compared by methods A and C, there were four specimens of each variety or species in alternating order (altogether 16 plants) in each pot. In the tests made by methods B and D there were eight of each of the species to be compared in a pot. The aim was that, as regards bulk, the smallsized plants should correspond to the other plants used in the same experiments and therefore three to six specimens of some graminids were left in place. The results have been calculated as if there had been 16 plants in a pot.

At the start of the experiments the peat was covered with a layer of slightly moistened sand ½ cm thick. Cylinders made of translucent PVC plastic (Ø 20 cm, height 30 cm, terylene voile top) were placed over the pots to cover the plants. The pots were placed in a white-walled cabinet in the laboratory. Above the light-dispersing ceiling of the cabinet there were four mercury lamps. The light intensity at the surface of the sand was 6 000 to 10 000 lux. The relative humidity of the air, measured inside the cylinders at the beginning of 30 experiments, averaged 74 % (range 48—93 %). At the end of the experiments the average humidity was 50 % (range 44—65 %). The temperature inside the cabinet increased during the experiments from 22 to 28°C on the average.

From 120 to 160 alate aphids were dropped into the cylinders in the middle of the circle of plants. The number of aphids that settled on each plants was counted after 15 minutes, then three times at successive 15-minute intervals, again after 3 hours, and after 24 hours from the beginning of the experiment. Immobile aphids whose stylet was on the plant surface were considered to be settled on the plant. In preliminary tests it was found that the differences in preference emerged within 24 hours and the order of preference did not change essentially when the experiment was continued for a longer period. After the aphids had settled, reproduction began, and when the experiment was continued for more than 24 hours the cereals started to suffer visibly from the aphid attack.

Results

Cereal varieties

The preference of *M. avenae* for 86 wheat varieties as host plants was studied by method A. The percentage of all the aphids settling on each variety is shown in Table 1. The deviations from the expected values (25 % of aphids on each of the four varieties) are in most cases of the order of a few percentage units, but in some cases nearly 10 percentage units. The mean of all the numbers presented in Table 1 is 25.0 and the standard deviation ± 4.4.

Table 1. Preference of *M. avenae* for wheat varieties. Four randomly chosen varieties were compared at a time. The figures denote the proportion of aphids on each variety in percentages

Taulukko 1. M. avenaen asettuminen vehnille. Kerrallaan verrattiin neljän lajikkeen kelpaavuutta siivellisten kirvojen ravintokasviksi. Luvut osoittavat koe-eläinten prosenttisen määrän lajikkeessa vuorokauden kuluttua

Variety *Lajike*	%	Variety *Lajike*	%
Jo 715	28.9	5099	24.6
731	26.9	5237	20.7
787	26.4	5528	25.0
4535	24.7	5901	30.3
4558	23.6	5986	34.1
4591	29.7	6008	15.5
4626	22.0	6028	20.2
4728	28.8	6180	18.1
4760	26.7	6680	26.5
4781	22.9	7034	23.9
4792	21.6	7294	31.5
6639	27.9	7497	25.3
6675	24.6	7669	27.2
6872	25.0	7671	28.1
6900	22.5	7831	20.8
6947	19.4	7892	25.7
7029	29.8	7949	24.5
7332	31.6	7973	23.3
7441	19.2	8054	25.1
7450	28.4	8182	28.6
7452	23.8	8234	18.4
Jufy I	25.9	8419	29.7
Kimmo	21.9	8457	23.2
Kloka	21.9	8495	25.9
Koga II	25.7	8566	22.7
Lera	28.2	8587	31.4
MGH 5836	24.2	8607	20.0
Nickersson 5913	29.8	8695	26.4
Nora	26.1	8712	25.1
Norröna	24.0	8713	19.3
Opal	20.0	8732	29.2
Orca	32.5	8756	23.5
Prins	27.6; 33.2	8807	19.6
Ring	24.8	8825	24.9
Skala	15.5	8845	32.1
Selkirk	17.5	Timantti	24.9; 29.3
Svenno	33.6	Touko	21.6
Sv 1320 B	15.7	Weib 5837	29.6
Ta c 3950	29.1	6180	25.1
4088	18.9	7389	23.6
4132	23.9	8348	21.7; 22.9
4406	28.1	8874	21.6; 24.6
4431	29.8	4225	24.4; 30.9

Table 2. Preference of *M. avenae* for wheat varieties and Paavo barley and *R. padi* for barley (b), oat (o), and wheat (w) varieties. Two varieties were compared at a time. The figures denote the proportions of aphids, in percentages, on the two varieties

Taulukko 2. M. avenaen asettuminen vehnille ja Paavo-ohralle sekä R. padin asettuminen ohra-, (b), kaura- (o) ja vehnälajikkeille (w) vuorokauden aikana. Kerrallaan verrattin kahden lajikkeen kelpaavuutta. Luvut osoittavat kirvojen prosenttisen määrän kummassakin lajikkeessa vuorokauden kuluttua * P < 0.05, ** P < 0.01

M. avenae		R. padi	
Variety *Lajike*	%	Variety *Lajike*	%
Orca	58.4	Ingrid o	45.5
Skala	41.6*	Pirkka o	54.5
Prins	54.9	Jo 20 w	45.1
Skala	45.1*	715 w	54.9
Prins	53.2	Paavo b	49.8; 51.1
Sv 1320 B	46.8**	Peragold o	51.2; 49.9
Ta c 8234	49.2	Ta c 1054 o	44.7
8587	50.8	818 o	55.3
Ta c 8807	38.0		
8845	62.0**		
Svenno	41.9		
Paavo	58.1*		
Selkirk	34.5 42.6 40.8		
Svenno	65.5**; 57.4*; 59.2**		

The varieties on which the aphids had settled in exceptionally large or small numbers were compared by method B (Table 2). The preference of the varieties proved to be same as that in the experiments with method A. For instance, Orca and Prince attracted more aphids than Skala, and Selkirk had more than Svenno. These differences were significant ($P < 0.05$). Seed of some varieties was only sufficient for a few experiments, which is why not all the varieties deviating greatly from the expected mean value could be compared with all the others.

The preference of *R. padi* for 127 oat, 24 wheat, and 14 barley varieties as host plants were studied by method A. The number of aphids on the different varietis in most cases deviated by only a few percentage units from the expected value. The mean of the numbers presented in Table 3 for oats is 25.2 and the standard deviation $\pm$ 3.9.

The differences between wheat varieties were of the same order of magnitude as between oats (Table 3). The range was between 13.4 and 29.8 percentage units, the mean 25.0, and the standard deviation $\pm$ 5.6.

The differences between barleys were, on the whole, of the same order of magnitude as between wheats and oats (Table 3). The range was between 14.2 and 30.0 percentage units, the mean 24.6, and the standard deviation $\pm$ 3.9.

The settling of *R. padi* on eight varieties was studied by method B (Table 2). Only the difference between oat varieties Ta c 1054 and Ta c 818 was significant ($P < 0.05$).

Other plants

Almost all the 59 species of Gramineae, Juncaceae, and Cyperaceae were less preferred than Sisu oats as host plants by *M. avenae* (Fig. 1). The differences in the proportions of aphids that settled on the other plant species tested and on Sisu oats was used as a criterion of the preference for a plant species in each experiment. Fewest aphids settled on *Carex* species, the differences between these and Sisu oats being 80 to 90 percentage units. On average, 90 % of the aphids settled on Sisu oats. The proportion of aphids

Table 3. Preference of *R. padi* for oat, wheat, and barley varieties. Four randomly chosen varieties were compared at a time. The figures denote the proportion of aphids on each variety in percentages after one day

Taulukko 3. R. padin asettuminen kaura-, vehnä- ja ohra-lajikkeisiin vuorokauden aikana. Kerrallaan verrattiin neljää lajiketta. Luvut osoittavat kirvojen prosenttisen määrän kullakin lajikkeella

Variety *Lajike*	%	Variety *Lajike*	%	Variety *Lajike*	%
Oats		Pendek	24.9	1277	26.3
Kaurat		Peragis	20.9	1282	27.5
Andax	29.4	Peragold	24.8	1290	25.3
Astor	22.0	Röykän Sisu	25.9	1296	22.2
Agr Line	29.4	Sisu	20.1; 20.6; 21.1; 22.2;	1309	30.6
Blenda	19.2		22.6; 24.7; 25.9; 33.1;	1322	26.9
Blixt	27.7		19.6	1333	20.3
Cebeco 759	24.1	Sol II	28.1	1335	27.6
Commando	22.0; 24.2	Supreme	25.4	1337	20.5
Condor	26.2	Ta b 2560	25.2	1341	25.6
Eho	25.4	4137	26.7	1356	26.4
Eno	24.3	4868	23.9	1365	30.9
Forward	28.2	5656	20.9	1379	23.0
Fusilier	22.0	5794	21.7	1384	19.7
Goldsherry	26.3	7235	19.5	1393	26.3
Guldregn III	20.3	7911	24.0	1577	25.7
Hannes	27.6	8111	24.9	1587	33.9
Jeannie	23.8	8846	24.9	1620	28.3
Jo 693	20.2; 23.6; 28.0	9792	32.1	1643	37.1
713	25.9; 29.9	9883	26.2	Tammi	25.2
720	24.4	Ta c 102	27.2	Tarpan	19.0
721	19.9	120	24.2	Titus	25.3
729	21.0; 25.3; 30.5	158	23.9	Wega	29.3
761	26.4	190	25.6	Weib 16 195	26.5
770	22.0	328	24.1	16 258	25.0
780	23.9	357	23.1; 26.2; 29.3; 32.9	16 340	29.5
782	27.6	573	27.8	16 357	27.6
784	25.2	585	24.5; 23.0; 29.9; 31.0	16 384	17.9
793	23.5	706	17.7	16 414	22.0
794	24.9	745	20.7; 21.0; 30.0	16 428	24.3
795	26.4	763	22.8	16 509	26.7
804	24.1; 26.7	766	24.9; 25.7	16 511	29.9
808	23.2; 26.3	812	31.0	Zandster	15.9
826	26.8	818	21.2; 21.7; 26.3	CB 52—31	21.3
Kultasade II	24.7	825	26.0	254	36.5
Kyrö	21.9	976	26.0	799	26.3
Marino	30.4	979	24.7		
Marne	29.6	982	27.9		
MGH		986	17.0; 19.4		
462	24.7	1035	19.6		
856	25.8	1039	34.2		
53—304	30.1	1043	21.7		
53—557	19.8	1048	27.4		
60—543	29.7	1054	30.6		
Nestor	27.8	1141	20.3		
Nip	25.2	1157	30.5		
Onward	21.1	1183	21.6		
Orion III	24.3	1260	20.9		

Variety *Lajike*	%	Variety *Lajike*	%	Variety *Lajike*	%
Wheats *Vehnät*					
Apu	28.0	Lera	25.0	Ta c 1733	29.6
Jo 715	22.5	Norröna	20.1	4431	29.8
731	27.1	Opal	23.6	5099	24.6
787	27.6	Prins	26.6	5237	20.7
4728	20.3	Skala	27.8	5528	25.0
4760	23.8	Svenno	21.7; 23.4	Tammi	22.9
4781	27.1	Ta b 6049	13.4	Timantti	23.6
4792	28.9			Touko	25.7
				Weib 7389	24.0

Table 3 (cont.) — *Taulukko 3 (jatk.)*

Barleys
Ohrat

Balder	24.1	Delisa	22.6	Pirkka	25.9; 25.9; 26.9
Balder J	24.1	Foma	25.8	Ta c 1904 ...	26.3
Bido	20.3	Ingrid	18.8; 26.2; 27.2; 28.4	2011 ...	30.0
Binder	26.6	Paavo	14.2; 17.8	2017 ...	29.5
Cebeco	25.8				
Dana	25.8				

settling on the other species was greater than on *Carex* but the differences between these and Sisu oats were usually of the order of 20—40 percentage units. Some species, however, seemed to be almost as well liked as Sisu oats. These were *Bromus* and *Lolium* species, and *Poa annua.*

To gain an idea of the variations in preference, some plant species were used in several experiments as one of the four species to be compared. The preference for *Agrostis tenuis* varied in the different experiments by rather more than 20 percentage units, for *Arrhenatherum elatius* by about 50, for *Festuca pratensis* by a little over 40, and for *Poa pratensis* by nearly 50 percentage units (Fig. 1).

In most cases the aphids settled on *Avena, Hordeum,* and *Triticum* species in much the same numbers as on Sisu oats, but on some (*A. orientalis* var. *pugnax* and *A. sativa* var. *aristata*) the number of aphids was slightly greater than on Sisu oat.

R. padi settled on most of the 47 Gramineae species tested in almost the same numbers as on Sisu oats (Fig. 1). The *Carex* species were evidently their least preferred group, but even on them *R. padi* settled in relatively larger numbers than did *M. avenae*. The preference for *Agrostis tenuis* varied in different experiments by 14, for *Calamagrostis neglecta* by 13, for *Dactylis glomerata* by 18, and for *Carex nigra* by 15 percentage units. There was thus less variation in preference than in the experiments with *M. avenae.*

In general, the number of aphids on all four species in an experiment was almost the same during the first few hours (Fig. 2). After one to three hours, the number of aphids started to decrease on some species, for which the preference proved to be slight at the end of the experiment. There was no correlation between the numbers of aphids on Gramineae, Cyperaceae, and Juncaceae 15 minutes and 24 hours after the beginning of the experiment. The correlation coefficient was close to 0.

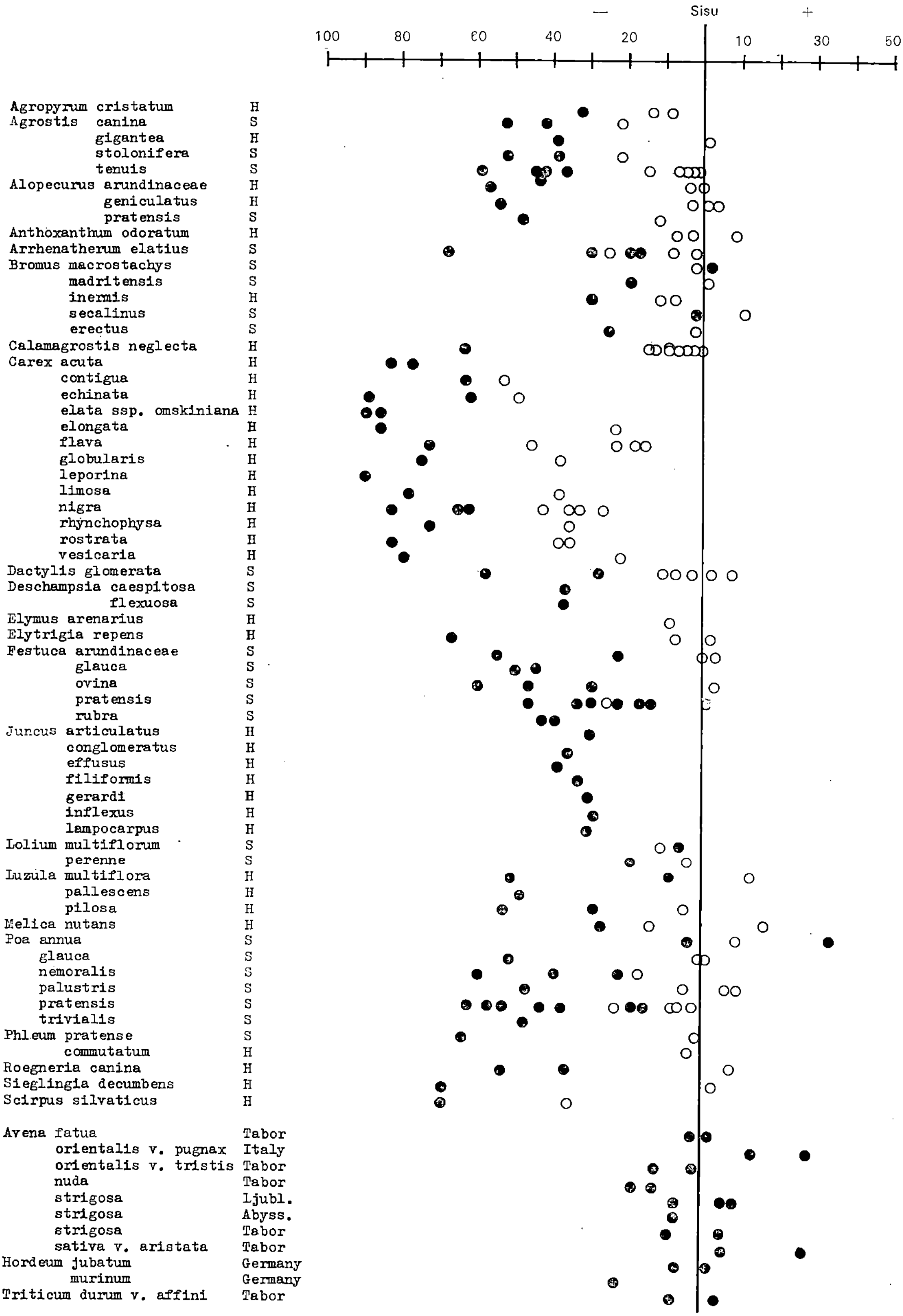
The dependence of preference on the age of the plant

M. avenae settled in equal numbers on Sisu oats aged 1, 2, 3, and 4 weeks (Table 4). The differences were not significant ($P > 0.05$).

The preference for some Gramineae species changed with age (Fig. 3). Calculated from the time of shooting, *Poa annua* under two weeks

Fig. 1. Preference of *M. avenae* (dots) and *R. padi* (open circles) for different plant species. Three species and Sisu oats were compared at a time. The proportion of aphids in percentages on each of four species was used as a criterion of susceptibility. The index of preference (abscissa) denotes the difference in percentage units between each species and the standard, Sisu oats. (+) means that there were more aphids on the species than on Sisu oats, (—) that there were fewer aphids on the species than on Sisu oats.

Kuva 1. Eräiden kasvilajien kelpaavuus M. avenaen (pisteet) ja R. padin (ympyrät) ravintokasveiksi. Kolmen lajin kelpaavuutta verrattiin kerrallaan Sisu-kauraan. Vaaka-akselin luvut osoittavat kuinka paljon eri kasvilajeille asettuneiden kirvojen prosenttiset määrät poikkesivat Sisu-kauralle asettuneiden kirvojen vastaavasta määrästä. (+) = kirvoja oli kokeilussa lajissa enemmän, (—) = kirvoja oli vähemmän kuin Sisu-kaurassa.



—
Sisu
+
100
80
60
40
20
10
30
50
Agropyrum cristatum H
Agrostis canina S
gigantea H
stolonifera S
tenuis S
Alopecurus arundinaceae H
geniculatus H
pratensis S
Anthoxanthum odoratum H
Arrhenatherum elatius S
Bromus macrostachys S
madritensis S
inermis H
secalinus S
erectus S
Calamagrostis neglecta H
Carex acuta H
contigua H
echinata H
elata ssp. omskiniana H
elongata H
flava H
globularis H
leporina H
limosa H
nigra H
rhynchophysa H
rostrata H
vesicaria H
Dactylis glomerata S
Deschampsia caespitosa S
flexuosa S
Elymus arenarius H
Elytrigia repens H
Festuca arundinaceae S
glauca S
ovina S
pratensis S
rubra S
Juncus articulatus H
conglomeratus H
effusus H
filiformis H
gerardi H
inflexus H
lampocarpus H
Lolium multiflorum S
perenne S
Luzula multiflora H
pallescens H
pilosa H
Melica nutans H
Poa annua S
glauca S
nemoralis S
palustris S
pratensis S
trivialis S
Phleum pratense S
commutatum H
Roegneria canina H
Sieglingia decumbens H
Scirpus silvaticus H
Avena fatua Tabor
orientalis v. pugnax Italy
orientalis v. tristis Tabor
nuda Tabor
strigosa Ljubl.
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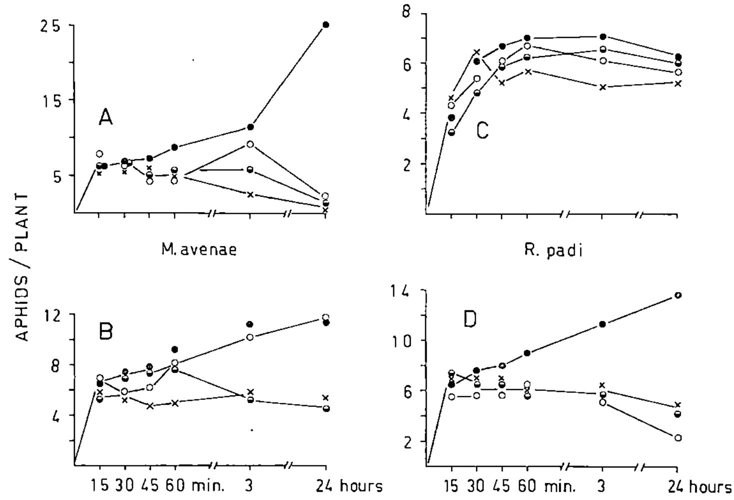

Fig. 2. Numbers of aphids on Sisu oats and on non-cereals in four host plant selection tests chosen at random as examples. In addition to Sisu oats (●) the species were as follows:

A *Carex limosa* (O), *C. nigra* (◒), *C. rostarta* (×)
B *Bromus macrostachys* (O), *B. madritensis* (◒), *Arrhenatherum elatius* (×)
C *Agrostis tenuis* (O), *Poa glauca* (◒), *Alopecurus geniculatus* (×)
D *Carex flava* (O), *C. globularis* (◒), *Scirpus silvaticus* (×)

Kuva 2. Kirvojen luku kasveissa neljässä esimerkiksi otetussa ravintokasvin valintakokeessa.

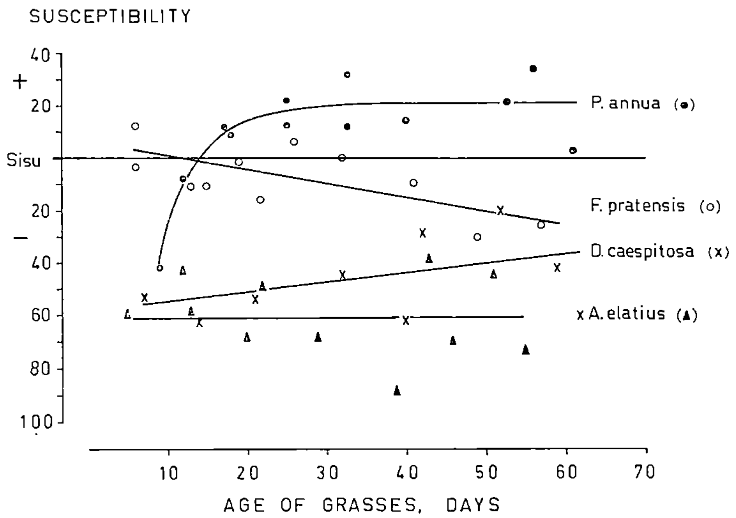

Fig. 3. The dependence of preference of *M. avenae* on the age of the plant. The proportion of aphids in percentages on Sisu oats (the standard) and on grasses was used as a criterion of preference. The index of susceptibility (ordinate) denotes the difference on the numbers of aphids settled on Sisu oats and on the grasses.

Kuva 3. Kelpaavuuden riippuvuus kasvin iästä. Pystyakselin luvut osoittavat kuinka paljon heinille asettuneiden kirvojen prosenttiset määrät poikkesivat Sisu-kauralle asettuneiden kirvojen määrästä. (+) = kirvoja oli kokeillussa lajissa enemmän, (—) = kirvoja oli vähemmän kuin Sisu-kaurassa.

old was preferred less than Sisu oats by *M. avenae* but the preferance for *P. annua* increased as the plants grew. Three weeks after shooting *P. annua* attracted greater numbers of *M. avenae* than Sisu oats. The preference for *Festuca pratensis* was reversed in the opposite way: when less than three weeks old the plants were equally preferred to Sisu oats, but with ageing the preference decreased to some extent. The preference for *Arrhenatherum elatius* and *Deschampsia caespitosa* was small, regardless of age.

Table 4. Preference of *M. avenae* for Sisu oats of different ages. The figures denote the proportion of aphids in percentages on oats after one day

Taulukko 4. M. avenaen asettuminen eri ikäisille Sisu-kauroille. Luvut osoittavat kirvojen prosenttisen määrän kasveissa vuorokauden kuluttua

Age of oats in weeks from shooting *Kasvien ikä viikkoina orastumisesta*	Number of aphids *Kirvojen luku* %
1	23.2
2	27.3
3	21.2
4	28.3

Conclusions

On the basis of host plant selection tests, it seems that *R. padi* prefers a wider range of host plants than *M. avenae*. On most of the Gramineae tested *R. padi* settled as numerously as on Sisu oats, but, with few exceptions, *M. avenae* settled in smaller numbers on the non-cereals tested than on Sisu oats. However, the reproduction of aphids on the various plant species was not studied, and thus there is no information about their true value as host plants for *M. avenae* and *R. padi*. In COON's (1959) experiments the number of progeny of *M. avenae* was small on *Poa annua* and the relative host efficiency of the species was less than that of *Festuca* species, *Avena sativa* or *Poa pratensis*. *Festuca* and *Lolium* species were more suitable as host plants than *Poa* species. After studying the reproduction of *R. padi* on various plants, VILLANUEVA and STRONG (1964) placed *Festuca arundinaceae* and *Poa pratensis* in the group of resistant species. According to ORLOB (1961 b), *R. padi* settled in greater numbers on plants on which they produced more progeny than on plants on which reproduction was less prolific. It remains to be shown whether the tendency to settle on certain plants is generally correlated with the true nutrient value of the plant species. Different investigations will probably yield different orders of preference for plant species, since different biotypes of aphid populations may differ greatly in respect to their host plants (see e.g. CARTIER and PAINTER 1956).

In the beginning of the experiments the number of aphids was the same on all the four plant species compared. The preference or non-preference only became apparent after a few hours. This observation support the conclusions generally made about the mechanism of host plant selection of aphids, namely that the gustatory stimulus is the factor that determines the preference for a plant (see e.g. THORSTEINSON 1960).

Summary

The preferences, shown for cereal varieties and for species of Gramineae, Cyperaceae, and Juncaceae as host plants by the English grain aphid, *Macrosiphum avenae* (F.), and the oat bird-cherry aphid, *Rhopalosiphum padi* L., were studied in laboratory experiments in the six-year period 1963—1968. The purpose was to clarify whether alate aphids settle within 24 hours in different numbers on cereal shoots and other three- or four-week-old plants available. In determinations of preference cereal varieties were compared four or two at a time in an experiment. When the preference for non-cereals was investigated, two methods were used: (1) Sisu oats was compared with three other species, or (2) only two non-cereal species were compared with each other. The dependence of preference on the age of the plant was studied by counting the numbers of

M. avenae settling on the same batch of Gramineae plants at successive intervals of some days with those on a batch of young shoots of Sisu oats, used as a standard.

Altogether, tests were made of the preference of *M. avenae* for 86 cereal varieties and 59 Gramineae, Cyperaceae, and Juncaceae species and of the preference of *R. padi* for 165 cereal varieties, and 47 Gramineae, Cyperaceae, and Juncaceae species. Initially, the aphids settled on most cereals in much the same numbers. The deviation from the expected numbers (25 % of the aphids on each of the four varieties of the experiments) were on the average of the order of four percentage units. The greatest deviation as 10 percentage units from the expected 25 % of aphids on each variety. The difference between some pairs of varieties was similar in all tests; for example, *M. avenae* always settled in significantly greater numbers on Selkirk wheat than on Svenno.

Nearly all the Gramineae, Cyperaceae, and Juncaceae species were less preferred as host plants of *M. avenae* than the standard, Sisu oats. *Bromus* and *Lolium* species as well as *Poa annua* deviated least from Sisu. *R. padi* settled on Gramineae species in almost the same numbers as on Sisu oats, but was clearly less numerous on *Carex*.

M. avenae settled in equal numbers on Sisu oats one to four weeks old.

Poa annua under two weeks old was less preferred than the shoots of Sisu oat as host plants of *M. avenae*, but on *Poa annua* over three weeks old the aphids settled in greater numbers than on Sisu oats. *Festuca pratensis* less than three weeks old were equal to Sisu oats, but the preference decreased as the plants grew older. The preference for *Arrhenatherum elatius* and *Deschampsia caespitosa* remained low, regardless of age.

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SELOSTUS

Viljojen sekä heinä-, sara- ja vihvilälajien kelpaavuus viljan kirvojen ravintokasveiksi

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Viljalajikkeiden sekä heinä-, sara- ja vihvilälajien kelpaavuutta viljakirvan, *Macrosiphum avenae* (F.), ja tuomikirvan, *Rhopalosiphum padi* (L.), ravintokasveiksi tutkittiin laboratoriokokein vuosina 1963—1968. Tavoitteena oli selvittää, asettuvatko siivelliset kirvat vuorokauden aikana eri suurin määrin valittavina oleviin viljojen oraisiin ja kolmen tai neljän viikon ikäisiin muihin kasveihin. Kerrallaan yhdessä kokeessa verrattiin joko neljän tai kahden viljalajikkeen kelpaavuutta. Muiden kuin viljojen kelpaavuutta selvitettäessä käytettiin kahta menetelmää: kerrallaan verrattiin toisiinsa (1) Sisu-kauraa ja kolmea eri kasvilajia, tai (2) vain kahta eri kasvilajia. Kelpaavuuden riippuvuutta kasvin iästä tutkittiin siten, että seurattiin *M. avenae*n asettumista samoihin heiniin ja Sisukauran nuoriin oraisiin tietyin aikavälein.

Yhteensä selvitettiin 86 viljalajikkeen ja 59 heinä-, sara- ja vihvilälajin kelpaavuutta *M. avenae*n sekä 165 viljalajikkeen, ja 47 heinä- ja saralajin kelpaavuutta *R. padi*n ravintokasviksi. Koe-eläimet asettuivat vuorokauden aikana useimpiin viljoihin hyvin samansuuruisin määrin. Poikkeamat odotetusta määrästä (25 % koe-eläimistä jokaisessa kokeen neljässä lajikkeessa) olivat keskimäärin neljän prosenttiyksikön suuruiset. Suurimmat poikkeamat olivat noin 10 prosenttiyksikköä odotetusta 25 %:n määrästä. Joidenkin lajikkeiden ero oli kaikissa kokeissa samansuuntainen: *M. avenae* asettui aina merkitsevästi suuremmin määrin Selkirk-vehnään kuin Svennoon.

Miltei kaikki heinä-, sara- ja vihvilä-lajit kelpasivat *M. avenae*n ravintokasviksi verranteena ollutta Sisu-kauraa huonommin. Vähiten poikkesivat Sisusta *Bromus*- ja *Lolium*-lajit sekä *Poa annua*. *R. padi* asettui heinälajeihin miltei yhtäläisin määrin kuin Sisu-kauraan, mutta saroihin selvästi vähemmän.

M. avenae asettui yhtä suurin määrin yhden-neljän viikon ikäisille Sisu-kauroille.

Kahta viikkoa nuoremmat *Poa annua*t eivät olleet Sisu-kauran oraiden veroisia *M. avenae*n ravintokasveina, mutta kolmen viikon ikäisille heinille koe-eläimet asettuivat suuremmin määrin kuin kauran oraille. Kolmea viikkoa nuoremmat *Festuca pratensis* -nadat olivat Sisukauran oraiden veroiset, mutta kelpaavuus väheni heinien iän lisääntyessä. *Arrhenatherum elatius* -heinäkauran ja *Deschampsia caespitosa* -lauhan kelpaavuus pysyi iästä riippumatta vähäisenä.

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Seria AGROGEOLOGICA, -CHIMICA ET -PHYSICA N. 47
Sarja MAAPERÄ, LANNOITUS JA MUOKKAUS n:o 47

THE IMPORTANCE OF SOIL BULK DENSITY IN SOIL TESTING

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Either volume or mass may be used in analysis as a measurement of basic quantity when the chemical properties of soil are being investigated. It is known that a plant uses roughly the same volume of soil to anchor its roots and take up water and nutrients, more or less irrespective of the soil density. It consequently seems that a measurement of volume would be the only unit of basic quantity for purposes of fertility analysis. This applies with even greater relevance in Finland, where soils of widely varying density are cultivated. In Finland one soil may have a volume weight 15 times as great as another. According to the method of soil testing used in Finland, the samples are extracted in a 1: 10 volume/volume ratio with acid ammonium acetate. The results are stated in milligrams of nutrients per litre of soil (Vuorinen and Mäkitie 1955, Kurki et al. 1965).

Air-drying and grinding of soil samples in the laboratory causes a change in bulk density, thus affecting the weight of a given volume used for analysis. For practical reasons, however, this »apparent bulk density» of the samples is used in routine soil testing. In the present paper the use of apparent bulk densities of various soil types in soil testing are compared with the use of »natural bulk densities» of the same soils, sampled from fields on a volume basis. All the samples were extracted in an identical manner.

Material and methods

The soil sample material was collected from the most typical soil types of cultivated lands in southern Finland. There were 33 sampling sites: 24 on grass ley, 8 on spring cereal fields, and one on meadow. The samples were taken in autumn 1964 between 19 October and 20 November, when the soil moisture content is relatively stable. The moisture content of the samples was somewhat higher than that of soil at field capacity according to Heinonen (1954). Topsoil moisture measured in volume percent averaged 31.6 in sandy soils, 43.4 in clay soils and 54.7 in mould soils.

The samples were extracted with a steel cylinder of c. one litre volume (1.052 dm^3) (Fig. 1), 90 mm high and 122 mm in diameter, which was driven into the ground with the aid of a rack and a small hammer. The cylinder was loosened with a spade, and the soil sample levelled off with a knife. Four replicates were taken from each of 3 successive layers at the sampling site. The uppermost replicates represent the plough layer to a depth averaging 5—15 cm, the second ones the subsurface (av. 25—35 cm) and the third the subsoil material (av. 45—55 cm). These layers are not of the same type of soil in all cases. The replicates were near each other, being taken over an area of 0.2 m² at the most.

The samples were air-dried for about 4 months in indoor storage. They were weighed from time to time in order to check that no further weight decrease was occurring. The storeroom temperature at the time was 23°C ± 1.5°, and the relative humidity 44 % ± 6 % units. The moisture content of the air-dried topsoil samples varied from 1.4 to 5.2 per cent in the mineral soils and 3.5—8.7 in the organic soils and, in the subsoil, from 0.3 to 5.1 per cent in the mineral soils and 3.3—11.2 in the peat soils.

After drying, the samples were ground in a mill whose wooden disc, revolving on a vertical axle, grinds the soil against the perforated floor of a steel vessel. The < 2 mm soil was used for analyses.

A standard volume of 25 ml was measured from each replicate for extraction. The measurement was made by hand using a 25-ml cylindrical aluminium cup above a tube of identical diameter opened to form a funnel (Fig. 2). This was filled with the soil which was to be analyzed and was then tapped 3 times against a rubber pad. The soil in the measuring cup then settled and packed down, compression being brought about by the weight of the soil column in the cylinder. It has been found that the error of measurement in this method is on average below 2 per cent (Mäkitie 1958).

The actual air-dried volume weights of the original soil samples (numbering 396) were calculated by weighing the entire air-dried sample and dividing the figure obtained by the volume of the cylinder. The apparent bulk density to be compared was obtained by weighing the 25-ml soil sample obtained by the »tapping-and-measuring» method used with the ground sample.

The samples were shaken for one hour with 250 ml of acid ammonium acetate (0.5 N CH_3COOH, 0.5 N CH_3COONH_4, pH 4.65) and filtered. Calcium and potassium were analyzed flame-photometrically, and phosphorus colorimetrically, by the molybdenum blue method. The particle size distributions of all mineral soil samples were determined by wet and dry -sieving and by the pipette method. Organic matter content was determined by sulphuric acid/chromic acid wet digestion with moderate external heating (O.M. = 1.73 × organic carbon).

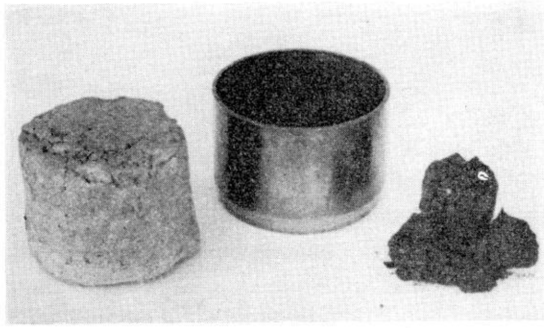

Fig. 1. A steel cylinder of one litre capacity used for sampling, a clay and a peat sample taken at near field-capacity are shown here after laboratory drying.

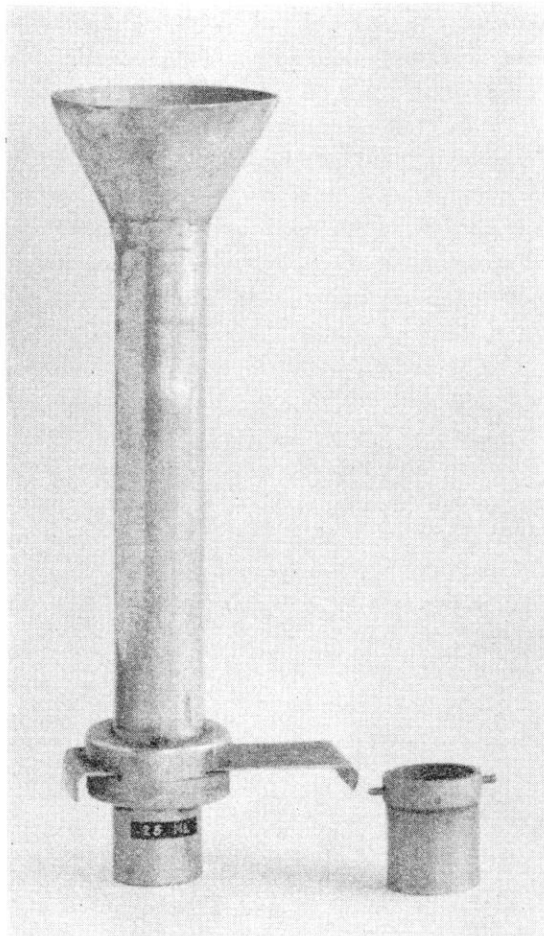

Fig. 2. A cylinder used for measuring volumes of ground soil for extractions.

Bulk densities

The bulk densities of the air-dried soils equivalent to the natural state of the samples are here called natural bulk densities and are shown as averages in Table 1. Side by side are the bulk densities obtained from soils by our ordinary laboratory method using a 25-ml measure and here called apparent bulk densities. The samples were measured and weighed 3 times, and the resulting averages were used in this study. The average bulk densities of the soils in the material vary from 0.31 to 1.26 for the topsoils, ranging more widely from 0.14—1.52, for the subsoils.

The natural bulk density of the soil is primarily dependent upon the organic matter content of the sample, being smaller the higher the organic matter content. The relationship is demonstrated by the extremely high correlation coefficient r = 0.966*** obtained from the material by means of the square roots of the single data (Fig. 3).

The particle size distribution of the sample, however, does not have any significant effect on the natural bulk density, except where the heaviest clay samples are concerned. This can be seen in the case of the low-humus subsoils from their average bulk densities, which vary within very narrow limits. In the heavy clays it is probably the high content of colloidal clay that tends to lower the bulk density. The highest single bulk density, of 1.69, was obtained from the subsoil of a sandy

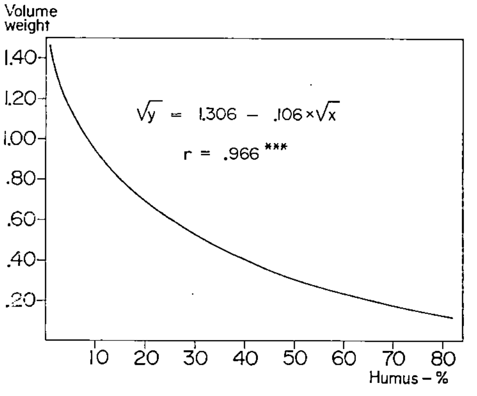

Fig. 3. The dependability of natural bulk density at air-dry basis upon the humus content of the soil; 98 samples.

finesand, but the surprisingly high bulk density of 1.64 was also obtained for a clayey silty finer finesand sample, while the lowest, 0.09, was obtained for a Sphagnum peat sample with an H_3 degree of humification.

Disparity between natural and apparent bulk densities

Table 1 shows the statistical significances of the differences between the natural bulk densities and the apparent bulk densities (obtained in the laboratory from ground samples). In most of the material, i.e. in 84 cases out of 96, this disparity is statistically very significant, and it was only in 4 cases that a 95 per cent confidence could not be established.

The disparity in the compared bulk densities was not always in the same direction, even in individual cases. This is especially so in the case of sands and mould soils. The statistically most reliable soil groups are silty clay in the topsoils, clayey silt, sandy clay, silty clay and Sphagnum peat in the subsoils. The apparent bulk density was smaller than the natural one in the soil groups ranging from sand to gyttja silt (1—9., Table 1). In the peats the disparity was in the opposite direction. As regards these soils, gyttja constitutes an intermediate soil group in the sense that the topsoils of gyttjas belong to the soils 1—9., (Table 1) and their subsoils to the peats.

Between the natural and apparent bulk densities of the topsoils there is an interrelation with an r-value = .958***. The steepness of the relationship is described by a straight line whose regression coefficient was .685 (Fig. 4). This line intersects an imagined bisector at the point x = y = .76. In theory, no error would thus occur with the measuring method employed in the laboratory when the bulk density of the sample is .76. The disparity will increase linearly when the bulk density rises above or drops below this value. In the graph in Fig. 3 the bulk density value of .76 corresponds to the humus content value of 16.5 per cent. Thus this type of measure-

Table 1. The »natural» and »apparent» bulk densities and the statistical significancies of their differences

Soil type [1])	Depth 5—15 cm							Depth 25—35 cm and 45—55 cm						
	n	Average bulk densities		Samples at different significance levels				n	Average bulk densities		Samples at different significance levels			
		In natural state (ranges)	Measured in laboratory	.999	.99	.95	< .95		In natural state (ranges)	Measured in laboratory	.999	.99	.95	< .95
1. Sand — *Hk*	3	1.200 (1.07-1.35)	1.140 (0.99-1.27)	1		1	1	7	1.460 (1.24-1.54)	1.430 (1.31-1.51)	1		4	2
2. Finesand — *KHt*	2	1.256 (1.10-1.41)	1.126 (1.02-1.23)	1	1			4	1.516 (1.36-1.65)	1.310 (1.22-1.42)	3	1		
3. Finer finesand *HHt*	3	1.128 (1.06-1.16)	1.027 (0.98-1.06)	1	1	1		5	1.434 (1.33-1.58)	1.241 (1.11-1.32)	5			
4. Clayey silt — *sHs*	2	1.062 (1.07-1.08)	0.899 (0.87-0.92)	2				6	1.494 (1.43-1.65)	1.043 (0.98-1.11)	6			
5. Sandy clay — *HtS*	5	1.190 (1.04-1.30)	1.025 (0.99-1.03)	4		1		7	1.454 (1.37-1.54)	1.154 (1.06-1.20)	7			
6. Silty clay — *HsS*	5	1.000 (0.93-1.11)	0.898 (0.86-0.96)	5				7	1.454 (1.40-1.55)	1.075 (1.04-1.18)	7			
7. Silty heavy clay — *hsAS*	-	—	—					3	1.448 (1.40-1.46)	1.128 (1.11-1.16)	3			
8. Heavy clay — *AS*	1	1.078 —	0.942 —	1				4	1.275 (1.26-1.28)	1.091 (1.06-1.13)	4			
9. Gyttja silt — *LjHs*	1	1.201 —	1.066 —	1				2	1.241 (1.21-1.27)	1.044 (1.03-1.06)	2			
10. Gyttja clay — *LjS*	1	1.069 —	0.956 —	1				3	1.038 (0.92-1.25)	0.957 (0.84-1.11)	1	1	1	
11. Gyttja — *Lj*	2	0.860 (0.74-0.98)	0.810 (0.69-0.93)	1			1	4	0.523 (0.34-0.99)	0.664 (0.46-0.92)	4			
12. Mould soil — *Mm*	6	0.605 (0.39-0.86)	0.688 (0.52-0.91)	2	2	2		-	—	—				
13. Carex peat — *Ct*	-	—	—					7	0.211 (0.13-0.27)	0.515 (0.34-0.67)	6	1		
14. Sphagnum peat — *St*	1	0.307 —	0.377 —			1		5	0.141 (0.10-0.18)	0.290 (0.16-0.43)	5			

[1]) 4.) ≥ 50 % silt fraction and ≥ 30 % clay fraction; 5.) 30 %—59.9 % clay and ≥ 20 % sand + finesand; 6.) 30—59.9 % clay and < 50 % silt; 7.) ≥ 60 % clay and ≥ 20 % silt; 8.) ≥ 60 % clay; 9.) like silt but 3—5.9 % humus content; 10.) ≥ 30 % clay and 3—5.9 % humus content; 11.) 6—39.9 % humus content; 12.) surface soil 15—39.9 % humus content.

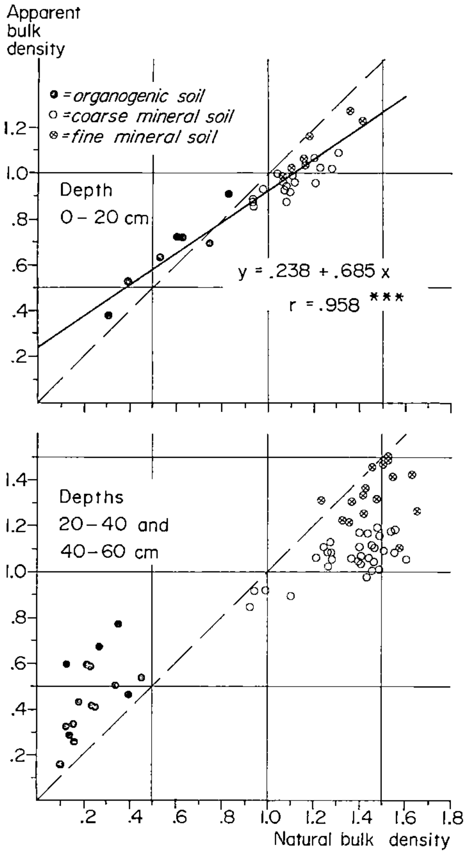

Fig. 4. The interrelation of bulk densities measured by laboratory method and in natural state.

ment will produce a minimum of error when employed on samples with a humus content near 16 per cent. It follows from the curvature of the graph that a change of one unit in humus content has a relatively greater effect on the error arising from the measuring method in soils containing little organic matter than in soils containing plenty of humus.

Level of soil testing results analyzed according to the two methods of determining bulk density

Table 2 shows for soil groups the amounts of calcium and potassium extracted from a quantity of soil obtained by volume measurement according to our laboratory method, as a percentage of that of an equal quantity of the soil in its natural state. The statistical minimum reliability of the difference refers to the poorest significance found for any soil group. When there is no asterisk expressing statistical significance in the column, the cases in the soil group have not all attained the level of significance employed.

There is a disparity in the extracted amounts of potassium and calcium in all the soil groups in the comparison. The disparity between the methods of measurement is smaller for the topsoils than for the deeper layers. An average of 86—95 per cent of the actual was obtained for extracted calcium in the various soil groups except for peat, for which an excess of 15 per cent was obtained. Correspondingly, 87—97 per cent of actual potassium was extracted, and, in the cases of Sphagnum peat, 19 per cent in excess of the actual. The difference was found to be a significant one (95 % reliability) in 24 cases out of 33 both for calcium and for potassium.

Soluble calcium and potassium of topsoils were obtained in too small amounts from mineral soils and in too high amounts from organic soils compared with the actual values. In peat soils the error is a considerable one, being greater the deeper the original location of the sample. The greatest average disparity for extracted calcium, a value 32 per cent lower than the actual, was obtained in the group of clayey silts at a depth of 45—55 cm, and the two nutrients showed their second greatest disparity in silty clay. In both deeper layers a minimum excess of 54 per cent of extracted Ca and K was obtained on an average, but an excess of 247 per cent for calcium and 200 per cent for potassium were obtained in the most extreme individual cases.

In the subsoils the statistical reliabilities of the differences are in the 99.9 per cent category for most of the soil groups, which is due to the greatness of the differences between methods and the smallness of the dispersion between replicates. This reliability limit was obtained in 47 cases for calcium and 36 for potassium out of a total of 64.

Where easily soluble phosphorus is concerned, a statistically significant difference for phosphorus contents was obtained in 7 cases only.

Table 2. The Ca- and K-values of the samples measured in laboratory as percentages of values measured from the natural state

	Depth 5—15 cm							Depth 25—35 cm							Depth 45—55 cm						
	Number of sites	Exchangeable Ca Aver.	Exchangeable Ca Ranges	Minimum reliability observed in all the sites	Exchangeable K Aver.	Exchangeable K Ranges	Minimum reliability	Number of sites	Exchangeable Ca Aver.	Exchangeable Ca Ranges	Minimum reliability	Exchangeable K Aver.	Exchangeable K Ranges	Minimum reliability	Number of sites	Exchangeable Ca Aver.	Exchangeable Ca Ranges	Minimum reliability	Exchangeable K Aver.	Exchangeable K Ranges	Minimum reliability
1. Sand — *Hk*	3	95.3	93- 99		93.9	90-100		4	110.9	100-125		100.3	94-107		3	93.9	92- 95		92.7	79-106	
2. Finesand — *KHt* ..	2	96.6	96- 97		92.4	85-100		2	97.2	82-112		82.1	77- 88		2	102.9	94-112		86.5	75- 98	
3. Finer finesand - *HHt*	3	92.2	91- 94	**	94.6	92- 96		3	90.6	78-101		90.4	73-100		2	94.5	93- 96		96.1	92-100	
4. Clayey silt — *sHs* ..	2	87.0	86- 88	*	88.4	85- 92	**	3	73.7	71- 78	***	73.9	70- 80	***	3	72.7	72- 74	***	68.0	66- 70	***
5. Sandy clay — *HtS*..	5	89.6	84- 96	*	87.6	80- 98		5	82.1	77- 87	***	80.5	76- 85	***	2	81.0	77- 85	***	79.2	75- 84	***
6. Silty clay — *HsS* ...	5	92.7	89- 98		90.9	84- 98		3	77.8	74- 81	***	75.3	73- 77	***	4	78.2	75- 81	***	75.7	73- 80	***
8. Heavy clay — *AS* ..	1	86.5		***	85.6		***	1	84.7		***	85.1		***	6	81.8	77- 87	***	82.0	78- 87	***
9. Gyttja silt — *LjHs* .	1	91.8		**	86.1		***	1	92.9		***	92.3		***	1	83.6		***	93.8		
10. Gyttja clay — *LjS* ..	1	90.0		***	88.0		***	1	89.2		***	87.2		***	2	103.2	103-104		96.1	94- 98	
11. Gyttja — *Lj*	2	94.6	92- 97		93.6	93- 95		3	131.1	96-185	*	125.7	95-173	*	1	134.2		***	141.7		***
12. Mould soil — *Mm*..	6	112.9	97-124		113.6	91-133		-	—		-	—		-	-	—		-	—		-
13. Carex peat — *Ct* ...	-	—		-	—		-	3	186.5	154-205	***	168.6	125-204		4	231.9	160-347	**	224.9	188-300	
14. Sphagnum peat — *St*	1	115.7		*	118.5		**	2	154.2	139-169	***	167.2	125-209		3	180.0	136-203	***	184.7	157-223	***

These were 4 cases of Sphagnum peat which produced greater than actual quantities of phosphorus, and 3 of sand or finesand in which the phosphorus contents were too low. The tendency among the soil types was thus the same as with calcium and potassium.

Discussion

The bulk densities shown were measured on air-dried soils because the measuring of soil samples for extraction is done on and the comparison made between air-dried soils. Heinonen (1960) has determined the bulk densities of Finnish soils at field capacity and shown the primary dependence of bulk densities upon the humus content of the soil, a result at which this study also has arrived. He also found that clay components lower the bulk density while sand increases it. According to the present investigation it is very difficult to agree with the latter contention, for in subsoils of low humus content, for instance, a bulk density of 1.45 was obtained for silty heavy clay and of 1.43 for finer finesand, i.e. the values were almost identical. Also, Marshall (1959) established that the greatest density is found in a soil when the particle size distribution of the soil varies as widely as possible from fine to coarse. The fine particles will then fill up the gaps between the coarser ones. Løddesøl (1934), Lundblad (1945), Valmari (1957), Mäkelä (1963) and Päivänen (1969) have determined bulk densities of dried peat soils, and compared the differences between field and laboratory determinations. They arrived at the result that a laboratory determination produces substantially greater values than does a field determination. In the investigations by Mäkelä (1963) the laboratory value in one case was 340 per cent as great as the actual value. The change, i.e. the increase, of bulk density with organic soils is, as Lundblad (1945) points out, due to the shrinkage of the organic matter in the soil during drying, and is the greater the more humified the soil is.

On the other hand, the grinding of the soil during laboratory treatment causes a loosening up of dense soils, particularly of silt and clay soils, which results in a lowering of bulk density; and the denser the soil has been, the more distinct is this change. When the soil sample contains components that become looser when ground, such as silt and clay, and on the other hand organic matter that shrinks when dried, such as clayey mould or gyttja soils, even a ground sample may produce almost correct bulk densities, as was previously shown.

Grinding levels out the density differences between different soil type groups. The dense soils become looser while the light soils such as the peats become denser. This, in turn, lessens the comparableness between soil groups.

The fact, that the soil amount obtained by volume measurement of laboratory-treated samples does not correspond to the volume of the soil in its natural state, causes erroneous results as regards extractable soil quantities. The differences between the extracted nutrient amounts in our comparison are almost directly proportional to the differences between the soil quantities, for the amount of extracted nutrients increases with changing extraction ratio in the manner shown by Mäkitie (1956). In respect of phosphorus content, however, the significance of the extraction ratio is less than for calcium and potassium, because the amount of easily soluble phosphorus is dependent on the solubility products of aluminum-, iron- and other phosphates. This product is not much affected by the quantity of soil from which the extractions are made. Nor was it possible, in many of the cases, to make a comparison, because of the low phosphorus contents at the lower limit of determinability of the method used.

The differences in calcium and potassium contents obtained in the comparison are considerably smaller for the topsoils than for the subsoils. This applies to both mineral and organic soils because the structural change caused during laboratory treatment is considerably more drastic where the subsoils are concerned. This source of error should be carefully considered in investigations comparing the nutrient contents of topsoils and undisturbed subsoils. The nutrient figures for dense subsoil do not exceed 70—80 per cent of the actual ones, on account of the soil-loosening effect of grinding mentioned previously.

The correction of the disparities revealed in the investigation so as to bring them into line with the actual values is not easy on account of the variation in the direction and magnitude of the disparity between various soils. It is evident that volume measurement is the only correct measure of the basic amount for extraction analysis, because a measurement of mass even in the light of the present investigation would, e.g. in a comparison between sandy soil and Sphagnum peat soil, produce an almost twentyfold error if the nutrients were expressed per volume unit of the natural soil.

An absolutely correct result will only be attained by taking the soil sample from the natural state with the help of a volume measure and then using this extracted soil amount as the basis for the soil sample to be analyzed. This procedure would be necessary particularly when samples have been taken from soils liable to shrink, especially organic soils.

With soils that become loosened when ground, i.e. with mineral soils, use might be made of harder tapping or shaking or even perhaps pressing-down when the volume is being measured. This would already bring us close to the true natural structure, especially in the case of topsoils, for which fertility studies are most important. With subsoils it is hardly possible to produce a natural dense structure from dry soil, even by compression.

Summary

1. The quantity of soil obtained with a volume measuring device from a sample dried and ground in the laboratory did not correspond to a quantity of equal volume of the soil in its natural state. Consequently, in the present comparative investigation the extracted nutrient amounts of calcium, potassium and phosphorus also differed from the actual amounts. This is because the nutrient amounts obtained by the soil measuring method employed in the laboratory were more or less erroneous when the contents are expressed as mg/l of soil.

2. Smaller than actual values were obtained for the extracted nutrients of the mineral soils, and larger than true values for those of the organic soils. The disparities were clearly smaller for the topsoils than for the lower layers. In the mineral soil groups both calcium and potassium values for topsoil and subsoil materials were respectively 5—14 per cent and 0—32 per cent too low on an average; while in the organic soils they were respectively 13—19 per cent and 26—132 per cent too high. The disparities in easily soluble phosphorus were in the same direction, but were not sufficient to allow conclusions to be drawn except for part of the material.

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SELOSTUS

Maalajin merkitys maan viljavuuden analysoinnissa laboratoriossa mitatun tilavuuden mukaan

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Etupäässä heinänurmilta Etelä-Suomesta otettiin tyypillisimmiltä maalajeilta 33 näytepaikalta, kolmesta kerroksesta, kaikkiaan 396 kpl 1.052 dm^3:n maanäytettä.

Pintamaassa ilmakuivan maan tilavuuspainot vaihtelivat 0.31—1.26 ja pohjamaassa 0.14—1.52 (taul. 1). Tilavuuspaino oli erittäin selvässä riippuvuussuhteessa näytteen humuspitoisuuteen kuvan 3 ilmaisemalla tavalla. Maan raekoolla ei ollut sanottavaa vaikutusta tilavuuspainoon.

Viljavuustutkimuksessa mitataan maamäärä kalsiumin, kaliumin ja fosforin uuttoon tilavuusmitalla. Laboratoriossa kuivatusta ja jauhetusta maanäytteestä mitattu erä ei kuitenkaan vastaa täysin samaa tilavuutta luonnontilaista maata. Tämän johdosta myös uutettujen ravinteiden määrät poikkesivat vertailututkimuksessamme todellisista. Taulukosta 1 ja kuvasta 4 selviävät eri tavalla saatujen tilavuuspainojen — luonnontilaisten ja »näennäisten» — keskinäiset suhteet maalajeittain. Taulukossa 2 ovat »näennäisellä» tilavuusmittauksella saatujen helppoliukoisten kalsiumin ja kaliumin määrät prosentteina todellisista.

Uutetuista ravinteista saatiin kivennäismailla todellista pienempiä ja eloperäisillä mailla todellista suurempia arvoja. Pintamailla poikkeamat olivat selvästi pienempiä kuin syvempien kerrosten kohdalla. Maalajiryhmien keskimääräiset kalsiumin ja kaliumin arvot olivat pintamailla 5—14 % ja pohjamailla 0—32 % todellista pienempiä kivennäismaissa ja eloperäisissä maissa vastaavasti 13—19 % sekä 26—132 % todellista suurempia. Helppoliukoisen fosforin poikkeamien suunta oli sama, mutta vain osassa aineistoa päätelmien tekoon riittävä.

ANNALES AGRICULTURAE FENNIAE, VOL. 9: 287—289 (1970)

Seria PHYTOPATHOLOGIA N. 25 — Sarja KASVITAUDIT n:o 25

ROOT ROT OF STRAWBERRY

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Received September 12, 1969

The Department of Plant Pathology has annually received from farmers samples of strawberries in poor condition with their roots more or less damaged. Since the damage has greatly resembled the root rot disease established by the author in red clover roots (YLIMÄKI 1967), the disease has been subjected to a more through study.

Material and methods

Additional samples were collected from strawberry cultivators so that the total investigated material consisted of 99 lots of samples (367 roots), of these 47 items were obtained from one of the most important strawberry production regions in Finland, the commune of Suonenjoki. The material was collected in a manner that would make it possible to obtain an average picture of the condition of the roots of strawberries in the region in question.

The analysis of the roots, the isolation of the fungi, as well as the identification of the fungi were carried out in the same way as in the author's study concerning the root rot of clover (loc. cit. p. 8).

Symptoms

The results obtained in the analysis serve to strengthen the impression of the disease received from single samples investigated earlier. The roots of diseased strawberries were invariably smaller than those of the healthy ones. On the surface of the taproots and the lateral roots there were spotlike or rather large areas darker than the surface elsewhere on the root.

Over one half of the studied taproots were rotted up to 40 % the rot being chiefly situated in the lower part of the root (Table 1). The decline of the lateral roots, when the severity of the disease increased, was established as a very

Table 1. The condition of root samples collected from Suonenjoki in 1966
Roots investigated 274

	The rotting degree of the taproot in % classes						Rotting in taproot			Lateral roots		
	0	1—20	20—40	40—60	60—80	80—100	upper part	middle part	lower part	abundantly	rather many	little
No. ..	17	58	49	65	67	18	8	16	30	4	17	20
% ...	6.2	21.1	17.9	23.7	24.5	6.6	14.8	29.6	55.6	9.7	41.5	48.8

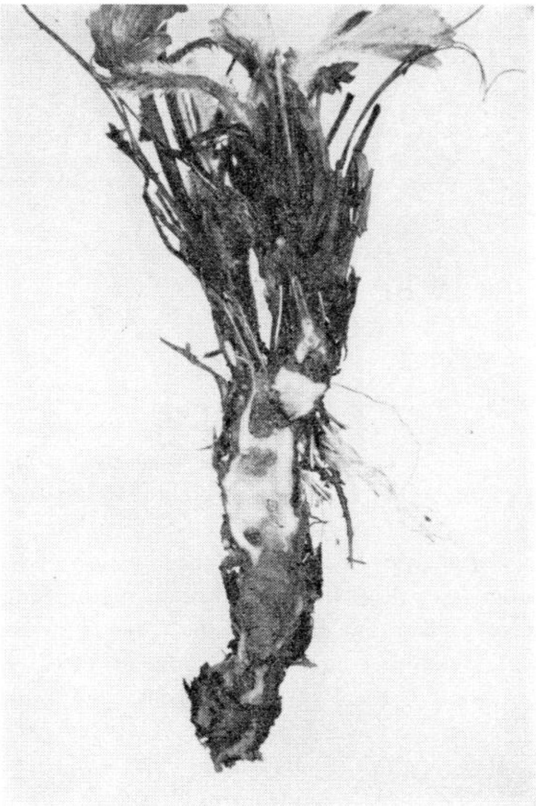

Fig. 1. Root rot of strawberry.

characteristic feature (Fig. 1). The parts above the ground of the strawberries suffering from root rot seemed ailing and were small in size often yellowish or brown. The runner plants often became infected and died.

Isolated fungi

A number of different fungi were isolated from the diseased strawberry roots (Table 2). These fungi are common soil infecting species and are known to infect many other plants besides strawberry (cf. Ylimäki 1967). Of all the isolated fungi well over one half belonged to the *Fusarium* species.

To establish the pathogenicity of the fungi, some inoculation tests were carried out in sterilized soil with healthy strawberry seedlings aged 2—3 ½months. It appeared that the access of fungi to the taproots of the healthy seedlings of the above age is possible through the lateral roots. Infection of the taproot is very slow. When fungi were planted in wounds made in the taproot (Table 3), the infection took place, but its advance in the taproot was slow.

It is evident that strawberry root rot is a disease complex where abiotic factors have among fungi a considerable significance. During winter and especially in autumn and spring, the alternate icing and thawing of the soil causes the breaking of the lateral roots in strawberry and also the damage in the taproot, and so the fungi in the soil obtain access to the roots. A similar situation can be caused by severe drying of the soil during the growing season as well as by some pests damaging the roots (Mäkinen 1967).

Table 2. Fungi isolated from strawberry roots

Fungus	No. of isolates
Fusarium poae (Pk.) Wr.	5
» *arthrosporioides* Sherb.	4
» *avenaceum* (Fr.) Sacc.	23
» *semitectum* Berk. & Rav.	4
» *acuminatum* (Ell. & Ev.) Wr.	7
» *culmorum* (W.G.Sm.) Sacc.	2
» *graminearum* Schw.	3
» *sambucinum* Fuckel	10
» *sambucinum* v. *coeruleum* Wr.	2
» *oxysporum* Schl. emend. Sn. & H.	17
Cylindrocarpon destructans (Zins.) Scholten	16
Botrytis cinerea Pers.	11
Rhizoctonia solani Kühn	4
» *crocorum* (Pers.) De Cand.	3
Phoma sp.	17
Verticillium sp.	2
Other, unidentified	17
Total	145

Table 3. Inoculation trials of strawberry

Variety Senga Sengana, age 3 ½ months. The mycelia and spore suspension of the fungi placed on the cut made at the neck of the taproot. Duration of trials 5 ½ months.

Fungus	Condition of roots 0—5
Fusarium oxysporum (654)	3.7
» *osysporum* (6631-2)	3.3
Cylindrocarpon destructans (608)	3.3
Phoma sp. (6616-2)	3.7
Control	5.0
F-value	12.9***
L.S.D.	0.54

The general condition, i.e. the carbohydrate reserves, affect the winterhardiness of strawberries (MADER and FELDMAN 1948) but also their susceptibility to soil fungi.

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SELOSTUS

Mansikan juurilaho

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Mansikkaviljelyksiltä kerättiin 31 kunnasta 99 näyteerää eli yhteensä 367 kpl mansikan juuria. Yli puolet pääjuurista oli vähintään 40-prosenttisesti lahonnut, ja lahoa todettiin pääasiassa juuren alaosassa. Taudille oli tunnusomaista myös juurihaarojen ja rönsytaimien tuhoutuminen. Juurista eristettiin joukko yleisiä maasieniä, joista yli puolet oli *Fusarium*-lajeja. Patogeenisuuskokeissa todettiin varttuneiden mansikkakasvien olevan täysin terveinä varsin vastustuskykyisiä. Pelto-oloissa niiden juuret ovat kuitenkin alttiita monenlaisille vioituksille, ja näitä sienet käyttävät infektioteinään.

ANNALES AGRICULTURAE FENNIAE, Vol. 9: 290—292 (1970)
Seria ANIMALIA NOCENTIA N. 44 — Sarja TUHOELÄIMET n:o 44

FROG-HOPPERS (HOM., CERCOPIDAE) IN STRAWBERRY PLANTATIONS

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Spittle masses of cercopids found in strawberry plantations have usually been assumed to be caused by *Philaenus spumarius* (L.), and this species has been blamed for the damage caused. In Finland, however, 8 cercopid species with nymphs that produce cuckoospit have been found. The cercopid fauna of strawberry plantations and the effect of *P. spumarius* and *Aphrophora alni* (Fall.) on the strawberry yield have been investigated at the Department of Pest Investigation of the Agricultural Research Centre. Part of the investigation has already been published (Halkka et al. 1967).

Material and methods

Data on the occurrence of cercopids in strawberry plantations were gathered from the records of the Department of Pest Investigation (see Vappula 1965). Observations were also made on the occurrence of these species on strawberry fields in various parts of the country. The life cycles and ecology of these species were investigated in 1965—1969, mainly on the island of Krokholmen, 16 km east of Helsinki (see Halkka et al. 1967, Fig. 4), in the Tvärminne archipelago, east of the Hanko Peninsula, and in the insectary at the Department of Pest Investigation at Tikkurila, some 15 km north of Helsinki. Experiments to clarify the effect of the nymphs on the strawberry yield, performed as described by Halkka et al. (1967, p. 15), were carried out with strawberry plants of the variety Ydun.

Results

Cercopids as pests of strawberry

In 29 of the last 45 years the Department of Pest Investigation has received information on the occurrence of cercopids as pests of strawberry. Such reports were most frequent in 1950—1952, when the temperatures of late spring and early summer were higher than normal or normal, while there was little rain and the strawberries were suffering from drought. Spittle masses of cercopids were found on strawberry fields almost throughout the region where strawberries are grown. Yield losses may have been slightly more frequent in the small plantations along the coast than in the fields inland. Small inland plantations have also suffered fairly heavy damage occasionally (Fig. 1).

Nymphs of two species, *Philaenus spumarius* and *Aphrophora alni*, were found on strawberries, and nymphs of *Neophilaenus lineatus* (L.) were found on weeds in these plantations. *P. spumarius* was commoner everywhere, being more numerous even on the strawberry fields where *A. alni* occurred. On the Krokholmen strawberry plantation, for instance, 87 per cent of the 355 nymphs found in 1967 were *P. spumarius*, as were 79 per cent of the 145 nymphs found in 1968; the re-

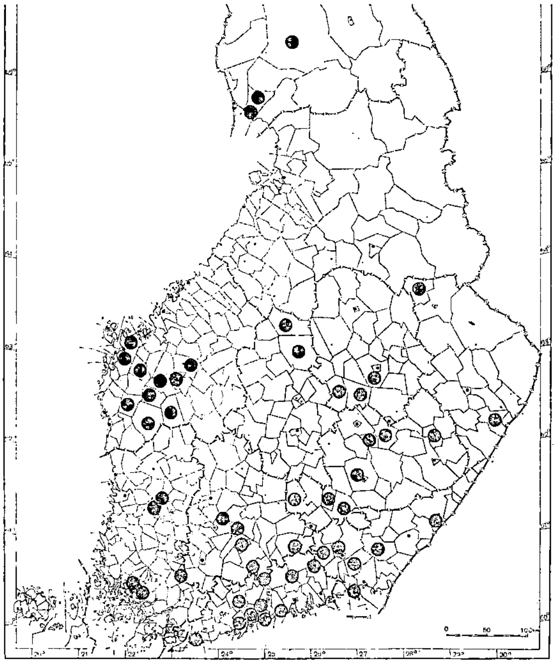

Fig. 1. Known localities of cercopids as pests of strawberries.

mainder being *A. alni*. Cercopid nymphs were usually most numerous on strawberry plots that were small, neglected or situated in the vicinity of wasteland bearing other host plants of cercopids. On the Krokholmen strawberry plantation there were 2.8 *P. spumarius* nymphs per plant in 1967, and 2.0 per plant in 1968.

The distribution of the *P. spumarius* and *A. alni* nymphs on the strawberry plants on June 24, 1968 were as follows:

	Philaenus	*Aphrophora*
Inflorescence		
Bud	7	—
Bract	40	1
Peduncle	21	2
Rosette leaf		
Blade	25	1
Petiole	6	12
Plant base	9	20

The *A. alni* nymphs were found considerably lower on the plants than those of *P. spumarius*. Even on the rosette leaf petioles and the inflorescences, they were located lower down on the respective parts than the *P. spumarius* nymphs. In some of the insectary cultures, nymphs of *P. spumarius* and *A. alni* were placed on the upper-

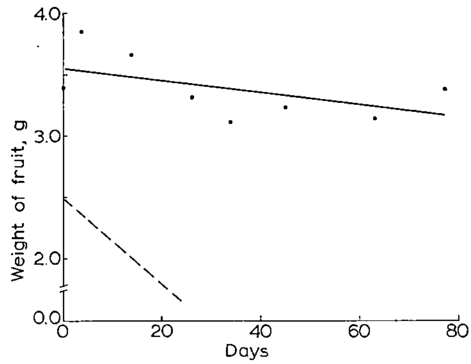

Fig. 2. Relationship between weight of strawberry fruits in grams and number of days spent by *A. alni* nymphs on the peduncle of the flower or fruit. Broken line that of *P. spumarius* according to HALKKA et al. (1967).

most part of the strawberry inflorescence, but almost all the *A. alni* nymphs moved down to the plant base, while only a few of the *P. spumarius* did so.

In insectary tests the feeding of *P. spumarius* nymphs on the flower shoot caused a marked decrease in the development of the fruits above the point at which they sucked ($r = -0.838^{**}$, $y = 2.497 - 0.035x$). It was not possible with similar tests to show that *A. alni* caused any decline in the strawberry yield ($r = -0.541$, $P > 0.05$), although the nymphs were substantially larger than those of *P. spumarius* and were kept longer on the strawberry inflorescence (Fig. 2).

Ecology of cercopids

P. spumarius is very common throughout almost the whole of Finland. The northernmost locality recorded is at InL, Ivalo, where a dense population was found at the edge of the village. *A. alni* is common in south and central Finland.

P. spumarius and *A. alni* overwinter in the egg stage. Eggs were found on strawberry plantations at the bases of the plants. The nymphs hatched from May 20 onwards. Hatching reached a peak at the turn of May—June. The last *P. spumarius* nymphs were found on August 2 and the last of *A. alni* on July 12. The first *P. spumarius* adults were found on July 4 and those of *A. alni* on July 8. The last *P. spumarius* adults were found at the beginning of October, and the last *A. alni* adults on August 29.

On the seashore meadows of Krokholmen the two species preferred the same host plants. Of *P. spumarius* (203 nymphs), 72 per cent occurred on *Filipendula ulmaria*, 15 per cent on *Lysimachia vulgaris*, 5 per cent on *Artemisia vulgaris* and 3 per cent on *Lythrum salicaria*. With *A. alni* (65 nymphs), the frequencies on these plants were 51, 14, 21 and 8 per cent respectively, and 6 per cent on *Angelica archangelica*. On the whole, the *A. alni* nymphs were found on types of meadow further from the water's edge in the undergrowth of the *Alnus glutinosa* zone. In the Tvärminne area *P. spumarius* was found in the inner and outer archipelago zones and in the marine zone on almost all the treeless skerries with dicotyledonous vegetation of a few square metres containing *Filipendula ulmaria*, *Lysimachia vulgaris* or *Lythrum salicaria*. *Neophilaenus lineatus* was common in the inner and the outer archipelago zones, but *A. alni* only on the larger islands of the inner and outer archipelago zones.

P. spumarius is polyphagous, and its nymphs feed chiefly on dicotyledons with herbaceous stems but also on those with woody stems. *A. alni* is also polyphagous, and its nymphs were found to feed on *Filipendula ulmaria*, *Artemisia vulgaris*, *Fragaria ananassa*, *Lysimachia vulgaris*, *L. thyrsiflora*, *Lythrum salicaria*, *Angelica archangelica v. litoralis*, *A. silvestris*, *Aegopodium podagraria*, *Anthriscus silvestris*, *Rubus idaeus* and *Chamaenerion angustifolium*. Nymphs of *Neophilaenus lineatus* chiefly inhabit grasses. They were found especially on *Deschampsia caespitosa* but also on *D. flexuosa*, *Calamagrostis* sp., *Alopecurus pratensis*, *Festuca rubra*, *Phalaris arundinacea*, *Carex nigra* and *C. magellanica*.

Discussion

According to Ossiannilsson (1950), the nymphs of *Aphrophora alni* usually live on herbs. In Finland, they seem rather rarely to attack strawberry plants. According to Nuorteva (1952), the adults move to bushes and trees, from which they migrate in late summer to the field layer in order to lay their eggs. As the nymphs usually live on the rosette leaves, and the nymphs living on the inflorescences do not decrease the yield, at least to any substantial extent, this species is probably not of any economic importance. *Philaenus spumarius* is a rather destructive pest, especially on small strawberry plantations surrounded by wastelands with alternative host plants or clover leys.

Summary

Nymphs of *Philaenus spumarius* (L.) and *Aphrophora alni* (Fall.) were found on strawberry plants, and nymphs of *Neophilaenus lineatus* (L.) on weeds in strawberry plantations. Only *P. spumarius* was found to be a pest of economic importance.

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SELOSTUS

Mansikkamaiden sylkikaskaat

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Mansikasta löydettiin *Philaenus spumarius* (L.) ja *Aphrophora alni* (Fall.) sekä mansikkamaissa olleista rikkakasveista *Neophilaenus lineatus* (L.) -kaskaiden toukkia. Kahden ensiksi mainitun ravintokasveiksi todettiin lähes yksinomaan kaksisirkkaisia ja viimeksi mainitun yksisirkkaisia kasveja. Vain *P. spumarius* -kaskaan todettiin olevan tuholaisen.

ANNALES AGRICULTURAE FENNIAE, VOL. 9: 293—295 (1970)

Seria PHYTOPATHOLOGIA N. 26 — Sarja KASVITAUDIT n:o 26

THE MICROFLORA OF CEREAL SEEDS IN FINLAND

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In Finland in rainy harvesting times, the gathering, handling, and storing of cereal yields meets with great difficulties, and in many cases great quantities of cereals decay. Lodging as well as germination in the ear on the field already greatly lower the quality of the yield and in these conditions many microorganisms regularly contribute to a detoriation of the situation. As a general rule, cereal that is unsuitable for seed or bread is used as fodder for domestic animals.

The Department of Plant Pathology has annually received from different sources mouldy cereal samples with requests to investigate their suitability for bread or for fodder. In some cases veterinarians have suspected that the illnesses in animals have been caused by decayed fodder. Knowledge on the microflora of cereal yields in this country is scanty. The main investigation has been carried out by RAINIO (1932) on scab in oats caused by *Fusarium roseum* Link (syn. *F. graminearum* Schwabe). As the microflora, especially some fungi, may affect the suitability for use of the yield, research on these problems has been included in the work of the Department of Plant Pathology since 1967.

To obtain a general picture of the diseases in our cereal yields, material of spring and winter cereals from different parts of the country was collected in the summers of 1966, 1967 and 1968 during the harvesting time. Samples were received from the Department of Plant Husbandry, Tikkurila, from agricultural experiment stations, from the State Granary and from the Work Efficiency Association. In addition, samples of cereals preserved fresh for fodder have been received from the Department of Animal Husbandry, Tikkurila, and from some agricultural experiment stations.

To examine the microflora in grains, the filter paper method was used: the grains were placed for two minutes in a 0.3 % solution of oxykinoline-sulphate and alcohol, whereafter they were washed with abundant sterilized water, 25 grains were placed in germination bowls with a diameter of 20 cm. On the bottom of the bowls there was a layer of filtration paper and cellulose saturated with sterilized water. The bowls were first kept in a cold chamber for three days at a temperature of 5—8°C, after this they were given UV-light and were then placed in the laboratory with a temperature of 18—20°C for 18 days. After the incubation period, the germination of the grains was counted and their microflora was preliminarily determined with the help of a stereomicroscope. For more accurate species determinations of the fungi, hyphal tip and conidia isolates were taken from the samples and placed on nutrient substance in petri dishes. As the nutrient medium in the isolation phase oat meal agar (pH 4.4—5.0) was used, and as the final maintenance PDA (Difco 0013—01).

Table 1. Microorganisms on cereal samples

	Yield samples					Samples of fodder cereals				
	Winter-wheat	Rye	Wheat	Barley	Total	Wheat	Rye	Barley	Oats	Total
No. of samples	237	130	533	261	1161	29	26	103	24	158
Acrospeira	38	32	35	42	147	0	1	5	1	7
Alternaria	227	122	521	261	1 131	26	18	53	27	124
Arthrobotrys	13	1	24	6	44	6	1	7	1	15
Aspergillus	12	5	16	10	43	1	0	13	3	17
Botryotrichum	1	0	42	11	54	7	12	13	11	43
Botrytis	47	29	75	10	161	1	3	13	2	19
Cephalosporium	35	37	78	75	225	8	8	27	11	54
Chaetomium	4	5	11	9	29	1	0	16	3	20
Cladosporium	241	164	441	245	1 091	40	32	60	36	168
Colletotrichum	1	0	31	17	49	0	0	9	1	10
Epicoccum	110	66	184	112	472	12	6	14	16	48
Fusarium	142	141	603	372	1 258	48	30	134	28	240
Gliocladium	3	7	6	9	25	5	1	38	0	44
Gonatobotrys	10	8	31	1	50	0	0	0	0	0
Helminthosporium	3	1	12	20	36	1	0	7	0	8
Mucor	13	32	53	28	126	10	8	63	3	89
Papularia	13	4	69	16	102	3	3	26	0	32
Papulaspora	2	2	44	7	55	4	3	4	2	13
Penicillium	195	103	372	167	837	26	21	88	13	148
Rhizopus	19	15	22	40	96	17	7	54	5	83
Septoria	0	0	18	8	26	0	0	0	0	0
Stemphylium	66	47	137	50	300	5	3	15	7	30
Trichoderma	4	5	5	5	17	3	1	24	2	30
Trichothecium	12	12	69	7	100	7	4	6	3	20
Other fungi	16	20	181	167	384	36	22	85	25	168
Bacteria	80	38	274	177	569	24	25	89	20	158
	1 307	896	3 354	1 870	7 423	291	209	863	220	1 583

In the determination of the fungi the classification of AINSWORTH (1961) has been followed. The *Fusarium* fungi have been determined according to GORDON (1960).

The diseases of a total of 1319 yield and fodder samples were studied, and in these 9006 fungi were determined by species or at least by genera. The microflora found in the cereal samples is almost the same as the microflora established in similar investigations abroad (MALONE and MUSKETT 1964). In yield and in the fodder samples (Table 1) there is reason to note the abundance of *Fusarium* fungi. The most common *Fusarium* species were *F. culmorum* (W.G.Sm.) Sacc., *F. avenaceum* (Fr.) Sacc., *F. poae* (Pk.) Wr., *F. arthrosporioides* Sherb., and *F. oxysporum* Schl. emend. Sn. & H.

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SELOSTUS

Viljasatomme pieneliöstö

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Yleiskuvan saamiseksi viljastomme pieneliöstöstä on vuosina 1966, 1967 ja 1968 kerätty koko korjuukauden aikana yhteensä 1 161 satonäytettä syys- ja kevätviljoista eri tahoilta maata. Niistä on tehty 7 423 pieneliömääritystä. Lisäksi on tutkittu 158 rehuviljanäytettä ja tehty niistä 1 583 pieneliömääritystä. Kaikissa näytteissä on runsaimmin ollut *Alternaria*, *Cladosporium*, *Fusarium* ja *Penicillium* -sukujen sieniä (taul. 1). Tavallisimmat *Fusarium*-lajit ovat näytteissä olleet *F. culmorum*, *F. avenaceum*, *F. poae*, *F. arthosporioides* ja *F. oxysporum*.

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Seria PHYTOPATHOLOGA N. 27 — Sarja KASVITAUDIT n:o 27

SOKERIJUURIKKAAN TAIMIPOLTE JA SEN TORJUNTA SUOMESSA

Zusammenfassung: **Wurzelbrand bei Zuckerrübe und seine Bekämpfung in Finnland**

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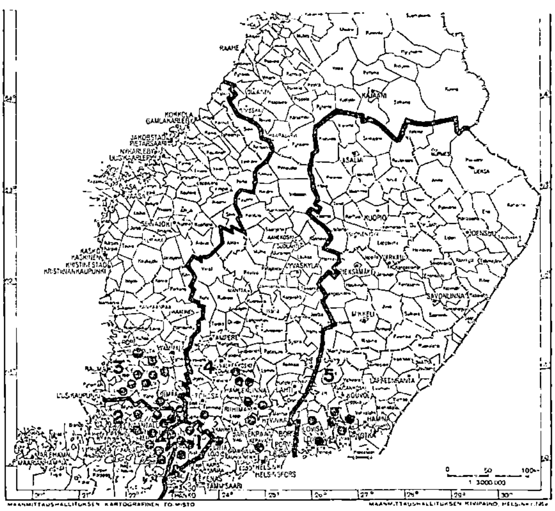
Suomi on pohjoisimpia alueita, missä sokerijuurikasta viljellään. Jotta maassamme, jossa kasvukausi on lyhyt, saataisiin mahdollisimman suuri juurikassato, on kylvö suoritettava aikaisin keväällä. Se tehdään yleensä huhti-toukokuussa heti kun pellot ovat muokkauskunnossa ja lämpötila riittävä kasvun alkamiselle (BRUMMER 1961). Lämpötilat ovat tällöin yleensä varsin alhaisia, tutkimusalueella keskimäärin 4.5—10.5 C° [1]) ja maan kosteus on usein suuri (BRUMMER 1960). Näissä olosuhteissa on sienien aiheuttamilla taimitaudeilla erinomaiset saastutusmahdollisuudet, ja niinpä taimipoltetta (Wurzelbrand, damping-off) onkin todettu esiintyvän yleisesti sokerijuurikasviljelyksillämme. Kasvitautien tutkimuslaitoksella suoritettiin 1950-luvun alkupuolella tutkimus taudin aiheuttajista sokerijuurikkaan viljelyalueella Etelä- ja Keski-Suomessa. Rinnan näiden tutkimusten kanssa on selvitetty sokerijuurikkaan taimipoltteen torjuntamahdollisuuksia peittauskokein v. 1954—69.

Aineisto ja menetelmät

Aineisto taimipoltteen aiheuttajien selvittämiseksi kerättiin v. 1953—55 maamme viiden sokeritehtaan, Salon Sokeritehdas Oy:n, Salo, Oy Juurikassokeri—Betsocker Ab:n, Naantali, Lännen Sokeri Oy:n, Säkylä, Turengin Sokeritehdas Oy:n, Turenki, ja Itä-Suomen Raakasokeritehdas Oy:n, Kotka, sopimusviljelyksiltä ja koetiloilta, yhteensä 154 viljelmältä 39 pitäjän alueella (kuva 1). Matkat tehtiin touko-kesäkuussa.



Kuva 1. Tutkimusalueet

Pitäjät, joista tutkimusaineisto kerättiin (merkitty mustalla pyörylällä) sekä sokeritehtaiden viljelyalueet: 1 = Salon Sokeritehdas, 2 = Juurikassokeri, 3 = Lännen Sokeri, 4 = Turengin Sokeritehdas, 5 = Itä-Suomen Raakasokeritehdas.

Abbildung 1. Untersuchungsgebiete

Die Gemeinden (durch einen schwarzen Punkt bezeichnet), in denen das Forschungsmaterial gesammelt wurde, und die Anbaugebiete der Rübenzuckerfabriken: 1 = Salon Sokeritehdas, 2 = Juurikassokeri, 3 = Lännen Sokeri, 4 = Turengin Sokeritehdas, 5 = Itä-Suomen Raakasokeritehdas.

[1]) Vuorokautiset keskilämpötilat 20. 4.—31. 5. vuosina 1931—60 Ilmatieteen laitoksen antamien tietojen mukaan.

Maanäytteitä otettiin 168:lta peltolohkolta ja niistä määritettiin maan reaktio elektrometrisesti. Taiminäytteitä otettiin 184:ltä peltolohkolta (näytteen suuruus 10—20 tainta). Taimista eristettiin taudinaiheuttajat menetelmällä, joka on kuvattu aikaisemmin (Linnasalmi 1952). Eristyksiä tehtiin yhteensä 240 sekä määritettiin taudinaiheuttajasieni. Sienilajien tyyppi-isolaateilla suoritettiin infektiokokeet sienien primaarisen patogeenisuuden varmentamiseksi. Käytettiin Halpinin ym. (1952) lasi-hiekka-menetelmään perustuvaa tekniikkaa (Ylimäki 1967) muunnettuna sokerijuurikastesteihin sopivaksi. Tarkastettu, mahdollisimman terve siemen (Hilleshögin diploidi- tai 1-itusiementä) puhdistettiin merkurikloridilla (0.1 %) ja tislatulla vedellä sekä idätettiin petrimaljoissa steriloidulla hiekka-alustalla. Kasvuhiekka saastutettiin kylvön yhteydessä sienisuspensiolla.

Peittauskokeet suoritettiin pääasiassa astiakokeina kasvihuoneessa höyrytetyssä mullassa (pH 6.5—7.0). Koesiemenet olivat Hilleshögin lajikkeita, joko diploidi- tai polyploidisiementä. Pyrittiin käyttämään voimakkaasti *Phoma betae*n saastuttamaa siementä, mutta suoritettujen sienianalyysien mukaan (herneenlehtivesiagarilla petrimaljoissa) oli eri vuosien koe-erissä aste-eroja saastunnan voimakkuudessa. Siemenmäärä koejäsenessä oli 125—200 siementä 2—5 kerranteena, koeaika 4—7 viikkoa. — Kahtena vuotena (1957—58) suoritettiin kenttäkokeet kaikkien sokeritehtaiden koekentillä. Salon, Naantalin mlk:n, Maarian ja Elimäen koekentät olivat savimaita, Janakkalan ja Köyliön hietamaita. Käytettiin *Phoma betae*n saastuttamaa Hilleshögin diploidisiementä, ruutukoko oli 30 m² ja kerranteita 6. Taimipolteanalyysit suoritettiin joka toisesta kerranteesta pientaimiasteella 3—6 viikkoa kylvöstä ennen harventamista. Sokerijuurikkaanviljelyn Tutkimuskeskus teki kokeista juuri- ja naattisatoanalyysit sekä sokerimääritykset. Koetulosten luotettavuus todettiin varianssianalyyseillä.

Peittauskokeissa tutkittiin v. 1954—69 yhteensä 46 peittausvalmisteen teho. Tulokset esitetään v. 1957—58 kenttäkokeissa olleesta kahdesta valmisteesta sekä 17:stä vuosien 1965—69 kasvihuonekokeissa parhaaksi osoittautuneesta valmisteesta:

VALMISTE	TEHOAINE	VALMISTAJA
Elohopeavalmisteet:		
Ceresan-neste 5965	metoksietylmerkuriasetaatti 1.90 %	Farbenfabriken Bayer AG, Saksa
Panogen M	metoksietylmerkuriasetaatti 1.24 %	Aktiebolaget Casco, Ruotsi
Panogen M 12	metoksietylmerkuriasetaatti 1.91 %	»
Täyssato-neste	metoksietylmerkuriasetaatti 1.90 %	Rikkihappo Oy, Suomi
Panogen [1]	metylmerkuridisyandiamidi 1.20 %	Aktiebolaget Casco, Ruotsi
Ceresan nestepeittausaine 4992 [1]	bismetylmerkurisulfaatti 1.00 %	Farbenfabriken Bayer AG, Saksa
Ceresan peittausneste 5938	metoksietylmerkurikloridi 2.10 %	»
Tillex Pulver	etoksietylmerkurihydroksidi 2.30 %	Farmos Oy, Suomi
Tiraamivalmisteet:		
Betoxin 50	tiraami 51 %	Ab Plantex, Ruotsi
Duphar TMTD-juurikkaan peittausaine	» 50 %	N.V. Philips-Roxane, Hollanti
Pomarsol Forte	» 80 %	Farbenfabriken Bayer AG, Saksa
Tirama 50	» 50 %	Fabriek van Chemische Producten
Tripomol 50	» 50 %	Vondelingenplaat N.V., Hollanti
Tripomol 80	» 80 %	»
Ceredon T	» 45 %	»
	benkinoksi 5 %	Farbenfabriken Bayer AG, Saksa
Tiokarbamaattivalmisteet:		
Dithane M-45	mankozebi 80 %	Rohm and Haas Co., USA
Triaram	etylenbistiokarbamyl-bis (dimetyltiokarbamylsulfidi) 50 %	Fabriek van Chemische Producten Vondelingenplaat N.V., Hollanti
Trimangol	manebi 80 %	»

[1] Valmisteen myynti kielletty Suomessa 1. 1. 1969 alkaen

Tulokset ja niiden tarkastelu

Taimipoltteen aiheuttajat

Yleisin taimipoltteen aiheuttaja oli *Phoma betae* (Oud.) Fr. (= *Pleospora betae* Björling). *Fusarium*-sienet muodostivat toiseksi suurimman ryhmän, lajeista yleisimpiä olivat *F. culmorum* (W.G.Sm.) Sacc., *F. oxysporum* Schl., ja aineistosta eristettiin lisäksi *F. sambucinum* Fuck. sekä *F. scirpi* Lamb. et Fautr. *Pythium debaryanum* Hesse sijoittui kolmannelle sijalle ja muutamista näytteistä eristettiin *Rhizoctonia solani* Kühn (taul. 1).

Taulukko 1. Sokerijuurikkaan taimipoltesienet
Tabelle 1. Wurzelbrandpilze der Zuckerrübe

Vuosi *Jahr*	Peltolohkojen määrä *Anzahl d. Ackerschläge*	Sieniеristysten määrä *Anzahl d. Pilzisolierungen*	*Phoma betae* määrä *Anzahl*	%	*Pythium debaryanum* määrä *Anzahl*	%	*Fusarium spp.* määrä *Anzahl*	%	*Rhizoctonia solani* määrä *Anzahl*	%
1953	88	116	48	41	22	19	46	40	0	0
1954	80	77	42	54	10	13	20	26	5	7
1955	16	47	23	49	7	15	17	36	0	0
Yhteensä — *Insgesamt*	184	240	113		39		83		5	
Keskim.% —*Durchschnittl.*%				47.1		16.2		34.6		2.1

*P. betae*n yleisyys on varsin luonnollista, koska sieni on siemenlevintäinen ja säilyy myöskin maassa. Vuosina 1960—61 suoritetuissa kauppasiemenen tarkastuksissa todettiin kaikki tutkitut erät enemmän tai vähemmän tämän sienen saastuttamiksi. Vaikeuksia tuotti myös saada infektiokokeisiin *Phoma*-vapaata siementä. Sokerijuurikkaanviljelyn Tutkimuskeskuksen välityksellä saaduista siemenistä olivat puhtaimpia Italiassa siemenviljellyt erät (vrt. WIESNER 1965). Kun peittauksen teho ei ole läheskään 100-prosenttinen nimenomaan *Phoma*n suhteen (vrt. peittauskoetulokset), tulee tämä sokerijuurikkaalle voimakkaasti patogeeninen sieni olemaan sokerijuurikasviljelysten jatkuvana haittana. *Fusarium*-lajit, jotka olivat sokerijuurikkaalla heikompia patogeeneja kuin *P. betae*, saattavat levitä siemenen mukana ja ovat peltomaissamme ilmeisesti yleisiä maasieniä aiheuttaen taimipoltetta mm. ristikukkaisilla (LINNASALMI 1952) ja apilalla (YLIMÄKI 1967). *P. debaryanum* oli *Fusarium*-sieniä voimakkaampi patogeeni sokerijuurikkaalla.

Sokerijuurikkaan vanhinta viljelyaluetta Suomessa ovat maan lounaisosat, nuorinta Pohjanmaa sekä Keski- ja Itä-Suomi. Tunnusomaista nimenomaan suomalaiselle viljelytekniikalle on sokerijuurikkaan viljely vuosikausia samoilla peltolohkoilla (BRUMMER 1965). Vielä vuosien 1953—55 aineiston keräyksen yhteydessä tavattiin Lounais-Suomessa kymmenittäin viljelmiä, joilla sokerijuurikasta oli viljelty yli 10 vuotta yhtäjaksoisesti samoilla kasvupaikoilla. Tarkoituksena oli pitää juurikas sijainniltaan sopivimmilla ja vuosien mittaan viljavuusarvoiltaan parantuneilla peltolohkoilla. Koska tutkimuksessa oli mukana myös uusia, hiljattain juurikkaan viljelyn aloittaneita tiloja, oli aineistossa yllättävän paljon viljelyksiä, joissa maan reaktio oli perin matala; lähes 40 %:ssa tutkituista lohkoista oli pH 4.0—5.9 välillä (taul. 2). Tässä tutkimuksessa ei selvitetty systemaattisesti taimipoltteen yleisyyttä eri viljelyalueilla, vaan keskityttiin nimenomaan taimipoltteisten viljelysten tutkimiseen. Koska maan happamuus haittaa sokerijuurikkaan viihtyvyyttä (vrt. BRUMMER 1961), oli luonnollista, että tutkimuksen piiriin joutui runsaasti juuri tällaisia heikkokuntoisia

Taulukko 2. Sokerijuurikasviljelysten peltolohkojen pH v. 1953—54
Tabelle 2. pH-Wert der Ackerschläge der Zuckerrübenfelder 1953/54

pH	Maanäytteet *Bodenproben* Määrä *Anzahl*	%
4.0—4.9	9	5.4
5.0—5.9	56	33.3
6.0—6.9	78	46.4
7.0—7.9	25	14.9

viljelyksiä, joilla sekä siemenessä kulkeutuvat että maassa elävät taimipoltesienet pystyvät helposti saastuttamaan taimistoa. Tutkimuksen mukaan esiintyi *Phoma*, *Pythium* ja *Fusarium* -sienien aiheuttamaa taimipoltetta melko tasaisesti eri viljelyalueilla, ja myöskin eri peltolohkoilta löydettiin yleensä kaikkia mainittuja sieniä. *Rhizoctonia solani* -esiintymät olivat Lännen Sokerin, Turengin sokeritehtaan sekä Itä-Suomen Raakasokeritehtaan lähiympäristöstä. Suoranaista riippuvuutta sienilajiston ja maan happamuuden välillä ei tämän aineiston nojalla todettu. McKAYn (1952) mukaan on *Pythium*-taimipolte erityisen yleistä happamissa maissa. GATES ja HULL (1954) taasen totesivat tutkimuksessaan, että *Fusarium*-sienet olivat happamien maiden taimipoltesieniä.

Havaintojen mukaan vaikuttivat kevään sääolot taimipoltteen yleisyyteen siten, että kylmät, sateiset kaudet kylvöaikaan edistivät taimipoltteen esiintymistä. Todettiin, että epäedullisina vuosina oli uusillakin viljelyalueilla Länsi- ja Keski-Suomessa tapauksia, joissa taimipolte esiintyi yhtä tuhoisana kuin vuosikausia sokerijuurikkaalla olleissa pelloissa Lounais-Suomen vanhoilla viljelyalueilla.

Ilmaston ja sääsuhteiden suuri merkitys taimipoltteen esiintymiseen on yleisesti tunnettu kaikkialla sokerijuurikkaan viljelyalueilla. Mainintoja alhaisten lämpötilojen ja maan suuren kosteuden taimipoltetta lisäävästä vaikutuksesta on lähes jokaisessa tätä tautia käsittelevässä tutkimuksessa. Alhaiset lämpötilat edistävät erityisesti *Phoma*-taimipoltetta, maan suuri kosteus *Pythium*-taimipoltetta (GATES ja HULL 1954, NÖLLE 1960).

Taimipoltesienilajisto Ruotsissa, Tanskassa ja Englannissa on pääosin samanlainen kuin Suomessa. *P. betae* ja *Pythium* -lajit ovat ankarimpien taimipoltetuhojen aiheuttajia, mutta myöskin *Fusarium*-sienet mainitaan yleisinä, joskin heikkoina patogeeneina sokerijuurikkaassa, *R. solani* on harvinainen (BJÖRLING 1945, MÖLLERSTRÖM ja KLINTEBERG 1964, RASMUSSEN 1967, GATES ja HULL 1954). Irlannissa ja Saksassa ovat lisäksi *Aphanomyces*-lajit vahingollisia taimipoltesieniä (McKAY 1952, NÖLLE 1960, WIESNER 1965).

Myöskin USA:ssa ja Kanadassa ovat tärkeimmät taimipoltteen aiheuttajat samat: *P. betae*, *Pythium*-lajit sekä *Aphanomyces*-suvusta erityisesti *A. cochlioides* Drechs. Huomattava ero on vain siinä, että *R. solani*, jolla ei Suomessa eikä muissakaan Euroopan maissa ole sanottavaa merkitystä sokerijuurikkaalla, on Pohjois-Amerikan juurikasviljelyksillä yleinen ja vahingollinen (COONS ym. 1946, McKEEN 1949). Meillä monissa muissa kasvilajeissa, mm. perunassa, tauteja aiheuttavat *Rhizoctonia*-rodut eivät näytä olevan patogeenisia sokerijuurikkaalle (vrt. LIN-

Taulukko 3. Sokerijuurikkaan peittauskokeet v. 1965—69 (kasvihuonekokeet)
Tabelle 3. Beizversuche bei Zuckerrüben 1965/69 (Gewächshausversuche)

Valmiste *Mittel*	Käyttömäärä g, ml/kg *Aufwandmengen g, ml/kg*	Terveet taimet [1]) suhdeluku *Gesunde Pflanzen [1]) Verhältniszahl*	Kokeiden lukumäärä *Anzahl der Versuche*
Elohopeavalmisteet — *Quecksilberpräparate*			
Ceresan-neste — *Ceresan-Feuchtbeize 5965*	6	473	2
Panogen M	6	382	1
Panogen M 12	6	418	3
Täyssato-neste — *Täyssato-Feuchtbeize*	6	326	1
Panogen	6	390	2
Ceresan nestepeittausaine *Ceresan Feuchtbeize 4992*	6	335	1
Ceresan peittausneste — *Ceresan Feuchtbeize 5938*	6	672	2
Tillex pulver — *Tillex Pulver*	6	576	2
Keskiarvo — *Mittelwert*		447	
Tiraamivalmisteet — *Thirampräparate*			
Betoxin 50	7	746	1
Pomarsol forte	5	409	1
Tirama 50	5	623	1
»	7.5	409	1
Tripomol 50	7	346	1
Tripomol 80	5	493	2
Ceredon T	6	374	2
Keskiarvo — *Mittelwert*		486	
Tiokarbamaattivalmisteet — *Thiocarbamatpräparate*			
Dithane M-45	6	326	1
Triaram	5	330	1
Trimangol 80	1.5	323	2
Keskiarvo — *Mittelwert*		326	

[1]) Peittaamattoman kontrollin suhdeluku = 100
[1]) *Verhältniszahl der ungebeizten Kontrolle = 100*

NASALMI 1952, MUKULA 1957, YLIMÄKI 1967). LE CLERGIN (1934, 1939) mukaan eivät myöskään USA:ssa perunan *R. solani* -rodut yleensä saastuta sokerijuurikasta.

Peittauskokeet

Peittauskokeissa, jotka suoritettiin astiakokeina kasvihuoneessa, keskityttiin tutkimaan siemenlevintäisen *P. betae*n torjuntamahdollisuuksia. Tärkeimmät peittausaineet olivat tiraami- ja elohopeavalmisteita, lisäksi muutama tiokarbamaattivalmiste (vrt. s. 297). Taulukossa 3 esitetyt suhdeluvut on laskettu terveiden taimien määrästä kokeen lopussa. Huolimatta koesiemenen saastuneisuuden eroista, mikä tekijä ensisijaisesti aiheuttaa vaihtelua suhdeluvuissa, ovat tulokset siinä määrin yhtenäiset, että ne antavat yleiskuvan peittauksen mahdollisuuksista *Phoma*-taimipoltteen torjunnassa. Peittauksella ei ainoassakaan tapauksessa saavutettu 100-%:sta tulosta, mutta tiraami- ja elohopeavalmisteilla peitattaessa nousi terveiden taimien määrä keskimäärin 4—5 -kertaiseksi kontrolliin verrattuna. Tiokarbamaattien teho oli heikompi, terveet taimimäärät noin kolminkertaiset. Suoritettujen varianssianalyysien mukaan erot olivat kaikissa kokeissa erittäin merkitseviä ($P < 0.001$).

Mainittakoon, että vertailevissa kokeissa rikotulla ja normaalilla diploidi- ja polyploidisiemenellä sekä perinnöllisesti 1-ituisella siemenellä ei voitu todeta selviä eroja peittauksen tehossa. Viitteitä saatiin siitä, että 1-itusiemen saattaa vioittua elohopeapeittauksesta, kun sitä vastoin tiraamivalmisteet eivät aiheuta vahinkoa (julkaisematon tulos).

Kenttäkokeisiin valittiin erityisesti taimipoltteen vaivaamia viljelmiä eri sokeritehtaiden viljelyalueilta. Jokaisen koekentän taimipoltesienilajisto analysoitiin pistokokein määrittämällä kustakin koejäsenestä 15—30:n taimipoltteisen taimen taudinaiheuttaja. Valtasieni oli kaikissa kokeissa *P. betae* (55—100 %), *P. debaryanum*in osuus oli 5—35 % ja *Fusarium*-sienien 5—25 %. *R. solani* tavattiin ainoastaan yhdessä kokeessa muutamassa taimessa (Elimäki 1957). Jakautuma oli siis saman suuntainen kuin sienien esiintyminen yleensä sokerijuurikasviljelyksillä (vrt. taul. 1).

Tulokset näistä kokeista esitetään terveiden taimien suhdelukuina, mikä ilmaisee välillisesti sekä itu- että jälkitaimipoltteen määrän; lisäksi on taulukkoon merkitty jälkitaimipoltteen prosenttinen osuus tuhosta (taul. 4). Vaihtelu eri kokeissa molempina koevuosina oli melko suuri, mutta silti voidaan todeta, että peittaus sekä tiraami- että elohopeavalmisteilla vähensi taimipoltetta jokaisessa kokeessa erittäin merkitsevästi ($P < 0.001$). Keskimäärin jäi valmisteiden teho näissä kokeissa, joissa oli kyseessä sekä siemen- että maasaastunnan estäminen, heikommaksi kuin edellä selostetuissa astiakokeissa siemensaastunnan torjumiseksi. Terveiden taimien määrät olivat keskimäärin 2—3 -kertaiset kontrolliin verrattuina. Tiraami- ja elohopeavalmisteet olivat suunnilleen samanveroiset, niiden tehoero ei ollut merkitsevä ($P > 0.05$).

Satotuloksiin ei peittaus vaikuttanut juuri lainkaan. Pienet erot juurisadoissa (taul. 4) sekä vähäiset vaihtelut peittauskoejäsenten naattisadossa ja juurikkaiden sokeripitoisuudessa eivät olleet merkitseviä (Sokerijuurikkaanviljelyn Tutkimuskeskuksen Tietokortisto 1965, V-B-1, koemonisteet 1957, 1958). Tämä on täysin luonnollista, koska eri koejäsenten kasvustoissa tavanomaisen valikoivan harvennuksen jälkeen oli normaali määrä terveitä taimia. Orgaaniset elohopeavalmisteet ja tiraamivalmisteet ovat myös ulkomaisten kokeiden mukaan parhaita peittausaineita *Phoma* ja *Pythium* -taimipoltteen torjunnassa (GATES ja HULL 1954, NÖLLE 1960, AMANN 1961, LÜDECKE ja WINNER 1963, MÖLLERSTRÖM ja KLINTEBERG 1964, RASMUSSEN 1967). Tiraamipeittaus on joissakin kokeissa ollut hieman elohopeapeittausta tehokkaampi (LÜDECKE ja WINNER 1963, RASMUSSEN 1967). Poikkeavia ovat DARPOUX'n ym. (1966) tulokset, joiden mukaan manebi- ja mankozebivalmisteet olivat elohopea- ja tiraamivalmisteita tehokkaampia *Phoma* ja *Pythium* -taimipoltteen torjunnassa.

Suomessa sokeritehtaat toimittavat siemenen sopimusviljelyksilleen peitattuna, v:een 1969 mennessä neljä tehdasta on käyttänyt peittausteknillisistä syistä elohopeavalmisteita, yksi v:sta 1966 osittain tiraamivalmisteita. Tämä menettely on taannut jonkinlaisen suojan taimipoltetta vas-

Taulukko 4. Sokerijuurikkaan peittauskokeet v. 1957—58 (kenttäkokeet)

Tabelle 4. Beizversuche bei Zuckerrüben 1957/58 (Feldversuche)

Koepaikka- ja -aika *Versuchsort und -zeit*	Peittaamaton, kontrolli *Ungebeizt, Kontrolle*				Panogen 6 ml/kg *Panogen 6 ml/kg*				Duphar TMTD juur.peitt.aine 7 g/kg *Duphar Rübenbeizmittel 7 g/kg*			
	Taimien määrä *Pflanzenzahl*	Terveet taimet, suhdeluku *Gesunde Pflanzen, Verhältniszahl*	Jälkitaimipolte % *Kranke Pflanzen %*	Juurisato tn/ha *Rübenertrag to/ha*	Taimien määrä *Pflanzenzahl*	Terveet taimet, suhdeluku *Gesunde Pflanzen, Verhältniszahl*	Jälkitaimipolte % *Kranke Pflanzen %*	Juurisato-poikkeama[1]) tn/ha *Rübenertrag Abweichung[1]) to/ha*	Taimien määrä *Pflanzenzahl*	Terveet taimet, suhdeluku *Gesunde Pflanzen, Verhältniszahl*	Jälkitaimipolte % *Kranke Pflanzen %*	Juurisato poikkeama[1]) tn/ha *Rübenertrag Abweichung[1]) to/ha*
Salo [2]) 1957	111	100	68	28.0	238	444	33	+0.4	255	447	37	+3.6
1958	269	100	30	28.3	348	132	29	+0.4	306	102	27	+0.8
Keskiarvo— *Mittelwert*	190	100	49	28.2	293	288	31	+0.4	281	275	32	+2.2
Naantali, mlk [3]) — *Landgem.* 1957	117	100	58	34.6	280	467	18	+0.4	263	347	35	+0.6
Maaria [3]) 1958	210	100	29	26.9	301	176	13	+0.1	286	176	8	—0.9
Keskiarvo — *Mittelwert*	164	100	44	30.8	291	322	16	+0.25	275	262	22	—0.15
Köyliö [4]) 1957	109	100	62	24.2	173	183	57	+0.1	233	283	53	0.0
1958	208	100	68	—	382	442	24	—	410	406	35	—
Keskiarvo — *Mittelwert*	159	100	65	(24.2)	278	313	41	(+0.1)	322	345	44	(0.0)
Janakkala [5]) 1957	114	100	81	14.4	212	205	79	+1.1	221	514	49	+0.7
1958	144	100	58	20.8	245	255	38	—0.4	236	260	34	+0.1
Keskiarvo — *Mittelwert*	129	100	70	17.6	229	230	59	+0.35	229	387	42	+0.4
Elimäki [6]) 1957	165	100	67	25.4	215	263	34	+0.7	220	248	39	—0.2
1958	138	100	30	21.2	143	136	8	—2.5	139	129	11	—2.3
Keskiarvo — *Mittelwert*	152	100	49	23.3	179	200	21	—0.9	180	189	25	—1.25
V. 1957 kokeet, keskiarvo *Versuche 1957, Mittelwert*	123	100	67	25.3	224	312	44	+0.5	238	368	43	+0.9
V. 1958 kokeet, keskiarvo *Versuche 1958, Mittelwert*	194	100	43	24.3	284	228	22	—0.6	275	215	23	—0.6
V. 1957—58 kokeet, keskiarvo — *Versuche 1957—58, Mittelwert*	159	100	55	24.8	254	270	33	—0.05	257	292	33	+0.15

[1]) Poikkeama kontrollin sadosta — *Abweichung vom Ertrag der Kontrolle.* [2]) Salon Sokeritehdas. [3]) Juurikassokeri. [4]) Lännen Sokeri. [5]) Turengin Sokeritehdas. [6]) Itä-Suomen Raakasokeritehdas.

taan, mutta huomioon ottaen taimipoltesaastunnan yleisyyden sekä siemenessä että maassa ja nykyisten peittausaineiden epätäydellisen tehon taimipoltesienien tuhoamisessa ei pelkällä siemenen peittauksella päästä taimipoltteisista kasvustoista. Harvan kylvön yleistyessä saattavat taimipoltevahingot tulla yhä suuremmiksi, kun ei harvennusvaiheessa ole runsasta taimistoa, johon tautisten taimien poiston jälkeenkin jää yleensä riittävästi terveitä taimia. Ainoa todella tehokas kemiallinen torjuntatapa tullee olemaan yhdistetty peittaus- ja kylvövaon käsittely fungisideilla. Tätä menetelmää on viime vuosina ryhdytty kokeilemaan mm. Hollannissa, ja alustavia kokeita on suoritettu myös Kasvitautien tutkimuslaitoksella. Menetelmä vaatii perusteellista kokeilua ja ennen kaikkea tarkoituksenmukaisten yhdistettyjen kylvö-fungisidikäsittelykoneiden suunnittelua ja tuotantoa, ennen kuin sitä voidaan menestyksellisesti soveltaa käytäntöön.

Tutkimuksen aikana on Sokerijuurikkaanviljelyn Tutkimuskeskus antanut monin tavoin auliisti apuaan. Tästä kiitokset erityisesti Tutkimuskeskuksen johtajalle prof. Veikko B r u m m e r i l l e sekä juurikassokeritehtaiden tutkimusagronomeille. Samoin esitän parhaat kiitokset tutkimusassistentilleni, agronomi Anneli T o i v i a i s e l l e. Valtion luonnontieteellinen toimikunta myönsi tutkimusta varten apurahan v. 1954.

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ZUSAMMENFASSUNG

Wurzelbrand bei Zuckerrübe und seine Bekämpfung in Finnland

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Untersuchungen über die Erreger von Wurzelbrand bei der Zuckerrübe (*Beta vulgaris* L. v. *saccharifera* Lge) in Finnland und die Bekämpfung dieser Pflanzenkrankheit durch Beizung sind in der Landwirtschaftlichen Forschungszentrale, ihrer Abteilung für Pflanzenkrankheiten in den Jahren 1953—69 ausgeführt worden. Das material zur Klarlegung des Artenbestandes der pathogenen Pilze, der Erreger des Wurzelbrandes, wurde auf den kontraktmässigen Anbaufeldern und den Versuchsgütern der fünf finnischen Rübenzuckerfabriken in Süd- und Mittel-Finnland, insgesamt in 39 Gemeinden, gesammelt (Karte, Abb. 1). Die Pflanzenproben wurden auf 184 Ackerschlägen entnommen (Grösse der Probe 10—20 an Wurzelbrand erkrankte Pflanzen), an Pilzisolierungen insgesamt 240 durchgeführt. An Bodenproben wurden 168 entnommen und ihr pH-Wert elektrometrisch bestimmt. Die Beizversuche gelangten als Gefässversuche in den Gewächshäusern der Abteilung für Pflanzen-

krankheiten sowie als Feldversuche auf den Versuchsfeldern der Zuckerfabriken zur Ausführung. Bei den Versuchen in den Jahren 1954—69 wurden insgesamt 46 Präparate angewandt. Es werden die Ergebnisse, die mit den 1965—69 bei den Gefässversuchen als die besten erkannten Präparaten (17) erzielt worden sind, sowie diejenigen Ergebnisse angeführt, die sich bei den 1957—58 den Feldversuchen benutzten Präparaten herausgestellt haben. Für alle Versuche ist eine Varianzanalyse ausgeführt worden.

Der häufigste und schädlichste Wurzelbrandpilz war *Phoma betae* (Oud.) Fr. (*Pleospora betae* Björling), 47.1 %, der Anteil von *Pythium debaryanum* Hesse betrug 16.2 %, derjenige der *Fusarium*-Pilze 34.6 %; die Arten *F. culmorum* (W.G.Sm.) Sacc., *F. oxysporum* Schl., *F. sambucinum* Fuck. und *F. scirpi* Lamb. et. Fautr. wurden im Versuchsmaterial bestimmt. *Rhizoctonia solani* Kühn war selten, 2.1 % (Tabelle 1). Die primäre Pathogenität dieser Pilzarten wurde durch Infektionsversuche gesichert. Bei den untersuchten Ackerschlägen war der Boden zu 40 % recht sauer, pH 4.0—5.9 (Tabelle 2). Ein unmittelbarer Zusammenhang zwischen der Bodenreaktion und dem Artenbestand an pathogenen Pilzen liess sich nicht feststellen.

Bei den Beizversuchen, die im Gewächshaus als Gefässversuche in gedämpfter Erde vor sich gingen, wurde mit *P. betae* natürlich verseuchter Hilleshög-Diploid- oder Polyploidsamen verwendet. Je nach dem verschieden starken Verseuchungsgrad der Saatgutpartien kamen bei den Versuchen Schwankungen im Effektivitätsgrad auch einer und derselben Präparate vor, aber in jedem Fall erhöhte die Beizung mit den bei den Versuchen angewandten Präparaten (Verzeichnis auf Seite 297) die Anzahl der gesunden Pflanzen, im Durchschnitt 3—5mal im Vergleich zu den ungebeizten Kontrollen. Die Wirkung der Thiram- und Quecksilberpräparate war ungefähr die gleiche, die Anzahl der gesunden Pflanzen im Durchschnitt 4—5fach. Die Thiokarbamatpräparate hatten eine schwächere Wirkung, die Anzahl der gesunden Pflanzen war etwa 3fach (Tabelle 3). Die Ergebnisse der Versuche erwiesen sich als sehr hochsignifikant ($P < 0.001$).

Bei den Feldversuchen, bei denen, ausser dem verseuchten *P. betae* -Saatgut, der Boden auch mit anderen Wurzelbrandpilzen verseucht war, kam die Wirkung der Beizung im Jungpflanzenstadium signifikant ($P < 0.001$) zum Vorschein. Auch bei diesen Versuchen war die Wirkung der Thiram- und Quecksilberpräparate ungefähr die gleiche, sie war aber geringer als bei den Gefässversuchen. Die Anzahl der Jungpflanzen vor dem Verziehen war, verglichen mit der Kontrolle, etwa 2—3 -fach (Tabelle 4). Die Differenz in der Effektivität war nicht signifikant ($P > 0.05$). — Die Beizung hatte keinen nennenswerten Einfluss auf die Erträge, was begreiflich ist, da man bei den Versuchen das übliche Verziehen ausführte, wobei es möglich war, aus der grossen Anzahl der vorhandenen Pflanzen die gesunden für das Weiterwachsen auszuwählen. Die Verhäufigung der Dünnsaat in Finnland samt der aus ihr sich ergebenden Verringerung des Pflanzenbestandes wird die Bedeutung der Massnahmen steigern, die der Bekämpfung des Wurzelbrandes gelten.

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RESISTANCE OF PLANTS TO THE PEA APHID ACYRTHOSIPHON PISUM HARRIS (HOM., APHIDIDAE)

II. Fecundity on different red clover varieties

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The fecundity of the pea aphid *Acyrthosiphon pisum* varies greatly on different plants, and considerable differences in fecundity have also been found between different varieties of the same plant (e.g. HARRINGTON 1941, 1943, CARTIER 1959, MARKKULA 1963, MARKKULA and ROUKKA 1970). JEWETT (1941) found slight differences in resistance between red clover varieties. WILCOXON and PETERSON (1960), by measuring pea aphid reproduction, etc., showed that the Dollard variety of red clover was more resistant than the Wegener variety. According to them, this resistance to aphids appeared to explain the much lower incidence of mosaic and pea stunt viruses in the Dollard than in the Wegener variety. Red clover varieties have also been found to differ in their reactions to damage (JEWETT 1941). The fecundity of the biotypes of pea aphid on red clover varieties have apparently not been studied.

In the present study measurements were made of the reproduction rate of the pea aphid on different red clover varieties grown commercially and experimentally in Finland, to show whether any differences exist in this respect between the biotypes of the pea aphid.

Material and methods

The red clover plants employed in the experiment were grown from seed in plastic pots. The substrate was peat, to which fertilizer was added to give the nutrient composition recommended by Viljavuuspalvelu Oy (Soil Testing Service Ltd, Helsinki). The age of the plants in the different tests varied from two to six months. In the summer months the tests were carried out in the insectary, where the conditions corresponded fairly closely to outdoor conditions. They were done at other times in a greenhouse with 18 hours of light and a temperature of 20—25°C. The tests included ten varieties of red clover, some of which were domestic varieties and some foreign.

There were three aphid biotypes, originating in red clover: 1 a, 1 b and 16. The biotype 1 b was red and the other two green. The aphids were reared on broad bean before the tests. Earlier studies (MARKKULA and ROUKKA 1970) showed that on Tammisto red clover the reproduction of biotype 1 a is very slight, that of biotype 1 b slight and that of 16 abundant. The newly-matured wingless aphids were transferred to rearing cages (see MARKKULA 1963) on identically aged leaves of test plants, one specimen to each cage. Depending on the test, there were 10 or 20 aphids per clover variety. The cultures were examined at weekly intervals, the progeny being removed and counted and every mother was transferred to the leaf immediately above. The total number of progeny of the aphids was ascertained.

Differences that were difficult to interpret occurred in the reproduction of the biotype 1 b in consecutive tests. Its reproduction was consequently studied on clover specimens of four varieties. In this latter test there were ten aphids per plant.

Results

Reproduction on different varieties

The reproduction rate of biotype 1 a was rather low on all the red clover varieties tested. The average number of progeny fell short of 10 (Fig. 1). Thus all the red clover varieties in the tests proved to be very resistant to this biotype. The number of progeny of biotype 1 b differed considerable on the different varieties. The average number of progeny was highest (84) on the Tapioi variety, where it differed very significantly ($P < 0.01$) from the numbers produced on the other varieties. The Tepa and Ulva varieties were the most resistant. The number of progeny on them was less than 20, being significantly ($P < 0.05$) smaller than on the other varieties except for Tripo. The reproduction rate of biotype 16 was high on all the varieties, the number of progeny being 79—88.

There was a high positive correlation ($r = 0.96$ and 0.97, $P < 0.01$) between number of progeny and lifespan of biotypes 1 a and 1 b on the different clover varieties.

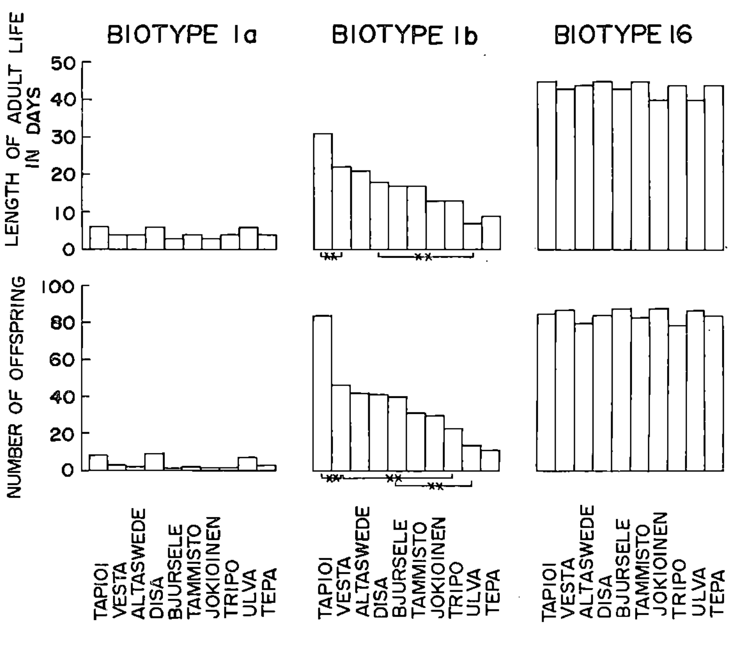

Fig. 1. The reproduction rate of pea aphid biotypes 1 a, 1 b and 16 on red clover varieties. The height of the columns shows the average number of offspring and the lifespan of the aphids on the test plants. The varieties Tapioi, Ulva, Tripo and Tepa are tetraploid, the remainder diploid. The entries below the columns show the very significant differences ($P < 0.01$) between the varieties.

Reproduction on different plant specimens of a single variety

The fecundity of biotype 1 b showed great variation between different specimens of a single plant variety (Fig. 2). The number of progeny was smallest on the variety Tepa. Of 19 plants of this variety, 17 had less than 12 aphid progeny, one had 51 and only one had a normal 91. The other varieties had a greater number of plant specimens on which reproduction was normal or almost normal. There were very significant differences in the reproduction of biotype 1 b ($P < 0.01$) between all the varieties except Alaskland and Disa.

There was a positive correlation between number of progeny and lifespan on different plant specimens.

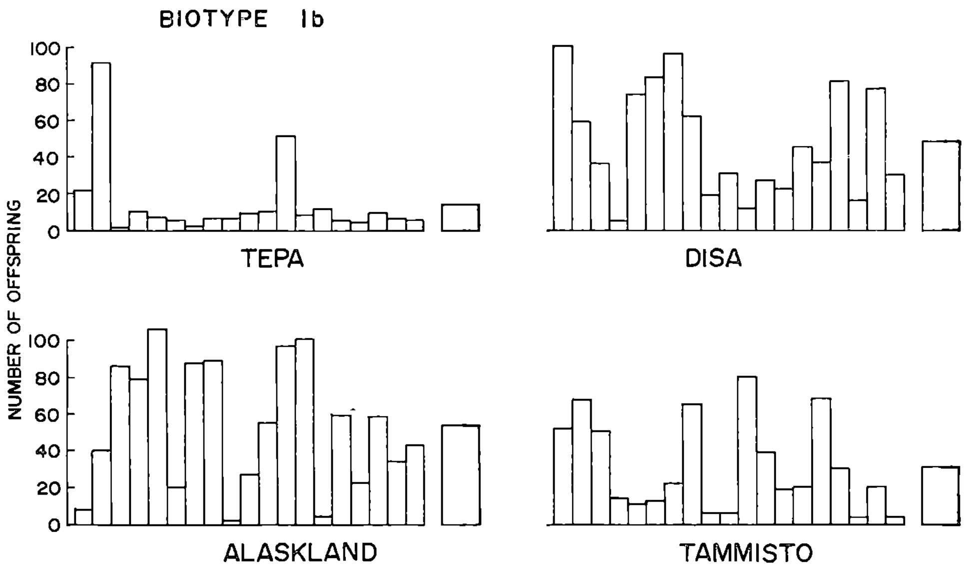

Fig. 2. The reproduction rate of biotype 1 b on different plant specimens of four varieties of red clover. The height of the columns shows the average number of offspring on each specimen of clover and on each variety (broad column).

Discussion

The biotypes differ in their reactions to various plant species and varieties (e.g. Cartier 1957, 1959, 1962, Cartier et al. 1965, Müller 1962, Markkula and Roukka 1970). There have only been two studies dealing with the reaction of the pea aphid to different red clover varieties. Jewett (1941) came to the conclusion that Kentucky and Tennessee clovers were slightly more resistant than the other varieties tested. Wilcoxon and Peterson (1960) showed that the Dollard variety was more resistant than Wegener to the pea aphid.

It became clearly evident in the present study that the extent to which the varieties of red clover are resistant is dependent on the biotype of the pea aphid. Biotype 16 reproduced abundantly on all the varieties studied, and it is obviously very difficult to breed red clover varieties resistant to this biotype. On the other hand, breeding would seem to be superfluous where resistance to biotype 1 a is concerned, for all the varieties studied proved to be very resistant in the tests. The ten varieties studied showed great variation in respect of biotype 1 b, and breeding for resistance may obviously produce significant results.

Before plant breeders can be expected to develop red clover varieties resistant to the pea aphid, it will be necessary to ascertain the incidences of the biotypes mentioned here, and to discover whether other biotypes with differing host plant relations exist in Finland. This survey, however, will be a very difficult task, particularly in terms of methodology.

Although a great deal of research has been done on the resistance of plants to the pea aphid, further study will be necessary in respect of the factors causing resistance. The problem would be greatly simplified if it could be explained why different red clover specimens differ so greatly in resistance, and why pea aphid biotypes diverge so greatly in their reactions to red clover. But the practical results that have been achieved even without a knowledge of the factors determining resistance should not be overlooked (see PAINTER 1951).

Summary

In the present study the fecundity of the pea aphid, *Acyrthosiphon pisum* Harris, on ten varieties of red clover was studied. The aphids used were of three biotypes 1 a, 1 b and 16, which originated from red clover.

All the clover varieties were highly resistant to biotype 1 a, the number of progeny on them being less than 10. Some of the varieties proved susceptible to biotype 1 b, and others resistant. Fecundity was greatest on the variety Tapioi, the number of offspring being 84, and fairly small on the varieties Tepa and Ulva, where it was less than 20. All the varieties proved susceptible to biotype 16. The number of progeny varied from 79 to 88.

The heterogeneity of the varieties was clearly evident. The reproduction rate of biotype 1 b differed between red clover specimens of one and the same variety. On some specimens the number of progeny was normal, c. 90, while on others the aphids produced only a few offspring.

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SELOSTUS

Kasvien kestävyydestä hernekirvaa vastaan

II. Hernekirvan lisääntyminen eri puna-apilalajikkeissa

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Tutkimuksessa pyrittiin selvittämään, onko meillä viljeltävien tai parhaillaan koeviljelyksessä olevien puna-apilalajikkeiden joukossa sellaisia, jotka olisivat resistenttejä eli kestäviä hernekirvaa vastaan. Tutkittavina oli 10 lajiketta. Ne ilmenevät kuvasta 1. Hernekirvat kuuluivat kolmeen puna-apilasta peräisin olevaan rotuun eli biotyyppiin: 1 a, 1 b ja 16.

Kaikki lajikkeet olivat erittäin resistenttejä rotua 1 a vastaan. Kirvojen jälkeläismäärä jäi niissä pienemmäksi kuin 10. Eräät lajikkeet osoittautuivat alttiiksi rodulle 1 b, toiset resistenteiksi. Jälkeläismäärä oli suurin ja hernekirvalle normaali Tapioi-lajikkeessa, 84 jälkeläistä, ja melko pieni lajikkeissa Tepa ja Ulva, vähemmän kuin 20 jälkeläistä. Kaikki lajikkeet osoittautuivat alttiiksi rodulle 16. Kirvojen jälkeläismäärä vaihteli niissä 79—88.

Lajikkeen epäyhtenäisyys ilmeni varsin selvästi (kuva 2). Rodun 1 b lisääntyminen oli erilaista saman lajikkeen eri kasviyksilöissä. Joissakin puna-apilayksilöissä jälkeläismäärä oli normaali, 90:n vaiheilla, toisissa kirvat synnyttivät vain muutamia jälkeläisiä.

Hernekirvan eri rotujen olemassaolo vaikeuttaa resistenssijalostusta ja resistenssin hyväksikäyttöä puna-apilan viljelyssä.

ANNALES AGRICULTURAE FENNIAE, Vol. 9: 309—312 (1970)

Seria ANIMALIA NOCENTIA N. 46 — Sarja TUHOELÄIMET n:o 46

PESTS OF CULTIVATED PLANTS IN FINLAND IN 1969

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Received November 20, 1969

The present survey, like previous ones (e.g. MARKKULA 1969), is based chiefly on the replies to inquiries sent to advisers of agricultural associations and also on samples and inquiries received at the Department of Pest Investigation and observations made by research workers.

Inquiries were sent to 207 advisers. Replies to the spring inquiry were received from 167 advisers, relating to 200 communes. The respective figures for the first summer inquiry were 129 and 149, for the second summer inquiry 139 and 158, and for the autumn inquiry 132 and 153. A general estimate of the abundance of pests over the whole growing season was given by 121 advisers of 130 districts. In 1969 the country was divided into 521 communes.

The percentage of apples damage by *Cydia pomonella* was estimated by 57 advisers, and by *Argyresthia conjugella* by 53 advisers. The percentage of pea pods damage by *Cydia nigricana* was estimated by 46 advisers.

Results and discussion

The abundance of pests was very low, despite the warm, dry summer. According to the replies, the average abundance was 2.1. In the five previous years, 1964—1968, when the data were gathered by the same method, the abundance figure varied from 2.3 to 3.0 and averaged 2.7.

Only five pest species caused damage equal to or greater than in the five-year period 1964 — 1968. These species were *Phyllotreta vittula*, *Hylemya antiqua*, *Plutella maculipennis*, *Anthonomus rubi* and *Zophodia convolutella* (Table 1). None of these, however, did exceptionally great damage.

Populations were sparse in several species e.g. *Macrosiphum avenae*, *Rhopalosiphum padi*, *Pieris brassicae*, *Meligethes aeneus*, *Nematus ribesii* and *Hydroecia micacea* (Table 1). The period of great abundance of *H. micacea*, which lasted for several years, seems to have come to an end.

According to the replies, *Cydia pomonella* damaged 15 per cent of the apples crop, and *Argyresthia conjugella* 11 per cent. *Cydia nigricana* caused damage to 11 per cent of the pea pods. These species were less injurious than during the five-year period 1964—1968. The preceding year was a year of exceptionally severe damage by *A. conjugella*. According to the corresponding inquiry, it had then caused damage to 73 per cent of the apples (MARKKULA 1969).

Three pest species normally of little economic importance occurred in exceptional abundance during the report year. These were *Hyponomeuta malinellus*, *H. evonymellus* (L.) and *Charaeas graminis* L.

Hyponomeuta malinellus made a surprising appearance in 1967 within household gardens in the city of Helsinki and in its vicinity, completely defoliating apple trees by the hundred (MARKKULA 1968). In the following year the area of destruction expanded and the damage became more severe. In 1969 the worst damage occurred

Table 1. Results of questionnaires. Severity of damage reported, using a scale 0—10. The frequency of damage shows the percentages of cultivations in which damage was found in the observation area

Taulukko 1. Tuhoeläintiedustelujen tulokset. Tuhojen ankaruus on ilmoitettu 0—10 asteikkoa käyttäen. Yleisyysluku ilmoittaa, kuinka monessa prosentissa havaintoalueen viljelyksistä tuhoa tavattiin

	Number of observations *Havaintoja* 1969	Severity of damage *Tuhojen ankaruus* 1969	Severity of damage *Tuhojen ankaruus* 1964—68	Frequency of damage *Tuhojen yleisyys* 1969	Frequency of damage *Tuhojen yleisyys* 1964—68
CEREALS — VILJAKASVIT					
Macrosiphum avenae (F.)	81	1.1	2.0	17	31
Oscinella frit (L.)	65	1.1	1.4	11	19
Phyllotreta vittula (Redtb.) etc.	125	**1.0**	0.9	15	20
Elateridae	59	0.9	1.4	18	19
Rhopalosiphum padi (L.)	54	0.8	1.3	15	18
FORAGE PLANTS — NURMIKASVIT					
Amaurosoma spp.	107	1.7	2.0	35	37
Apion spp.	65	0.9	1.4	10	22
VEGETABLES — VIHANNESKASVIT					
Hylemya antiqua (Meig.)	92	**2.4**	2.2	24	28
Hylemya brassica (Bché) and *H. floralis* (Fall.)	81	1.8	2.4	30	33
Plutella maculipennis (Curt.)	79	**1.9**	1.9	23	24
Halticinae, on crucifers	143	1.9	2.4	36	46
Cydia nigricana (F.)	48	1.8	2.2	35	36
Pieris brassicae (L.) etc.	79	1.4	2.1	31	33
Trioza apicalis Först.	54	1.4	1.7	24	32
Phaedon cochleariae (F.)	47	1.3	1.5	16	28
Mamestra brassicae (L.)	41	1.0	1.7	18	27
Psila rosae (F.)	42	0.7	1.2	12	15
TURNIP RAPE — RYPSI					
Meligethes aeneus (F.)	67	1.4	2.3	30	54
SUGAR BEET — SOKERIJUURIKAS					
Pegomya betae (Curt.)	90	2.0	2.3	53	54
Lygus rugulipennis Popp. etc.	76	1.8	2.6	52	55
Chaetocnema concinna (Marsh.)	108	1.7	1.9	36	43
Silpha opaca L.	63	1.5	1.8	39	40
APPLE — OMENAPUU					
Cydia pomonella (L.)	62	2.2	2.6	27	42
Hyponomeuta malinellus (Zell.)	46	1.7	1.8	25	26
Argyresthia conjugella Zell.	59	1.7	3.9	27	49
Aphis pomi DeG	68	1.5	1.8	21	28
Lepus europaeus Pallas and *L. timidus* L.	90	1.5	1.7	13	15
Panonychus ulmi (Koch)	28	1.4	1.7	14	26
Microtus agrestis (L.)	82	1.2	—	7	—
Psylla mali (Schmidbg.)	71	0.8	1.2	12	21
Arvicola terrestris (L.)	69	0.4	—	3	—
Xyleborus dispar (F.)	62	0.3	0.8	1	7
BERRIES — MARJAKASVIT					
Cecidophyes ribis (Westw.)	124	2.2	2.3	31	33
Stenotarsonemus fragariae (Zimm.)	78	2.0	2.1	25	29
Anthonomus rubi (Hbst)	45	**1.8**	1.6	29	26
Aphididae, on Ribes species	65	1.8	2.0	29	30
Incurvaria capitella Cl.	95	1.8	2.1	24	28
Byturus urbanus (Lind.)	61	1.6	2.1	27	32
Nematus ribesii (Scop.) and *Pristiphora pallipes* Lep.	73	1.4	2.1	14	22
Pachynematus pumilio Knw.	64	1.4	1.7	22	28
Zophodia convolutella (Hbn.)	35	**1.2**	1.2	12	16
PESTS ON SEVERAL PLANTS — USEIDEN KASVIEN TUHOLAISET					
Hydroecia micacea (Esp.)	70	0.9	1.6	23	25
Deroceras agreste (L.) etc.	41	0.5	1.8	18	29

100—200 kilometres from the original centre of destruction, but, considering the whole area affected, the damage was slighter than it had been during the preceding year. Periods of great abundance comprising several consecutive years and recurring at long intervals, are typical of this species (Junnikkala 1960); the present population high seems to be coming to an end. *H. evonymellus* has been occurring in exceptional abundance in South and Central Finland ever since 1966. Bird cherry trees (*Prunus padus*) eaten bare of leaves have been common in these regions for several years consecutively. The heavy infestation continued. The figure for severity of damage was 4.1 and the frequency figure 39.

In the latter part of last century and to some extent in the beginning of the present one, *Charaeas graminis* was regarded as the worst pest in Finland (e.g. Reuter 1901, Vappula 1965). With the progress of ley farming, its periods of destruction have become less frequent. The last occasion on which this species occurred in exceptional abundance was in 1953, chiefly in Central Finland (Vappula 1965). Since that time it has hardly been found. During 1969, the larvae of the antler moth occurred in exceptional abundance, mainly in the county of Oulu. Data were received from a score of districts (Fig. 1). Over large areas the larvae devoured all the tufted hairgrass (*Deschampsia caespitosa*) but did not touch the sown hay. The figure for severity of damage was 2.0 and the frequency figure 10.

No new pests were observed, and the number of species known as pests remains at 1 101.

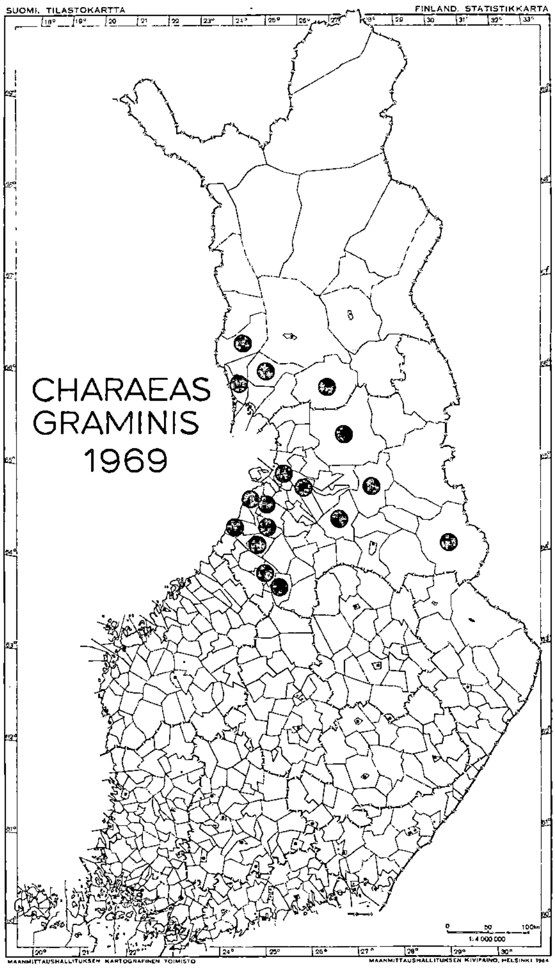

Fig. 1. Incidence of *Charaeas graminis*.
Kuva 1. Niitty-yökkösen toukkien tuhoista saatiin tietoja 17 kunnasta.

Summary

The abundance of pests was low, despite the warm, dry summer. Only five species caused damage equal to or greater than that in the five-year period 1964—1968. These species were *Phyllotreta vittula*, *Hylemya antiqua*, *Plutella maculipennis*, *Anthonomus rubi* and *Zophodia convolutella*. Defoliation of apple and bird cherry by *Hyponomeuta malinellus* and *H. evonymellus* continued. *Charaeas graminis*, almost unobserved since 1953, occurred in exceptional abundance in part of North Finland.

Cydia pomonella damaged 15 per cent of the apples, and *Argyresthia conjugella* 11 per cent. *C. nigricana* damaged 11 per cent of the pea pods.

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SELOSTUS

Viljelykasvien tuhoeläimet 1969

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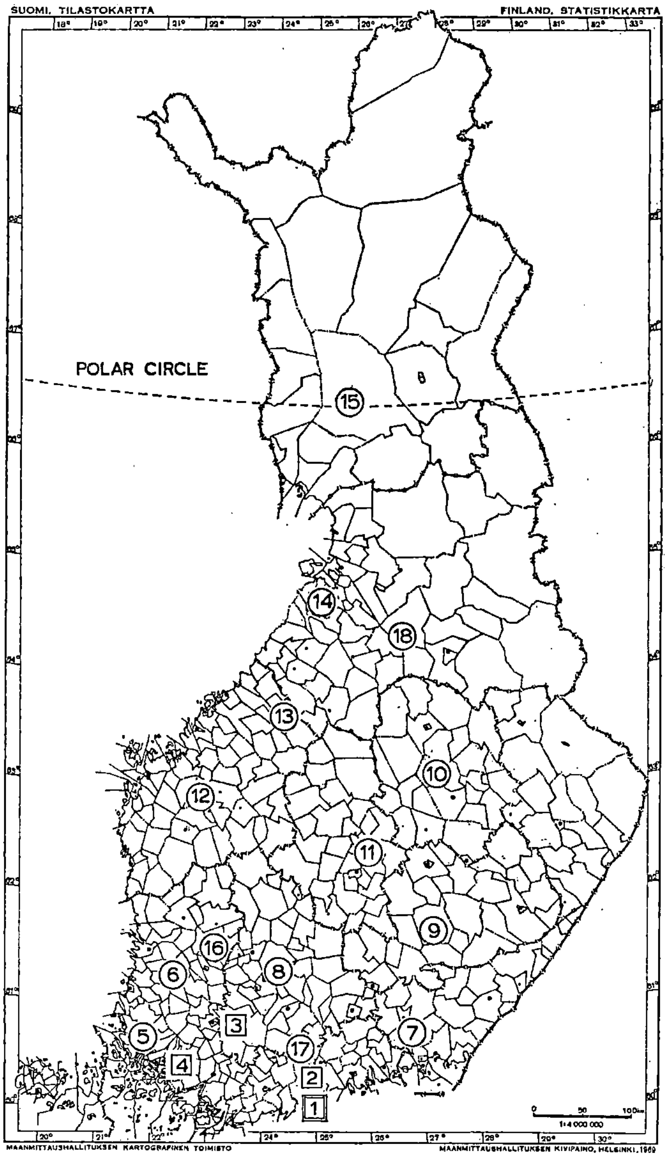
Lämpimästä ja poutaisesta kesästä huolimatta tuholaisten aiheuttamat vahingot olivat varsin vähäisiä. Vain viisi tuhoeläinlajia aiheutti saman suuruisia tai suurempia vahinkoja kuin viisivuotiskautena 1964—1968. Nämä lajit olivat ohrakirppa, sipulikärpänen, kaalikoi, vattukuoriainen ja karviaiskoisa. Omenankehrääjäkoin ja tuomenkehrääjäkoin runsaan esiintymisen kausi jatkui. Niittymatoja oli kuudentoista vuoden jälkeen poikkeuksellisen paljon pääasiassa Oulun läänin alueella.

Yksityiskohtainen katsaus on esitetty Koetoiminta ja Käytäntö -lehdessä n:o 12/1969.



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