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ECOLOGY AND CONTROL OF TIMOTHY GRASS FLIES (AMAUROSOMA SPP., DIPT., SCATOPHAGIDAE) AND THE EFFECTS OF CHEMICAL CONTROL ON THE FAUNA OF THE FIELD STRATUM

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The ecology and control of the timothy grass flies *Amaurosoma flavipes* and *Amaurosoma armillatum* were investigated in western Finland, and the distribution and fluctuations in the abundance of these flies throughout Finland were studied with the aid of data accumulated over the period 1894—1971.

Both species extend beyond the Arctic Circle. *A. flavipes* is found on young leys, and *A. armillatum* on older leys. *A. flavipes* is the more common, its distribution is more southeastern, and it is found in higher proportions on organic soils than on mineral soils. The life cycles of these two species are alike, and a larva consumes c. 48 %, i.e. 2.3 cm, of the ear of timothy grass.

The number of ears damaged by timothy grass flies tends to be great for two consecutive years at intervals of six years. When damage is moderate or scanty, c. 5 % of the ears are damaged.

In experiments performed in cultivated forest clearings the number of offspring of *A. flavipes* was positively correlated with the number of the parental generation. An attempt was made to destroy the populations of the two species by interrupting the cultivation of timothy grass or by treating whole clearings with insecticides. The populations could be brought down to a very low level, but when cultivation of timothy was resumed it took only about 3 years for the number of specimens to return to the original level. No resistant varieties have been found, but the loss in seed yield is smaller in long-eared than in short-eared varieties. Of the insecticides tested, parathion, dimethoate, dicrotophos, bromophos and trichlorphon are effective against timothy grass flies. With DDT or parathion treatment the numbers of specimens of the various insect orders in the field layer fell by about 70—80 %, and with trichlorphon by c. 50 %. With the two former insecticides the effect was apparent longer than with trichlorphon.

Research on the ecology and control of timothy grass flies has been proceeding in Finland since 1894 at least. Most of the observations made are to be found in the numerous published reports on the occurrence of pests, a summary of which was drawn up by VAPPULA (1965). In 1930—1933 Jaakko Listo, Instructor at the Normal School of Agriculture, studied the

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ecology of these species and also made experiments on their control. However, he died in 1935 and his data were never published. Listo's work on the anatomy, life cycle, enemies, damage done by and control of timothy grass flies was good in its day and revealed much that was new. But his work is no longer worth publishing, because several articles on timothy grass flies have subsequently appeared (e.g. BARNES 1935, KING, MEIKLE and BROADFOOT 1935, WAHL 1943, GOLEBIOWSKA 1949, MÜHLE 1953, COGHILL and GAIR 1954, BORG 1959, RICOU 1967, AHNERT 1969). Moreover, most of his material has been destroyed and many of his notes are illegible. These notes, however, were available to us when we were writing the present article, and all information worth publishing is presented here.

After Listo's death MANTERE (1937) carried out experiments on timothy grass fly control by cultivation techniques, and HUKKINEN (1946) made the first trial with DDT. Since then, further investigations on the ecology and control of these flies have been made in the period 1958—1970, under the direction of the senior author (M.R.). Three preliminary reports of the practical applications of this work have already been published (RAATIKAINEN 1963, 1968, 1970).

Material and methods

The life cycle of timothy grass flies was studied on a timothy grass seed crop growing east of the city of Vaasa in western Finland in 1958—1962. In this area timothy grass seed leys made up 5—10 % of the arable land, and most of the sampling was done at Laihia (about 63°N, 22°E), which lies some 20 km southeast of the city. The samples of adult flies were gathered with a sweep net (see HEIKINHEIMO and RAATIKAINEN 1962) from leys of varying age established in a nurse crop, 200 sweeps with the net making one sample. The other observations on the life cycle were made in the field. The permanent collection also contains material taken by J. Listo at Tikkurila and Järvenpää. These areas are outside the seed-growing regions proper, and lie 16 and 35 km north of the capital, Helsinki.

Data on the fauna of timothy grass flies have been gathered from various parts of the country. The collections in the largest museums, Listo's data and the literature have also been studied.

An examination of the *Amaurosoma* species in leys of different ages was made by the sweep-netting method. There were 26 first-, second- and third-year leys, and 17 leys 4 or more years old. Netting was done between 14 May and 4 June 1959. The areas selected for sampling were cultivated clearings surrounded by forest, each including within one km a first-year, a second-year and a third-year ley and, if possible, also a ley 4 or more years old. These localities were all in the coastal area of the Gulf of Bothnia, most of them in the vicinity of Vaasa, but some well to the south of this town.

An attempt has been made to deduce the fluctuations in the abundance of the timothy grass flies from the variations in the damage they caused in the period 1894—1970. Data were gathered chiefly from the records of the Department of Pest Investigation, from the notes made by Listo in the early 1930s, from the annual reviews of pest occurrence given until 1961 in the compilation prepared by VAPPULA (1965), and from the manual by SAALAS (1933). In addition, there are personal observations made since 1958.

The experiments on control through cultivation techniques were arranged in southwestern Finland during 1959—1963, in the communes of Kalanti (3 sites), Laitila (3), Rauma Rural District (3), Noormarkku (1), Ahlainen (2), Merikarvia (2) and Siikainen (1). The localities were stretches of open land averaging 2.6 (0.3—7.1) hectares surrounded by forest, and the crop rotations were those normally employed by the farmers in this area. Seven of the sites were on mineral soil, and six were on organic soil. On average, timothy amounted to 49 % of the crops grown in these areas, oats to 34 %, mixed cereals to 2 %, barley to 5 %, spring wheat to 2 %, rye to 1 % and potatoes or roots to 1 %. Fallow covered 4 %, and pasture 2 %. These cultivated clearings were examined every year at the beginning of June, after the timothy grass flies began to emerge. The abundance of timothy grass flies in the clearings is expressed by an index, in which the average number of timothy grass flies per sample taken from the leys in each clearing is multiplied by the total acreage of the leys in that clearing. In the correlation calculations, however, the acreage of the leys tilled in a given year is not included in the index for the P generation, because it has been found that very few timothy grass flies come from tilled leys of the preceding year.

The resistance of various strains and varieties of timothy to timothy grass flies was studied at Ylistaro in 1964 and 1965.

Experiments on chemical control were arranged in Laihia, Ylistaro, Nivala and Laukaa, which are within the timothy seed cultivation areas of western and central Finland. On commercial farms the insecticides were usually applied with a tractor-driven sprayer. The volume of spray was 200—250 litres per hectare. The experimental plots averaged 2 300 m². In 1968—1970 chemical control experiments were made on peat soil at Revonlahti, in the northern part of the region of seed cultivation. The plots there were only c. 400 m², and the experiments contained 4 replicates.

The variance analysis employed in the statistical treatment was supplemented by a Tukey-Hartley test, and the means which do not differ from another have been given identical letters after them. The effectiveness of the insecticides against arthropods was calculated as a percentage from the formula

$$100\ (k_2t_1—k_1t_2)/k_2t_1$$

in which k_1 = number or weight of arthropods on control plot before treatment, k_2 = the same after treatment, t_1 = number or weight of arthropods on tested plot before treatment, and t_2 = the same after treatment. The method is by no means ideal, but it gives a brief and lucid description of the results when accompanied by a graph. The shape of the curves also reveals the weakening of the effect of the insecticide and the restoration of balance in the fauna as a result of emergence and/or immigration.

Results

A. Distribution of Amaurosoma species in Finland

In Finland it has been found that it is the larvae of *Amaurosoma flavipes* Fall. and *A. armillatum* Zett. that are injurious to timothy. Both these species are distributed throughout the region where timothy grass is grown for seed, and evidently north of it as well, but as there are no exact data for the northernmost part of Finland the northern boundary of the species remains indefinite (Figs. 1 and 2). However, damage due to *Amaurosoma* larvae has been found in Finland at Karigasniemi (69°24′N) and on the west bank of the Tenojoki, on the Norwegian side (70°2′N), and the northern boundary for *Amaurosoma* species destructive to timothy consequently appears to lie north of Finland.

Both species are very frequent in all timothy leys. According to Figs. 1 and 2, *A. flavipes* is more frequent than *A. armillatum* in southeast Finland, while in northwest Finland *A. armillatum* has been reported from a greater number of places than *A. flavipes*. A general picture of the relationships between the species was obtained by dividing Finland into 6 areas by longitude and latitude (Fig. 3). The relationship between the species within each area was calculated from all the sources of information available. It was found that *A. flavipes* made up 95.2 % in the southeasternmost area and the percentage declined steadily towards the northwest. Nevertheless, even there it slightly outnumbered (56.6 %) *A. armillatum*. Among the 19 715 specimens of these timothy grass flies making

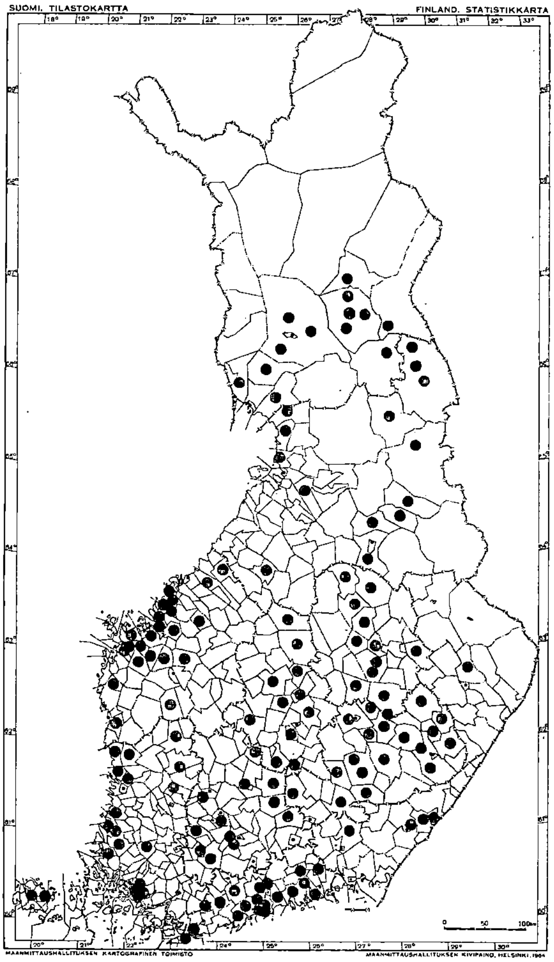

Fig. 1. Known localities of *Amaurosoma flavipes* in Finland.

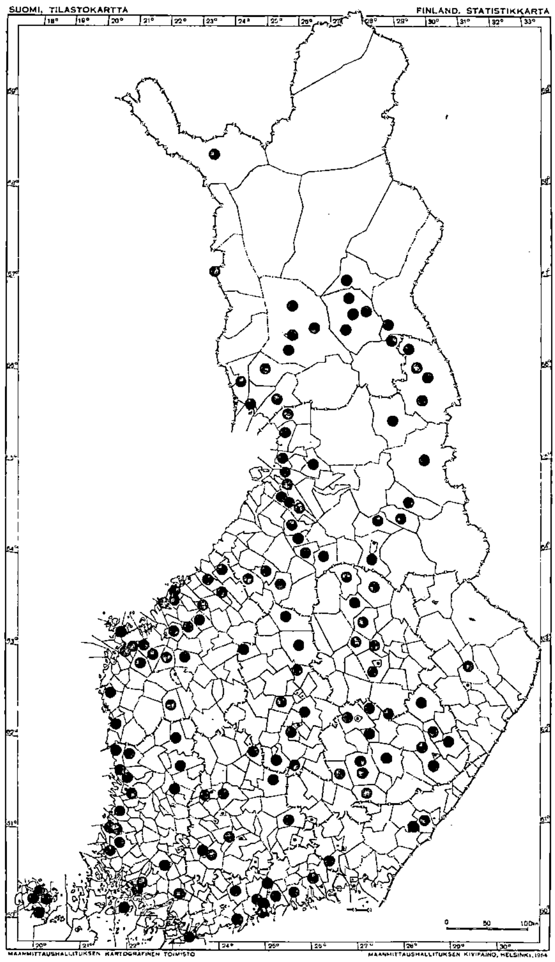

Fig. 2. Known localities of *Amaurosoma armillatum* in Finland.

up the material from the entire country and gathered from about 400 localities, *A. flavipes* amounted to 74.4 %.

B. Life cycle and damage

Both species hibernate as puparia in the soils of timothy leys. Development is resumed when the environmental temperature rises to c. 2—3°C — according to experiments performed by Listo in a thermostat at a relative humidity of c. 70—75 %. The material used in these experiments had been kept over the winter in a cellar, where in May, before the experiment was begun, the temperature rose to about 6°C and development was resumed to some extent. *A. flavipes* seems to emerge some 12 hours or so before *A. armillatum*, the males of both these species emerging about 1—2 days before the females (Fig. 4). The formulae for the duration of development are: *A. flavipes* female $t(T-1.6) = 1\,512$, and male $t(T-3.3) = 938$; *A. armillatum* female $t(T+0.6) = 1\,607$, and male $t(T-2.4) = 950$, in which t = pupal period in days and T = mean temperature during the pupal period.

According to samples netted in the field, the adults of the two species emerge simultaneously, males of both species being more numerous

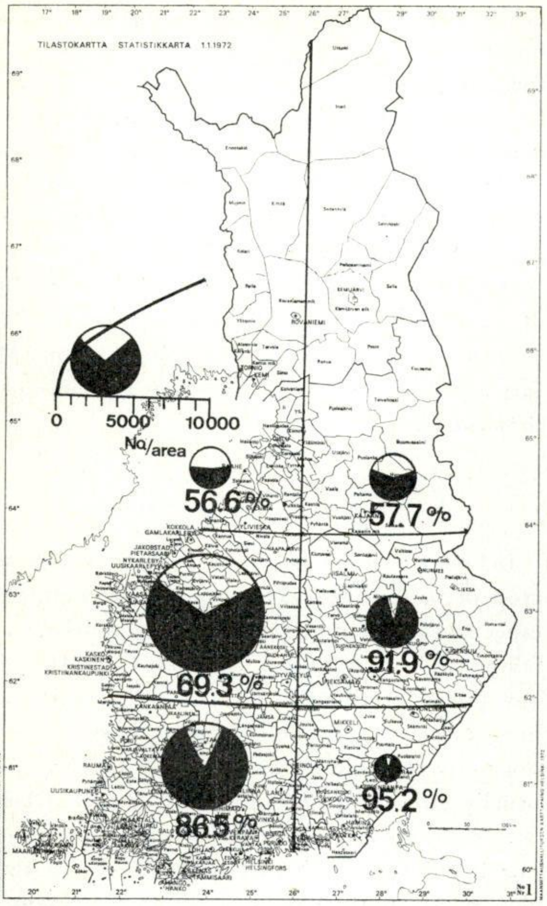

Fig. 3. Proportions of *Amaurosoma flavipes* (black sector and % figure) and *A. armillatum* (white sector) in various regions. Size of circle indicates number of specimens in the sample.

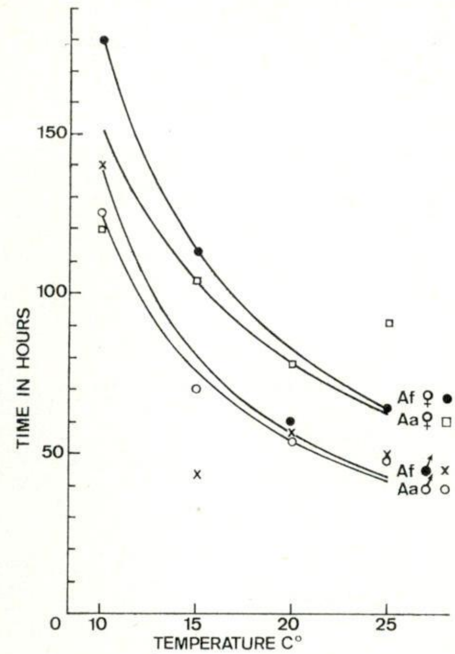

Fig. 4. Duration of pupal development in the two sexes of *Amaurosoma flavipes* (Af) and *A. armillatum* (Aa) after hibernation.

than females during the early part of the season of occurrence and less numerous in the latter part (Fig. 5, Table 1). This suggests that the males emerge earlier than the females, and it is possible that they have a shorter life span. These species emerge about one week earlier on quickly warming mineral soils than on slowly warming peat soils. According to the samples gathered by Listo at Tikkurila, the first adults of *Amaurosoma* were found on 15 May in 1931, 18 May in 1932 and 29 May in 1933. At Laihia, about 350 km north of Tikkurila, the first adults were found on 14 May in 1959, 20 May in 1960, 15 May in 1961 and 21 May in 1962. The fluctuation of 1—2 weeks in the time of emergence corresponded to the fluctuations in temperature. However, the thermal sum of the atmosphere cannot be used to express the time of emergence with sufficient accuracy, and no measurements on the temperature of the soil are available.

Adults occur for about one month. The first eggs were found in the field 5—10 days after the emergence of the first adults, and eggs were found for 3 weeks. The females of both species ordinarily lay their eggs on the upper surface of the leaf blade of timothy, near the ligule and parallel with the veins of the leaf. The females lay several eggs per day. Listo states that in experimental conditions one *A. armillatum* laid a total of 29 eggs. In the field a shoot usually had one egg on the most central or highest leaf, but in dense populations and particularly in cultures these species lay a number of eggs adjacent to one another on the same leaf. Listo observed that the eggs of *A. armillatum* hatch

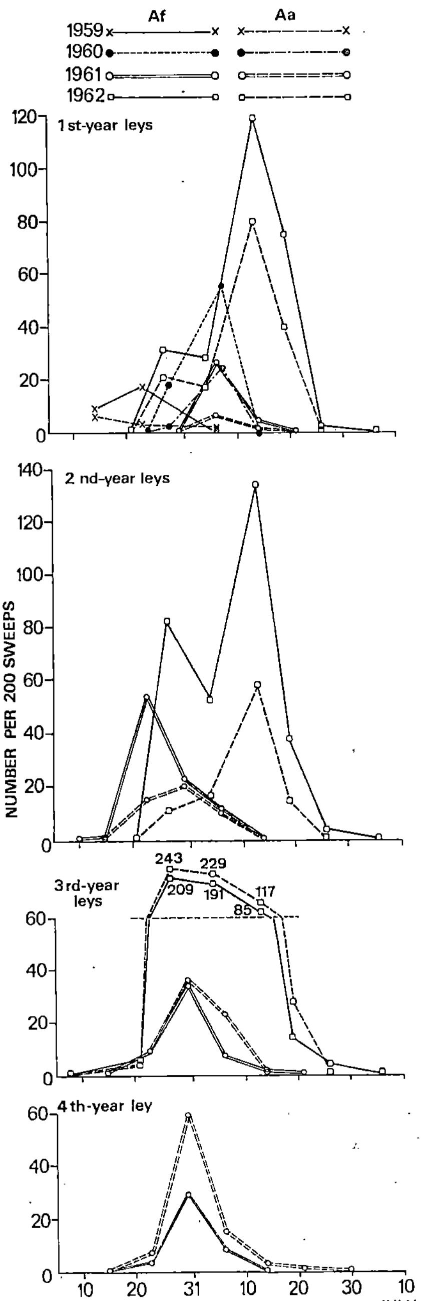

Fig. 5. Numbers of *Amaurosoma flavipes* (Af) and *A. armillatum* (Aa) adults in 200 net sweeps in leys of various ages at Laihia 1959—1962.

in 5—6 days. The larvae then make their way in between the top leaves and so to the ear.

In the field the eggs hatch from the end of May onwards, and hatching seems to reach a peak in the beginning of June. The larva feeds on the ear when this is still inside the sheath for a period of c. 3 weeks, and nearly all the larvae leave the plant in June before earing occurs. A few larvae may remain on the plant while the ear is emerging. Most of the larvae pupate in the soil, but some of them do so in the sheath or on the ear.

It has been ascertained that the larvae of *A. flavipes* and *A. armillatum* feed only on the ears of *Phleum pratense.* Of a collection of 241 ears gathered from various parts of the country, they had eaten 48$\pm$1.6 (S.E.) %.

C. Occurrence in various habitats

In Finland a ley is usually established in a nurse crop of oats, barley, wheat or rye. Sometimes, especially in the north, the ley is established on fallow land or with turnip as nurse crop. Hardly any pupae of timothy grass flies hibernate in first-year leys, and adult timothy grass flies do not move into the ley until spring. The leys are usually either pure timothy leys or mixed leys with some clover and other herbs amounting to one fourth. In southern Finland there are also clover leys. Both the coverage and the productivity of the timothy in the ley are maximal in the second year, and then decline (Table 2). The total productivity of the ley also declines after the second year, but there seems to be no decline in the coverage of the plants of the early summer, at least.

The numbers of adults of both *Amaurosoma* species appear to be in positive correlation with the amount of timothy in old leys. However, these correlations were not statistically significant, as the data were few and the dispersion great. The numbers of both species per 200 sweeps of the net were highest in the 2nd-year leys and declined with the ageing of the ley. The number of *A. flavipes* declined more sharply than the number of *A. armillatum*, and thus the proportion of the latter species increased with the ageing of the ley. Both sexes of both species migrated by flying to other leys a few days after emergence. They flew at a height of 2 metres at

Table 1. Proportion of males of *A. flavipes* and *A. armillatum* in timothy leys 1959—1962. The samples mentioned in Fig. 5 have been divided into 3 consecutive groups as equal as possible in numbers of specimens every year, and the values for the successive years have been combined.

Third parts of season of occurrence	*A. flavipes*			*A. armillatum*		
		Males			Males	
	Total	No.	%	Total	No.	%
I	434	228	52.5	332	230	69.3
II	484	234	48.3	446	237	53.1
III	470	115	24.5	343	96	28.0

Table 2. Number of adults, sex ratio and ratio between the two *Amaurosoma* species in leys of various ages.

Age of ley, years	Cover of vascular plants %	Cover of timothy grass %	*A. flavipes*			*A. armillatum*			*A. flavipes* % of *A. flavipes* + *A. armillatum*
			Total no.	Females %	No./200 sweeps	Total no.	Females %	No./200 sweeps	
1	61	57	1 206	58	46.4	386	43	14.8	75.8
2	75	62	1 631	61	62.7	744	49	28.6	68.7
3	74	54	1 185	55	45.6	630	47	24.2	65.3
≥4	76	37	379	54	22.3	363	48	21.4	51.1

least. It seems that more males than females made their way to first-year leys, at least at the beginning of the migration. Females of *A. armillatum* were particularly uncommon on young leys (Table 2).

The abundance of these *Amaurosoma* species on various soils was investigated in a series of 82 samples netted in various parts of the country. In this material 1908 adults were netted above organic soils and 85.8 % of them were *A. flavipes.* From above mineral soils 1 402 adults were netted, and 73.0 % were *A. flavipes.* The samples were from large cleared areas where both mineral and organic soil occurred in the same clearing and thus it was possible for the flies to make their way to either kind of soil every year. Samples gathered in 1959—1963 from clearings with only one kind of soil and surrounded by forest were also classified by soil. This material contained the following proportions of *A. flavipes* ($t = 15.62$; $P < 0.001$):

	Total no. of specimens of both species	*A. flavipes* %
Organic soils	7 239	91.1
Mineral soils	3 634	79.6

According to both sets of samples the proportion of *A. flavipes* is higher on organic than on mineral soils, and no difference in the distribution of the two species can be discerned where the two species have a choice of soil.

D. Fluctuation

There seems to be a distinct fluctuation in the abundance of adults of timothy grass flies from year to year. However, no clear picture of this fluctuation in abundance can be obtained, as no data systematically collected over a long period are available. The best picture is given by observations on the proportion of damaged ears. As each damaged ear normally contains only one larva of a timothy grass fly, the number of damaged ears must reflect the number of larvae. But as even three larvae occasionally feed on a single ear the number of larvae is actually greater than the number of damaged ears. The number of larvae per damaged ear seems to have been higher in dense than in sparse populations. Thus the variation in the proportion of damaged ears is probably smaller than the variation in the number of flies.

Subjective errors may have had some influence on the results, especially in the earlier years for which little information is available. But when

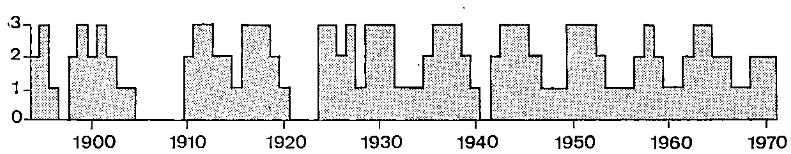

Fig. 6. Damage caused by timothy grass flies to timothy ears 1894—1970. 0 = not known, 1 = slight, 2 = moderate, 3 = severe.

the data for the years 1894 to 1971 are combined, in main features they probably give an accurate reflection on the actual fluctuations in the abundance of timothy flies. The data (Fig. 6) reveal that the damage caused by these timothy flies tends to be severe for 2 consecutive years at intervals of 6 years. Unfortunately, the categories of damage are relative and cannot be reported in the same way as the proportion of damaged ears. The only dates for which there is ample material are the years 1932 and 1966—1968, when damage was slight or at most moderate. On average, 5 % of the ears were damaged during these years. In the worst years 50—90 % of ears have been damaged locally, but there are no averages for large areas. The average losses have obviously been considerably below these peak figures even in years of peak population densities, for the average fluctuation in the abundance of timothy grass flies does not seem to be very great. In recent years, for instance, the extent of the damage has only varied from about 3 to 7 % over a wide area. In individual fields and over smallish areas, however, fluctuations in abundance have been greater.

E. Control

Factors influencing population size

To reduce the density of the population attempts can be made to regulate migration, to decrease reproduction or to increase mortality. The experiments performed in the clearings clearly show that forests present a considerable barrier to the spread of both species. Thus every smallish cultivated clearing has an *Amaurosoma* population of its own, divided into subpopulations on the timothy grass leys and margins of plots. It was never possible to destroy the whole population of *Amaurosoma* in a clearing, for specimens would survive on timothy at the edges of fields and ditches. After a new stand of timothy had been established both female and male timothy grass flies were always to be found there in a short time, which indicates active migration within the population (see also Table 2).

So far there is insufficient information on the number of progeny, but *A. armillatum* may have fewer offspring than *A. flavipes*. Hymenopterous parasites are a significant cause of mortality. Their importance varies somewhat from place to place, but experiments in clearings surrounded by forest indicate that the number of offspring (F_1 generation) is usually correlated with the number of specimens of the parent (P) generation at least in the case of *A. flavipes*. For instance, in 1960 the sizes of the *A. flavipes* populations were correlated with the sizes of the populations of 1959 ($r = 0.62$, $P < 0.05$), and the population sizes of 1963 with those of 1962 ($r = 0.73$, $P < 0.01$). This indicates, for instance, that the factors controlling population size have a very similar influence over a wide area, and that the size of the P population is evidently one of the factors most decisively affecting the size of the F_1 generation. In the case of *A. armillatum* no correlation between the sizes of the F_1 and P generations in clearings could be shown, but this does not prove that there is no such correlation in this species. It was merely a matter of there being so few specimens of this species that no sufficiently representative samples could be obtained. When the two species are treated as a single population, however, the size of the F_1

generation is correlated with that of the P generation; e.g. the correlation between the sizes in 1963 and 1962 was $r = 0.94$, $P < 0.001$.

Reduction of population size

Populations of timothy grass flies can be markedly reduced, and sometimes perhaps even completely wiped out, by temporarily interrupting timothy growing within the whole cleared area, by early mowing of the timothy or by treating the leys and the margins of ditches and fields in the whole clearing with insecticide right at the start of oviposition.

In six forest clearings all the timothy leys were ploughed up and the populations of timothy grass flies were reduced to a few score specimens at the margins of fields and ditches and on spring cereals growing as weeds. The experiments revealed that during the ploughing and tilling of the leys the pupae in the few top cm of the soil became buried more deeply, and that only a small fraction of the number that normally reach the adult stage appeared the following year in such clearings. Consequently, it is not necessary to stop timothy growing altogether, and for practical needs it will be enough if all the old timothy leys are ploughed up after harvest in the same year in which a new timothy ley is established. After such reduction the populations of both *Amaurosoma* species increased, again in accordance with a sigmoid curve (Fig. 7). *A. flavipes*, however, outnumbered *A. armillatum* (third year $t = 2.73$, $P < 0.05$). But the experiment was only continued for 4 years, a period which is too short for either species to reach its upperlimit of abundance. The population densities also grew from year to year. This is illustrated in the following table, which shows the numbers of specimens per 200 sweeps of the net after the resumption of timothy growing.

	A. flavipes	*A. armillatum*
1st year	9 ± 5	2 ± 1
2nd year	51 ± 20	5 ± 2
3rd year	219 ± 124	16 ± 2
4th year	199 ± 76	54 ± 11

Thus, by interrupting timothy growing it is possible to reduce the density of the timothy grass flies for some years and so to cut down the amount of damage caused by them. But this form of control is only possible, when it can be applied to entire clearings, and it is very difficult to employ in large cleared areas where land is owned by several farmers. Because of the rapid increase in population density, the growing of timothy would obviously have to be discontinued every two or three years if this method were employed.

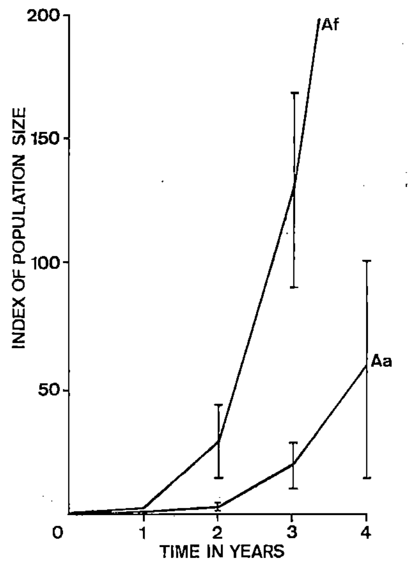

Fig. 7. Growth in size of population of *Amaurosoma flavipes* (Af) and *A. armillatum* (Aa) in cultivated forest clearings upon resumption of continuous cultivation of timothy.

Another way to reduce the population is to mow the timothy for fodder in the period when oviposition is over but before the larvae have gone down into the soil. Mowing should then be done after the season of occurrence of the adults and while the larvae are half-grown. This method although it does lower the population density, is applicable only in areas where the timothy can be harvested very young. Moreover poorer results seem to be obtained than by abandoning the cultivation of timothy for a year. Subsequently, the *Amaurosoma* populations probably increase in the same way as in the ex-

Table 3. Combined results of control experiments on *Amaurosoma* spp. in 1961 and 1962. Percentage of effectiveness calculated from the numbers of damaged ears, which were shown in checks to be 5 per m². $F = 3.41$, $P < 0.05$.

Treatment	Product	Active ingredient		No. of trials	Effect %
		%	kg or l/hectare		
Trichlorphon wettable powder	Dipterex	80	0.64	8	47
DDT spray	Täystuho T	20	0.80	10	60
Parathion spray	Bladan E 605	35	0.28	4	68
Trichlorphon wettable powder	Dipterex	80	0.80	4	77

periments performed in forest clearings (cf. Fig. 7).

Experiments on the destruction of *Amaurosoma* populations were also carried out by treating entire clearings with insecticides. There were six such clearings, and all the leys and grass margins in them were treated with DDT at the season of adult occurrence. According to samples netted before and after treatment, effectiveness of control was 73 % for adults of *A. flavipes* and 60 % for adults of *A. armillatum*, but the difference between the species is not significant. Thus chemical control did not give very good results, and within a year or two after treatment the population density had returned to its former level.

Delayed earing

Timothy grass flies lay most of their eggs within a couple of weeks, and thus a delay of a week or two in earing may prevent damage. As long ago as 1930 Listo carried out experiments with mowing. There were two test sites with plots of 5×24 m where the timothy grass was mown at different times. There where no replicates. The results were as follows:

Mown	Site of Experiment A Ears		Site of Experiment B Ears	
	number examined	% damaged	number examined	% damaged
Not	843	11.0	949	21.0
24 May	787	4.7	838	10.5
31 May	462	2.6	252	2.4

The experiments were on a small scale but the results were similar to those of later experiments. The proportion of ears damaged by timothy grass flies is small in the later-mown

Table 4. Effect of various quantities of trichlorphon (Dipterex) upon *Amaurosoma* spp. $F = 26.3$, $P < 0.001$.

Active ingredient kg/ha	No. of attached ears per 5 m²	Effect %	P<0.05
Untreated	17.4	—	a
0.32	11.4	36	a
0.64	8.5	50	b
0.96	6.1	63	c

timothy grass leys, as is particularly clear when the results are expressed as the number of such ears per m². But this cannot be used as a means of control on seed leys, for, when mown, timothy produces very few ears, and the seed yield will be even lower than if no measures are taken.

Resistance of varieties

In 1964 and 1965 observations were made at Ylistaro on a timothy grass plot, where four local strains were being tested in addition to the Tammisto and Tarmo varieties. All the strains and varieties had ears damaged by timothy grass flies, and there were no significant differences between them.

Chemical control

In 1961 and 1962 chemicals to control timothy grass flies were applied about 2 weeks after the emergence of the first adults, i.e. at the time when the density of the adult population was near its maximum. These experiments, made on 2—4 June, showed that, apart from the previously used DDT, parathion and trichlorphon were suitable insecticides, although they had to

Table 5. Control experiments on *Amaurosoma* spp. 1969 and 1970. F = 77.29, P < 0.001.

Treatment	Product	Active ingredient %	Active ingredient 1 or kg/ hectare	No. of attached ears per 10 m^2	P<0.05	P<0.001
Untreated				99.8	a	a
Trichlorphon wettable powder	Dipterex	80	0.64	38.3	b	b
Bromophos spray	Nexion 25	25	0.15	36.8	b c	b
Dicrotophos spray	Bidrin	24	0.24	33.8	b c	b
Dimethoate spray	Rogor L 40	40	0.40	29.0	c	b

be used in the largest quantities recommended in the directions (Tables 3 and 4). On account of the deleterious effects of DDT this insecticide has not been recommended since 1968, and under the Pesticide Act in force since 1 September 1969 the only one of these insecticides that can be used for control of timothy grass flies is parathion. As parathion, too, is acutely a very toxic insecticide, a new study on control was begun in 1968. However, hardly any trials with timothy grass flies were included in the experiments arranged that year. According to the experiments of the next two years, which were made when the adult density had already reached a maximum again, some other insecticides besides parathion gave adequate effectiveness of control (Table 5).

Side effects of chemical control

The side effects of insecticides on the fauna of the field layer were studied at four localities. In 1961 such experiments were made at Ylistaro (Y) on a second-year ley and at Nivala (N) on a third-year ley; and in 1962 at Laihia on a first-

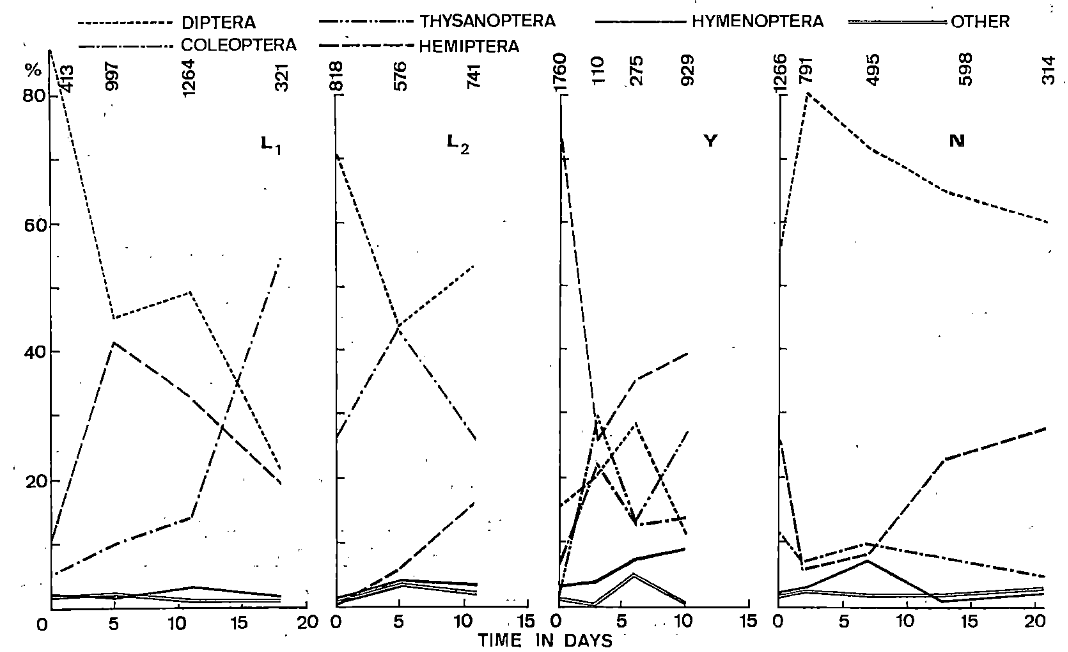

Fig. 8. Composition of the fauna of the field stratum in timothy leys in 4 localities. L_1 = Laihia 1 and L_2 = Laihia 2, Y = Ylistaro, N = Nivala. For further details see text.

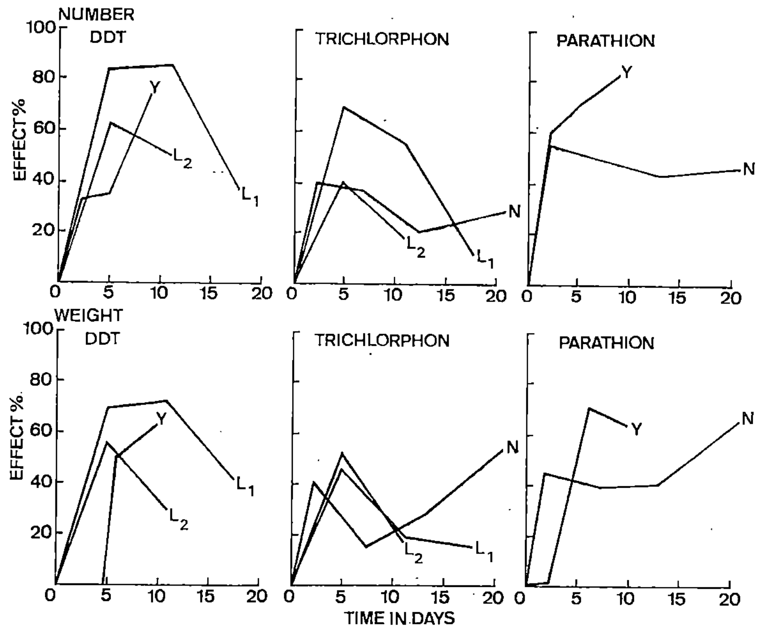

Fig. 9. Effects of 3 insecticides on the total number and weight of specimens of the arthropod fauna of the field stratum. Explanations of symbols in Fig. 8 and text.

year ley (L_1) and a second-year ley (L_2). There were two replicates in each experiment, and these were combined for the calculation of the percentages of effectiveness. The composition of the fauna of the control plot at each of these localities during the experiments is shown in Fig. 8, where the total numbers of arthropods in the samples are given at the top of each graph, the proportions of the various groups being expressed in broken lines as percentages of the total. The largest group was composed of Diptera, except at Y, where the leafhopper *Doliotettix pallens* (Zett.) was most abundant and raised the Hemiptera above the Diptera. The second largest group generally consisted of Hemiptera. On first-year ley (L_1) *Javesella pellucida* (F.) was dominant among them, occurring mainly as the nymph during the period of treatment but becoming adult during the experiment and largely migrating into cereals. *Doliotettix pallens* was dominant in second- and third-year leys and appeared as the nymph throughout almost the whole period of treatment but became adult during the experiment and migrated in part to other stands. Generally the Coleoptera made up the third largest group. Of these, *Meligethes aeneus* F. was dominant at L_1 and L_2, while representatives of the family Elateridae were abundant throughout. Thysanoptera were most abundant at Y and increased in numbers during the experiment on account of immigration. The proportion of Hymenoptera was rather small everywhere, and that of the Araneida group smaller still (c. 1.2 %).

The experiments show (Fig. 9) that with DDT the number of arthropods fell by about 80 %, with parathion by c. 70 % and with trichlorphon by c. 50 %. However, the results varied greatly from one locality to another and no significant differences could be established. The effect of the control treatment, especially with parathion and DDT, was observable for several weeks or even in the following year; but the effect of trichlorphon was less lasting, and arthropods that emerged later in the locality or immigrated into it, soon restored the reduced populations of

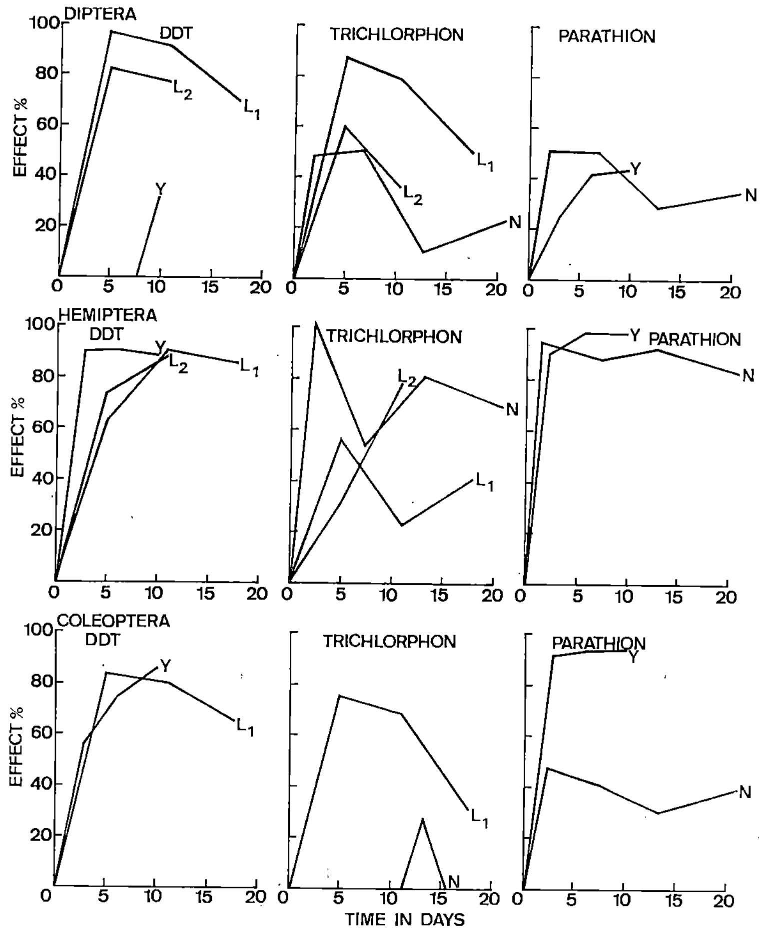

Fig. 10. Effects of 3 insecticides on the numbers of specimens of different orders in the field stratum. Explanations of symbols in Fig. 8 and text.

several species. The effects of the various insecticides on the decrease in the total weight of the arthropods (Fig. 9) were very similar to their effects on the numbers of specimens.

Of the representatives of the various orders, most specimens of almost every species were apparently killed by the DDT, this being the insecticide with the broad range of action in the conditions, and destroying c. 80 % of the specimens of all the orders studied (Figs 10 and 11). The effect of parathion seemed to be slightly weaker, and the variation in susceptibility among the representatives of each group in the various experiments was greater. The effect of parathion on the Diptera seemed to be especially weak. The effect of trichlorphon was weakest, and varied greatly from locality to locality even among the representatives of one and the same order. Generally it seems to have destroyed only about half the number of all insects present. Its effect, too, was briefer.

F. Discussion

Eleven *Amaurosoma* species have been found in Finland (Hackman 1956) but only *A. flavipes* and *A. armillatum* have been shown to be pests of timothy grass, although other species do occur in the leys. Nor have any other *Amaurosoma* species been found to cause damage to timothy

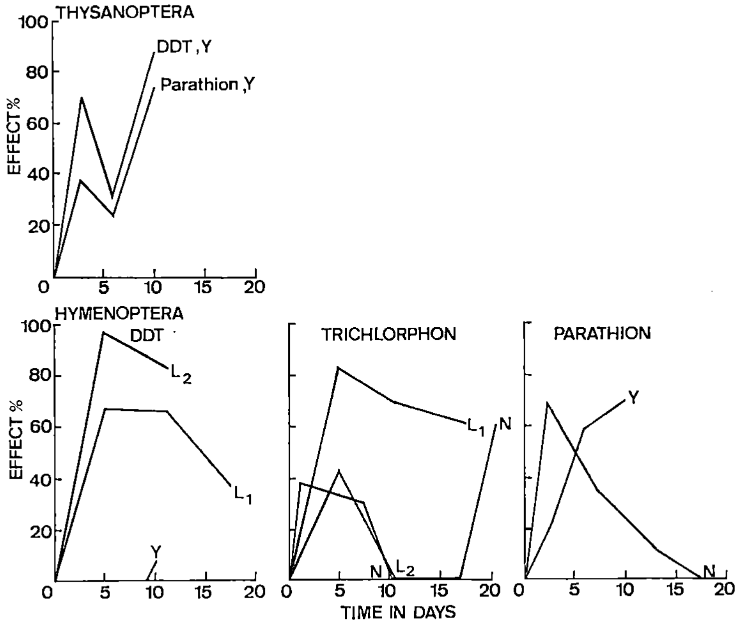

Fig. 11. Effects of insecticides on the numbers of specimens of different orders in the field stratum. Explanations of symbols in Fig. 8 and text.

in other countries. According to HACKMAN (1956) *A. armillatum* is commoner than *A. flavipes* in southern and central Finland, but according to the present study it is distinctly less common. The museum samples used by Hackman were chiefly gathered from meadows and old leys, whereas in the present investigation material from all habitats was used. This may help to explain the difference, for when all habitats are included *A. flavipes* proves to be the commoner species of the two, being concentrated in leys of 1—3 years of age, which used to cover c. 33 % of the arable land and 3 % of the whole land area of Finland.

In Finland the proportion of *A. armillatum* is greatest in the northwesternmost and most oceanic areas. When we consider the frequencies of the two species throughout their whole range, *A. armillatum* is concentrated in Europe in the most oceanic northwesterly parts, where in southwestern Sweden (BORG 1959) and the British Isles (BARNES 1935), for instance, it occurs in greater abundance than *A. flavipes*. In turn, *A. flavipes* is most common in the southeastern and southern areas, which are more continental, e.g. in Siberia, Soviet Russia, Poland, eastern Sweden, central Europe and eastern France (KARPOVA 1930, WAHL 1943, GOLEBIOWSKA 1949, BORG 1959, RICOU 1967).

According to the present investigation, and also according to BORG (1959), the life cycles of *A. flavipes* and *A. armillatum* are so alike that even if differences between them do exist, they are not of importance for purposes of control, at least not in Finnish conditions. However, there are differences in habitat. The proportion of *A. flavipes* is slightly greater on organic than on mineral soils but, according to the collection of over 14 000 specimens studied here, this difference is less great than that found in Sweden by BORG (1959), who was working with a few hundred specimens only.

The start of emergence depends on the thermal sum and varies by 1—2 weeks, which would be equivalent to a translocation of c. 500—1 000 km south. In the research area (c. 63°N) emergence began about 17 May; some 500 km south, in Sweden, it starts about 11 May

(BORG 1959), and some 1 300—1 400 km south, in central Europe, it begins at the end of April (WAHL 1943, AHNERT 1969), as it does in France some 2 000 km to the south but over 700 m above sea level (RICOU 1967).

According to KARPOVA (1930), WAHL (1943) and BORG (1959), the loss of yield in damaged ears amounts to c. 50 %, but in the British Isles, according to COGHILL and GAIR (1945), it is only 32 %. In Finland the figures are 51 % according to MANTERE (1937) and 48 % according to the present study. Length of ear of Finnish timothy varieties averages 4.9 cm, according to HEIKINHEIMO (1960), and that of the English S variety 7.1 cm, according to COGHILL and GAIR (1945). Judging by the above figures, the larvae destroyed the flowers to a distance of 2.3 cm in Finland and in the British Isles. The actual amount of damage is thus the same in both countries, but the percentage of damage is smaller in varieties with long ears than in those with short ears. Consequently, in breeding work it is worth aiming for long-eared varieties, in which the percentage of damage will be smaller.

Weather factors affect the abundance of timothy grass flies and the severity of the damage they do (e.g. AHNERT 1969). This could not be established in the present investigation, although data was available for a period of 78 years. Fluctuations in abundance were evidently not very great and perhaps not so regular as might be concluded from Fig. 6. They were very similar, however, to those in Sweden, even having the same rhythm (see BORG 1959). In Finland, however, the peak occurrence seems to have taken place about one year earlier than in Sweden.

At the beginning of the 1930s no effective method of controlling timothy grass flies was known in Finland (SAALAS 1933). Experiments, were then made on the value of sodium fluoride + sugar for control, and when this proved effective it was recommended in the mid—1930s. Two products containing sodium fluoride, called Syötti and Maistos, were put on the market, but do not seem to have been used at all generally. Sodium fluoride was still recommended in the 1950s and 1960s for the control of timothy grass flies (e.g. JAMALAINEN and KANERVO 1953, VAPPULA 1955 and KANERVO 1962, 1967), but its use has been prohibited since 1 September 1969.

DDT was available for agricultural purposes in 1946, and on the basis of experiments with dusting and spraying, was recommended from the start, for the control of timothy grass flies (HUKKINEN 1946). The most recent recommendations are from the 1960s (RAATIKAINEN 1968). Products containing DDT were never officially approved for this purpose, however, and since September 1969 their use has been prohibited.

It was possible to use lindane to control timothy grass flies right from the time it was put on the market in 1946. It was never officially approved for the purpose but was recommended in the 1950s (JAMALAINEN and KANERVO 1953, VAPPULA 1955). Since 1 September 1969 the use of this insecticide has also been prohibited in the control of timothy grass flies.

It was possible to use trichlorphon for the control of timothy grass flies from the time it was put on the market in 1959. The first experiments were made with it in 1961. It was not approved but has been recommended for this purpose (RAATIKAINEN 1963, 1968). The use of this insecticide in the control of timothy grass flies has been prohibited since 1 September 1969.

Parathion could be used to control timothy grass flies from the time it was marketed, in 1949, but it was not recommended for the purpose until the 1960s (RAATIKAINEN 1963), and is nowadays the only insecticide that is both permissible and economic for the control of timothy grass flies in Finland. According to profitability analyses, it is not economic to use parathion every year, but only when the number of damaged ears is estimated to have risen to c. 10 % or higher.

Parathion is effective on many pests but the control of the timothy grass flies cannot be combined with that of the gall midge *Contarinia* *kanervoi* Barnes (see RAATIKAINEN, SAVAS and TINNILÄ 1968), because *C. kanervoi* must be destoyed about three weeks later than timothy grass flies. Useful animals die as well as pests, for parathion is more effective against wide range of species than trichlorphon, for instance. Further study of the use of trichlorphon and the insecticides listed in Table 5 in the control of timothy grass flies is called for. These may provide very adequate control but in Finland the areas treated will probably always be very small, as only some 20 000 hectares have been used here annually for cultivation of timothy grass seed, and even of this only a very small part will probably be treated.

Attempts to control timothy grass flies include many other approaches besides treatment with insecticides (e.g. BARNES 1935, KING, MEIKLE and BROADFOOT 1935, MANTERE 1935, GOLEBIOWSKA 1949, MÜHLE 1953, BORG 1959, AHNERT 1969). Frequent attempts have been made to reduce the size of the populations by mowing or grazing the timothy, by ploughing or burning the stubble, by keeping the timothy ley for only 2—3 years, by destroying the subpopulations in the surrounding vegetation, etc. But it seems improbable that any of these methods even if temporarily successful, will have lasting effects (Fig. 7). Attempts have been made to reduce the yield loss by creating good conditions for the growth of timothy, e.g. by fertilization or melting the snow early, cultivating long-eared varieties or growing timothy on large continuous plots. The use of repellants has also been investigated, and resistant strains have been sought, but so far the best results have been obtained with insecticides.

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SELOSTUS

Timoteikärpästen ekologiasta, torjunnasta ja kemiallisen torjunnan vaikutuksista kenttäkerroksen eläimiin

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Keltakoipisen (*Amaurosoma flavipes*) ja kirjokoipisen timoteikärpäsen (*A. armillatum*) ekologiaa ja torjuntaa selvitettiin Länsi-Suomessa v. 1958—1965 ja levinneisyyttä sekä runsaudenvaihtelua koko Suomessa v. 1894—1971.

Molempia lajeja esiintyi napapiirin pohjoispuolella saakka (kuvat 1 ja 2). Keltakoipinen timoteikärpänen oli nuorten timoteinurmien ja kirjokoipinen vanhojen nurmien laji. Edellinen oli runsaampi ja kaakkoisempi (kuva 3). Sen osuus timoteikärpästen koko määrästä oli orgaanisilla mailla suurempi kuin kivennäismailla. Molempien lajien elämänkulku (kuvat 4 ja 5) oli samanlainen ja toukat vioittivat timotein tähkästä noin 48 % eli 3.2 cm.

Timoteikärpästen vioittamien timotein tähkien määrä oli suuri keskimäärin kahtena peräkkäisenä vuotena noin kuuden vuoden välein (kuva 6). Vioituksen ollessa keskinkertaista tai niukkaa vioittuneita tähkiä oli noin 5 %.

Metsien ympäröimillä aukeilla tehdyissä kokeissa keltakoipisen timoteikärpäsen F_1-polven yksilömäärä oli positiivisessa korrelaatiossa P-polven yksilömäärään. Molempien lajien populaatiot yritettiin hävittää lopettamalla timotein viljely tai käsittelemällä koko aukeat torjunta-aineilla. Populaatiot saatiinkin hyvin pieniksi, mutta yksilömäärä kohosi jokseenkin entiselleen noin kolmantena vuonna (kuva 7) timotein viljelyn alettua. Kestäviä lajikkeita ei todettu, mutta pitkätähkäisissä lajikkeissa satotappio jää pienemmäksi kuin lyhyttähkäisissä. Timoteikärpäsiin tehosivat mm. parationi, dimetoaatti, diklorfossi, bromofossi ja triklorfoni. DDT- ja parationikäsittelyt alensivat kenttäkerroksen hyönteisten yksilömääriä noin 70—80 % ja triklorfonikäsittely noin 50 % (kuvat 8—11). Edellisten aineiden vaikutus näkyi kauemmin kuin triklorfonin.

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Seria ANIMALIA NOCENTIA N. 58 — Sarja TUHOELÄIMET n:o 58

EXPERIENCES OF CUCUMBER GROWERS ON CONTROL OF THE TWO-SPOTTED SPIDER MITE TETRANYCHUS TELARIUS (L.) WITH THE PHYTOSEIID MITE PHYTOSEIULUS PERSIMILIS A.H.

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MARKKULA, M., TIITTANEN, K. & NIEMINEN, M. 1972. **Experiences of cucumber growers on control of the two-spotted spider mite Tetranychus telarius (L.) with the phytoseiid mite Phytoseiulus persimilis A.H.** Ann. Agric. Fenn. 11: 74—78.

In 1970, predatory mites were on sale in Finland for the first time. That year 120 growers, i.e. 22 % of all cucumber growers, used these phytoseiid mites to control the two-spotted spider mite. Replies to an inquiry showed that 55 % of these growers had succeeded in controlling the pest with predatory mites alone. The others had to use acaricides, the reason most frequently being that too few phytoseiid mites were placed on the plants at the beginning.

Those growers who succeeded in controlling two-spotted spider mites with phytoseiid mites alone reported that the results were clearly better than those previously obtained with chemical control, and that the costs were lover. They placed phytoseiid mites (3.5/m^2) av. 14 days after damage by the spider mite was observed and transferred phytoseiid mites to different parts of the crop av. 14 times during the growing season. Biolocigal control had cost 0.82 marks/m^2 and chemical control 1.11 marks/m^2. Of those who replied to the inquiry 95 % stated that they would continue to use the phytoseiid mites the following year.

Strictly speaking, the era of biological control of the spider mite actually began with the publication by DOSSE (1958) of the first results of laboratory investigations into the effectiveness of the phytoseiid mite *Phytoseiulus riegeli* Dosse (= *Phytoseiulus persimilis* Athias-Henriot) in the control of the two-spotted spider mite *Tetranychus telarius* (L.). In applications of the new biological method investigations in the laboratory and trials in actual nurseries in various countries generally gave favourable results (e.g. CHANT 1961, BRAVENBOER and DOSSE 1962, HUSSEY et al. 1965, KOCH 1965, BÖHM 1966, VOGEL 1966, BRAVENBOER 1969, GOULD et al. 1969, MCCLANAHAN 1970, PRUSZYNSKI et al. 1970, GOULD 1971). However, the method has not yet been regarded as ready for use by commercial growers (BRAVENBOER 1969, MCCLANAHAN 1970). Several articles intended for growers and advisers have been published in Finland (e.g. TIITTANEN 1968, NIEMINEN 1971) but the results have not been reported to an international readership.

The first phytoseiid mites in Finland were

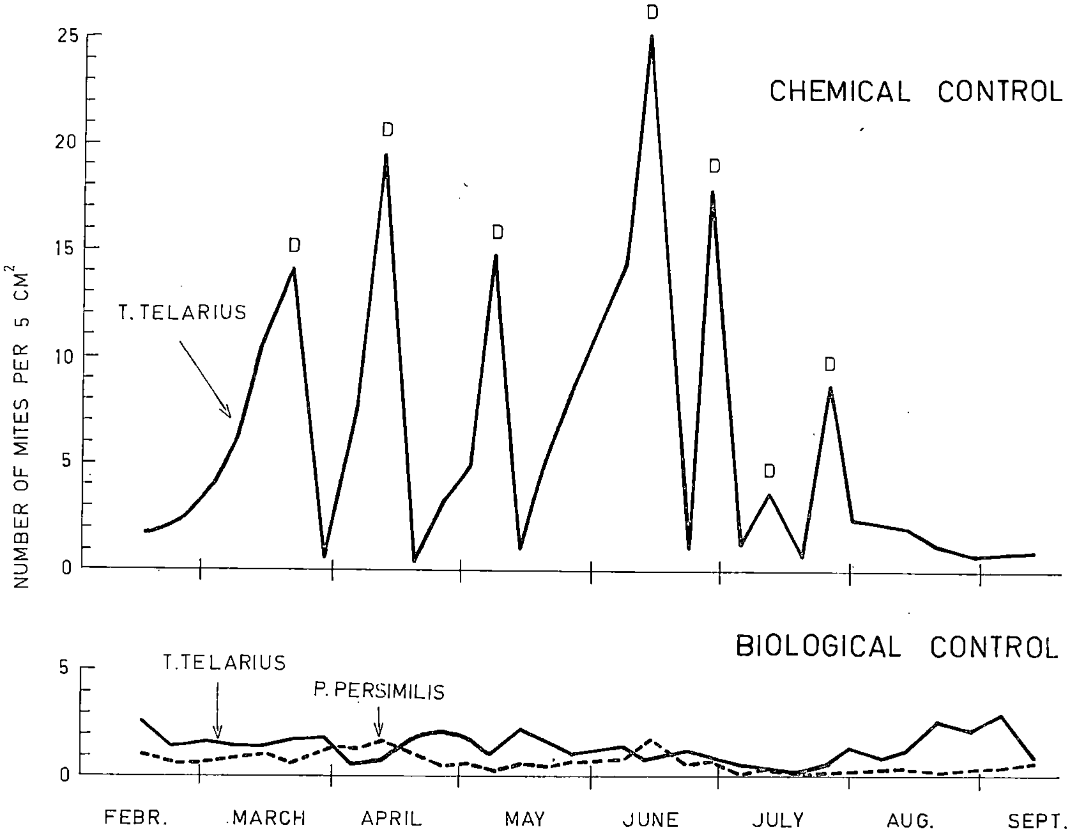

Fig. 1. The effect of chemical and biological control on the number of *Tetranychus telarius* in a commercial cucumber crop in 1967. Dicofol was used in the one part of the greenhouse when *T. telarius* increased to a level causing damage. *Phytoseiulus persimilis* were placed in the other part of the greenhouse immediately when the first traces of damage by *T. telarius* appeared and were transferred from one plant to another at weekly intervals. D = treatment with dicofol.

obtained from Switzerland (Dr. R. Maag AG, Dielsdorf) in autumn 1965. Subsequently, a population of phytoseiid mites of varying number was maintained on dwarf bean at the laboratories of the Department of Pest Investigation, and the relationship between the phytoseiid mite and the spider mite was investigated from many angles.

Experiments on the effect of the phytoseiid mite in commercial crops were started in February 1966 (Fig. 1). Since 1968, that is for 4 years, Mr. Lapila has used phytoseiid mites alone for control of the two-spotted spider mites in a cucumber nursery 1 600 m^2 in size.

After the investigations and practical trials carried out at the Department of Pest Investigation, production of the phytoseiid mite was started by the end of 1969 at the Biological Laboratory of Kemira Oy, producer of pesticides. At the beginning of the following year Kemira began to sell phytoseiid mites to growers. The predators were sold in packages of 100, with instructions prepared at the Department of Pest Investigation. At the first sign of damage by the two-spotted spider mite the predators were immediately to be placed on the cucumber plants. There was to be one predator to every 5—10 spider mites, the plants were to be examined once a week, and, when necessary, predators or prey were to be transferred from one plant to another.

Material and methods

At the end of 1970 the Department of Pest Investigation sent questionnaires to those cucumber growers who had purchased phytoseiid mites from Kemira Oy. In the questionnaire the growers were asked about their experiences with the chemical control of the two-spotted spider mite during the 5-year period 1965—1969, their estimate of the yield losses, the number of treatments, the cost and the results of the treatment, and the types of acaricides which had been used. In addition, they were asked to state the cost of chemical control of other cucumber pests. In the questions concerning 1970, the growers were asked when the spider mites were first observed and when the phytoseiid mites were placed on the plants, the number of phytoseiid mites purchased, how often they were transferred to different parts of the crop, the cost and the result of the control method, whether pesticides were used in addition to phytoseiid mites, and whether the grower intends to continue with biological control of two-spotted spider mites in the coming growing season. The purpose of the inquiry was to obtain information about the experiences of the growers and suggestions on how to improve the control method.

In Finland, cucumbers are grown in greenhouses, the total area in 1970 being 45 hectares. Of some 500 growers, 120, i.e. 22 %, bought predatory mites. Replies were obtained from 81 growers, i.e. from 62 % of those who bought predators. They have used phytoseiid mites on 6.7 hectares, i.e. 16 % of the total area.

Results

Chemical control

The growers estimated the yield loss caused by the two-spotted spider mite without control at 59 %. During the 5-year period 1965—1969, according to the answers, cucumbers were treated with pesticides nine times during a growing season on average. Yield losses were heavy notwithstanding chemical control and only 1/4 of the growers reckoned that the result of such control was good. The cost of chemical control was 0.75 marks/m² per growing season (Table 1). The acaricides azobenzene, dicofol and kinomethionate were the chief chemicals used for the control of the two-spotted spider mite.

On average, control of other pests of cucumber cost 0.15 marks/m² per growing season (Table 1). Thrips were the other pests most frequently mentioned.

Table 1. Growers' experiences of chemical control of cucumber pests during the 5-year period 1965—1969.

	Replies	Average	S.D.
Control of two-spotted spider mite			
Yield loss without control . .	70	59 %	20.22
Number of treatments	71	8.7	6.70
Yield loss with control . . .	63	20 %	12.61
Costs in Fmks/m²:			
Pesticides	64	0.52	0.55
Labour	49	0.23	0.49
Total		0.75	
Result of chemical control: .	75		
Good		23 %	
Satisfactory		61 %	
Poor		16 %	
Control of other cucumber pests			
Costs in Fmks/m²:			
Pesticides	81	0.07	0.28
Labour	81	0.08	0.39
Total		0.15	

Table 2. The costs and the results of chemical and biological control of the two-spotted spider mite. These data were obtained from the 34 growers who used no acaricides for the control of two-spotted spider mites.

	Chemical control 1965—1969		Biological control 1970	
	Average	S.D.	Average	S.D.
Costs in Fmks/m²:				
Pesticides				
Phytoseiid mites	0.65	0.72	0.54	0.84
Labour	0.46	0.77	0.28	0.45
Total	1.11		0.82	
Result of control:				
Good	10 %		70 %	
Satisfactory	70 %		30 %	
Poor	20 %		—	

Biological control

The two-spotted spider mites were controlled with phytoseiid mites alone on 34 crops, i.e. 55 % of the growers who answered this question had been successful. On those crops the phytoseiid mites had been placed on the plants, on the average, 14 days (S.D. 15.4) after damage by the spider mite was observed. On average, 3.5 (S.D. 5.3) phytoseiid mites were placed on each m^2 and they were transferred to different parts of the crop 14 times (S.D. 34.0) during the growing season. The growers estimated that biological control was cheaper than chemical control. Biological control on these crops had cost 0.82 marks/m^2 and the annual cost of chemical control during the 5-year period was 1.11 marks/m^2. The results of biological control were clearly better (Table 2).

On the other 28 crops pesticides had to be used. The most important reason for failure of biological control was that too few phytoseiid mites had been placed on the crops at the start, on average only one per m^2 (S.D. 0.9).

Of the 81 growers who replied to the inquiry, 95 % stated that they would continue with biological control in the coming growing season.

Discussion

The figures obtained from the inquiry are based chiefly on estimates and at best are only approximations. The dispersion of the figures is naturally wide, for many reasons.

In appraising the success of chemical control it must be borne in mind that some growers treat their plants regularly at intervals of 7 or 10 days, whereas others spray only when damage is obvious. There are also many cases between these extremes. The data indicate that control of the two-spotted spider mite is a difficult problem for cucumber growers, and is not wholly solved by the use of pesticides.

With four exceptions, the reports on the use of the phytoseiid mite were from growers employing the predators for the first time. They started biological control on their own initiative on the basis of the brief instructions and perhaps some newspaper articles and lectures. The advice given in the instructions was of necessity fairly general in character.

For many reasons two-spotted spider mites appear on cucumber plants at very different times, often immediately after these have been transplanted but frequently not until several weeks later. Some growers noticed the spider mites and the damage they caused immediately, others not until the plants were showing yellowed leaves. Consequently, the predators were placed on the plants at very different times, usually too late. Some growers examined the plants every day and moved the phytoseiid mites and spider mites frequently enough, others not at all or only a few times.

It is clear that a high proportion of the growers were able to make effective use of phytoseiid mites for the control of two-spotted spider mite on greenhouse cucumbers. Thus the situation in Finland differs from that reported some time ago in Holland (Bravenboer 1969) and, according to M. J. Wyatt, from that in England (McClanahan 1970). The great interest in the biological control of the two-spotted spider mite in Finland is shown by the fact that 95 % of the growers who replied to the inquiry have stated that they will continue to use the predators. With increasing experience among growers, the results are sure to be better than in the first year.

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SELOSTUS

Vihannespunkin biologinen torjunta kasvihuoneissa

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Petopunkin käyttöä kasvihuoneviljelysten pahimman tuholaisen vihannespunkin torjuntaan on tutkittu eri puolilla maailmaa useiden vuosien ajan. Tulokset ovat olleet enimmäkseen myönteisiä, mutta käytäntöön ei menetelmä juuri ole päässyt.

Tuhoeläintutkimuslaitoksessa aloitettiin tutkimukset vuonna 1965. Useiden vuosien aikana järjestettiin kokeita viljelijöiden kurkkuhuoneissa, ja tulokset olivat hyviä. Kemira Oy aloitti petopunkin massalisäämisen vuonna 1969 ja myynnin vuonna 1970.

Vuoden 1970 aikana osti yli 500 kurkunviljelijästä 120 eli 22 % petopunkkeja ja ryhtyi vihannespunkin biologiseen torjuntaan. Kasvukauden lopulla Tuhoeläintutkimuslaitos lähetti petopunkkeja ostaneille viljelijöille tiedustelun, jossa kysyttiin kokemuksia vihannespunkin kemiallisesta ja biologisesta torjunnasta.

Viljelijöiden antamien vastausten mukaan on vihannespunkin aiheuttama sadon menetys ilman torjuntaa 59 %. Torjunta-aineiden käytöstä huolimatta on sadonalennus 20 %.

Vihannespunkin torjunta pelkästään petopunkkien avulla onnistui 55 %:lla viljelyksistä. Torjuntatulos oli parempi ja kustannukset halvemmat kuin edellisenä viisivuotiskautena kemiallista torjuntaa käytettäessä. Näillä viljelyksillä petopunkit (keskim 3.5/m^2) sijoitettiin kasvustoon keskimäärin 14 vrk:n kuluttua vihannespunkin vioituksen ilmaantumisesta ja niitä siirrettiin kasvukauden aikana keskimäärin 14 kertaa. Kustannukset olivat 0.82 mk/m^2; aikaisemmin kemiallista torjuntaa käytettäessä 1.11 mk/m^2.

Viljelijöiden kokemukset petopunkin käytön tehokkuudesta olivat yleensä myönteiset. He arvostivat suuresti sitä, ettei tarvinnut huolehtia varoajoista eikä pelätä kasvien vioittumista torjunta-aineiden vaikutuksesta. Viljelijöistä 95 % ilmoitti jatkavansa biologista torjuntaa seuraavana kasvukautena.

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Seria PHYTOPATHOLOGIA N. 34 — Sarja KASVITAUDIT n:o 34

STRAWBERRY POWDERY MILDEW AND ITS CONTROL ON ZEPHYR STRAWBERRIES

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TAPIO, EEVA 1971. **Strawberry powdery mildew and its control on Zephyr strawberries.** Ann. Agric. Fenn. 11: 79—84.

The powdery mildew of strawberries (*Sphaerotheca macularis* (Wall. ex Fries) Jaczewski) is noticeably more abundant in coastal areas of Finland than inland. Large temperature fluctuations, the resulting variations in relative humidity and lack of rain favour mildew infection. Several fungicides were tested in 1970 and 1971 to determine their effectiveness in controlling powdery mildew on the susceptible Zephyr-strawberry variety.

Of the fungicides tested, benomyl controlled mildew most effectively, and gave the greatest yield increases when the results of both years were taken into account. The other fungicides — captan+sulphur, dichlofluanid, dinocap, folpet and quinomethionate — proved effective the first year (1970), but did not give satisfactory control during the second year, when mildew was particularly severe in the experimental area. Benomyl is thus well suited for the control of strawberry powdery mildew, since its use also gives quite good control of strawberry grey mould.

Introduction

Powdery mildew of strawberries (*Sphaerotheca macularis* (Wallr. ex Fries) Jaczewski) does not generally cause much damage in Finnish strawberry plantings. However, RAINIO (1930) mentions having found it in many areas in the central and southern parts of the country. Resistance to the disease varies considerably among different varieties (cf. PERIES 1961). Early varieties are generally more susceptible than late ones. Of our previously cultivated varieties, Deutsch Evern and Macheraus Frühernte were susceptible to mildew, as HAEGERMARK (1961) has found in Sweden. Powdery mildew and its control have now come to the fore again as the cultivation of the early and heavy-yielding Danish variety Zephyr increases. Senga Precosa, cultivated to a limited extent, is also rather susceptible to mildew.

Materials and methods

The experimental area was situated at Rilaxholm, Kirkkonummi, on the coast of the Gulf of Finland. It was on a gently sloping hillside with a southern exposure. Observations were also made in several localities, mostly inland. Since there was no weather recording equipment at Kirkkonummi, comparisons of the years 1970 and 1971 are based on data from the nearest weather station at Seutula, about 40 km northeast of the experimental area and about 20 km from the coast. In addition, weather observations

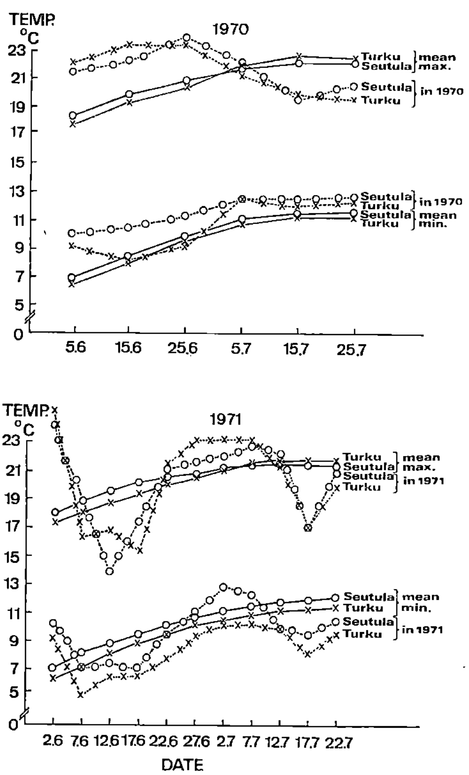

Fig. 1. Mean maximum and minimum temperatures at flowering and fruiting time in 1970 and 1971, and 30-year mean (1941—1970).

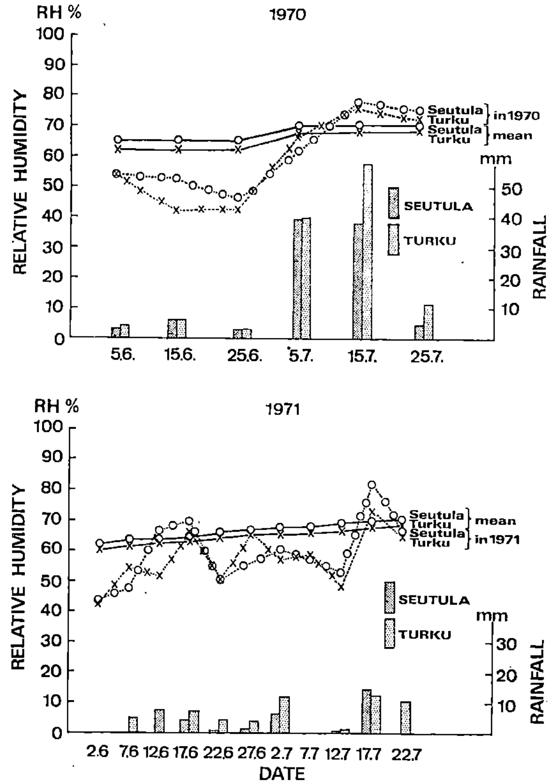

Fig. 2. Relative humidity (%) and rainfall (mm) at strawberry flowering and fruiting time in 1970 and 1971, and 30-year mean (1941—1970).

from the coastal stations at Turku were compared with those from Seutula.

Experiments to study the effectiveness of various fungicides were made on a plantation of Zephyr strawberries. In the plantation, the rows were about 80 m long, spaced at 1 m, and provided with a black plastic mulch. The experimental plots each consisted of single 10 metre rows. There were four replicates in 1970 and six in 1971. Sprayings began when flowering started on 8.6. and was repeated at weekly intervals taking into account the waiting periods for the various fungicides. In 1970 the mean daily temperature on the treatment days was 22°C; in 1971, 18° and 19°C on the first two days of spraying and 24°C on the third. The fungicides were applied with an atomizing motor sprayer using 5 times the normal concentrations and 4 l of spray per 100 metres. Berries were picked and the fruit analyzed 6 times each year, starting on 3. and 4.7. and finishing on 22.7. Seawater was given by trickle irrigation at fruiting time.

The occurrence of powdery mildew and factors affecting it

The local abundance and time of powdery mildew infection are closely dependent upon conditions — above all temperature and humidity — predominating in the growing site. According to Peries (1961), the optimum temperature for strawberry powdery mildew is 20°C, infection occurs from 5—30°C and the conidia develop between 15 and 30°C. The disease has appeared rather frequently since the establishment of the plantation at Kirkkonummi in 1968, as well as other Zephyr plantations further west along the coast. Infection was particularly severe in 1971. Only 20 kilometres or

Table 1. The development of the yield and powdery mildew of strawberries at Kirkkonummi a) in 1970, b) in 1971. Rainfall during the flowering and fruiting time in 1970 about 100 mm, in 1971 about 15 mm in total (normally 70 mm)

a) Treatment	Date					
	3. 7.	6. 7.	9. 7.	13. 7.	16. 7.	22. 7.
	Total yield kg/a (a = 100 m²)					
Benomyl	24.5	53.0	76.7	99.3	105.9	110.5
Captan + sulphur	25.4	52.8	78.8	102.7	108.6	114.8
Dichlofluanid	25.4	53.0	77.7	102.0	108.3	116.0
Dinocap	26.5	57.4	85.6	111.8	117.9	122.9
Folpet	30.3	62.3	87.7	115.3	111.4	131.1
Quinomethionate	26.5	56.6	81.9	105.0	122.3	116.8
Control	24.3	50.4	74.1	97.0	104.3	110.1
	Mildew berries kg/a					
Benomyl	0.0	0.4	0.5	0.8	1.1	1.8
Captan + sulphur	0.1	0.1	0.1	0.1	0.1	0.7
Dichlofluanid	0.1	0.1	0.2	0.2	0.3	0.7
Dinocap	0.4	0.9	1.3	1.4	1.7	2.2
Folpet	0.0	0.1	0.5	0.7	0.9	1.4
Quinomethionate	0.0	0.0	0.0	0.1	0.2	0.5
Control	2.5	5.4	12.2	19.7	23.1	26.0

b) Treatment	Date					
	4. 7.	6. 7.	8. 7.	11. 7.	15. 7.	22. 7.
	Total yield kg/a (a = 100 m²)					
Benomyl	2.0	4.8	18.2	41.0	83.6	110.4
Dichlofluanid	1.9	4.1	14.1	33.3	66.9	91.3
Dinocap	1.6	3.9	13.0	31.1	77.5	100.6
Folpet	1.6	3.9	13.0	31.1	77.5	99.9
Quinomethionate	2.1	5.5	14.3	31.5	81.9	97.9
Control	1.8	4.3	15.0	23.8	71.5	98.9
	Mildew berries kg/a					
Benomyl	0.2	0.8	3.6	8.3	25.6	52.7
Dichlofluanid	0.8	1.2	3.4	7.3	24.3	47.0
Dinocap	0.5	1.8	6.7	18.1	58.5	81.5
Folpet	1.1	2.3	7.7	21.2	48.6	71.2
Quinomethionate	0.2	0.5	2.6	5.9	20.4	48.3
Control	1.1	3.4	12.6	28.5	61.0	89.0

more from the coast, powdery mildew has not been found on fruit and usually is not found on the leaves until the end of harvest. Daily temperature fluctuations on the coast in early summer are greater than inland (Fig. 1). The low night temperatures caused by sudden cooling of the air give rise to a higher relative humidity régime than inland. This favours the germination of powdery mildew conidia (cf. Yarwood 1957). It does not, according to Peries (1961), have any effect on the development of infection or upon mycelial growth. Rapid transpiration during the warm and often windy days on the coast lowers cell turgor pressure and promotes the penetration of the germ tube into the epidermal layer (Howard and Horsfall 1960). On the other hand, some workers (eg. Yarwood 1957) have found that powdery mildew thrives in stagnant air in greenhouses better than in the open. This, however, may be due to other factors such as temperature and light.

In a given location, variations in climatic conditions in different years can affect decisively the infection time and intensity of a powdery mildew outbreak. Weather conditions in 1970 and 1971 differed considerably (Figs. 1 and 2).

Table 2. Effect of several fungicides on strawberry powdery mildew a) in 1970, b) in 1971

a) Treatment	Waiting period days	No. of appli- cations	Rate per applic. product %	act. ingr. g/a	Total yield kg/a	Marketable yield kg/a	Ratio	Diseased fruit %	Per cent mildew on foliage 5. 8.	15. 8.
Benomyl	7	3	0.04	4	110.5	109.3	130	1.1	64.0	71.5
Captan+sulph.	4	3	0.4	32+93	114.8	114.0	136	0.7	54.5	68.3
Dichlofluanid	14	2	0.25	25	116.0	115.3	137	0.7	46.0	55.8
Dinocap	21	1	0.05	2.25	122.9	120.6	143	1.9	53.5	62.8
Folpet	1	3	0.2	20	131.1	129.6	154	1.1	57.5	64.8
Quinomethionate	14	2	0.05	2.5	116.7	116.2	138	0.4	38.2	49.0
Control	—	—	—	—	110.1	84.1	100	23.6	84.5	85.6
F-value							8.6***	23.3***	8.7***	3.74*
LSD							21	5.5 %	15.2 %	18.0 %

b) Treatment	No. appli- cations	Rate per applic. product %	act.ingr. g/a	Total yield kg/a	Marketable yield kg/a	Ratio	Diseased fruit %	Per cent mildew on foliage 13. 7.	10. 8.
Benomyl	3	0.06	6	110.4	61.4	602	44.3	25.3	95—100%
Dichlofluanid	2	0.25	25	91.3	43.6	424	52.1	26.7	»
Dinocap	1	0.06	2.7	100.6	19.2	188	80.8	40.7	»
Folpet	3	0.2	20	99.9	28.7	281	71.2	47.5	»
Quinomethionate	2	0.05	2.5	97.8	49.7	487	49.0	25.7	»
Control	—	—	—	98.9	10.2	100	89.5	67.0	»
F-value						15.16***	53.27***	44.7***	
LSD						140	7.4%	7.1%	

In 1970, June (flowering time) was considerably warmer and drier than usual. Temperatures did not vary much (Fig. 1). At fruiting time, temperatures were below average, and the approx. 100 mm rainfall considerably exceeded the average of 70 mm (Fig. 2). Abundant rainfall or a persistent water film have been found to prevent powdery mildew infection (Rogers 1959, Hawker 1960) and even to destroy conidia within 8 hours (Peries 1961). Thus in 1970 mildew increased slowly and was easily controllable with the fungicides (Table 1 a).

In 1971, the first week of June was very warm, but temperatures fell to considerably below normal in the middle of the month (flowering time). The relative humidity rose sharply at this time (Figs. 1 and 2). Temperatures increased and the humidity fell rapidly again at the end of the month. The weather at fruiting time was warm and dry except for a cold spell during the last week of picking. The rainfall at this time was low, altogether about 15 mm (normally 70 mm). The relative humidity levels were also below average (Fig. 2). According to local observations, however, the humidity did rise when night temperatures fell to very low values. The lack of rain, the sudden variations in temperature and humidity and the windy weather apparently provided the right conditions for a severe outbreak of powdery mildew at this site in 1971 (cf. Madsen and Thuesen 1965) (Table 1 b). Plants in the area surrounding the plots had been irrigated once with 30 mm of fresh water. This irrigation decreased to some extent the severity of the powdery mildew on the strawberries in this area.

Control experiments with fungicides

In 1970, all the fungicides used were effective against powdery mildew (Table 2a). These were benomyl (Benlate), captan+sulphur (Orthocide 20), dichlofluanid (Euparen), dinocap (Karathane), folpet (Ortho Phaltan) and quinomethionate (Morestan). In the treated plots, berry mildew scarcely appeared at all. Yield increases due to fungicidal control of powdery mildew were significant and were greatest with

Table 3. Residue analysis of strawberry fruits sprayed for powdery mildew control

Treatment	No. of applications	Rate per applic. g a.i./a	Waiting period days	Interval treatmentanalysis days	Residue ppm	Highest permitted residue ppm
Benomyl	3	6	7	8	0.6	2.0
Dinocap	1	2.7	21	19	0.7	1.0
Quinomethionate	2	2.5	14	14	0.2	0.3

the folpet treatment. After harvest mildew increased greatly and fungicidel applications on 5.8. failed to give significant control.

In the 1971 experiments, benomyl, quinomethionate and dichlofluanid were most effective against powdery mildew (Table 2 b). Folpet and particularly dinocap were relatively ineffective. Dinocap was noticeably effective during the first two pickings but because of the required waiting period single application had no effect after a month. Only the benomyl-treated strawberries gave a much higher total yield than the controls (cf. SCOTT et al. 1970). Dichlofluanid gave lowest total yield, and the other fungicides had no effect on total yield. In Norway, GJAERUM (personal communication) has found that dichlofluanid has a phytotoxic effect on Zephyr strawberries. In Denmark, benomyl has proved slightly more effective than other fungicides against powdery mildew (NØDDEGAARD et al. 1970).

The distribution of berry yields with time was noticeably different in 1970 and 1971 (Table 1). In the first year, more than 90 % of the yield was picked within the first 10 days. The flowering and early fruiting period was warm, becoming cooler and wetter only after picking started. In the second year, development was considerably slower, and only about half the berries ripened during the first 10 days. The weather was very cool and dry at flowering time. It became suddenly warmer when the berries ripened, but cooled down again during the last week of picking.

None of the residues (Table 3) exceeded the tolerance limits on strawberries treated with benomyl, dinocap or quinomethionate when the respective time intervals between treatment and picking had been allowed.

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SELOSTUS

Mansikanhärmä ja sen torjunta Zefyr-mansikasta

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Mansikanhärmää (*Sphaerotheca macularis* (Wallr. ex Fries) Jacz.) on todettu esiintyvän eteläisellä ja lounaisella rannikkoalueella huomattavasti runsaammin kuin sisämaassa. Suuret lämpötilan vaihtelut, tästä johtuvat relatiivisen kosteuden vaihtelut sekä vähäsateisuus edistivät härmän runsasta esiintymistä vuonna 1971. Kirkkonummella Zefyr-mansikalla suoritetuissa fungisidien vertailevissa kokeissa tehosi benomyyli parhaiten härmään ja lisäsi eniten marjasatoa. Muut härmän torjunta-aineet: kaptaani+rikki, diklofluanidi, dinokappi, folpetti ja kinometionaatti osoittautuivat ensimmäisenä koevuonna 1970 tehokkaiksi, mutta eivät antaneet tyydyttävää torjuntatulosta toisena vuonna, jolloin härmän esiintyminen oli poikkeuksellisen runsasta. Benomyyli soveltuu senkin vuoksi hyvin mansikanhärmän torjuntaan, koska se samoja kukinnanaikaisia ruiskutusaikoja käytettäessä tehoaa sangen hyvin myös mansikan harmaahomeeseen.

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Seria PHYTOPATHOLOGIA N. 35 — Sarja KASVITAUDIT n:o 35

FUNGICIDAL CONTROL OF STRAWBERRY GREY MOULD (BOTRYTIS CINEREA PERS.)

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Tikkurila, Finland

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TAPIO, EEVA 1971. **Fungicidal control of strawberry grey mould (Botrytis cinerea Pers.).** Ann. Agric. Fenn. 11: 85—93.

The results of experiments conducted over a period of several years in the Department of Plant Pathology for the control of strawberry grey mould agree with those made in many other countries. The best control is obtained by spraying three times during the flowering period with dichlofluanid or benomyl. The third treatment of dichlofluanid can be replaced with captan, folpet or thiram to minimize the higher toxicity and avoid the long waiting time between final application and fruit harvest that is required for dichlofluanid. However, strawberries grown under cloches for one month before the first treatment were injured by benomyl. Benomyl gave very good control and dichlofluanid good control of strawberry leaf spot diseases. When the required interval between final application and harvest was observed residues on fungicide-treated berries did not exceed the tolerance limits.

Introduction

In Finland, about 900 ha of strawberries are grown in addition to some cultivation for home use. Production is mainly concentrated in three areas, Southwest, Southeast and East-central Finland (aprox. 63°30'N). Recent contracts between growers and processors will increase the strawberry area.

Grey mould caused by the fungus *Botrytis cinerea* Pers. is the most serious strawberry disease in Finland as in many other countries. Rainfall during the two months' (c. 10.6.—10.8.) flowering and ripening time, an important factor in grey mould development, is normally about 150 mm. It varies, of course, considerably from year to year and also to some extent in different parts of the country. At present, effective control of grey mould can be obtained only by the use of fungicides. Chemical control trials have been conducted continuously by the Department of Plant Pathology since 1956.

Material and methods

Field trials were conducted from 1956—1959 with the cultivars Ydun, Rubin and Bliss which have soft berries susceptible to grey mould, and during the last ten years with Senga Sengana which is also rather sensitive although its berries are more firm.

In experiments conducted at Tikkurila the plots were single rows 4 metres long and in

Table 1. Effect of fungicides on *Botrytis* rot of strawberry fruits at Piikkiö in 1965

Treatment	No. of applications	Rate per applicat. g a.i./a =100 m²	Senga Sengana			Pocahontas		
			Ratio of healthy yields	% of diseased fruits	mean berry weight g	Ratio of healthy yields	% of diseased fruits	mean berry weight g
Dichlofluanid spray	3	25	208	15.0	12.8	140	2.0	11.8
Dichlofluanid dust	3	15	166	20.0	13.9	94	7.0	11.2
Thiram spray	3	32	163	23.0	12.7	109	7.0	10.8
Control	—	—	100 (77.0 kg/a)	43.0	12.8	100 (83.0 kg/a)	9.0	11.5
F-value			6.86**	51.38***		4.24*	3.82*	
LSD			21	5.7%		28	5.0%	

trials conducted in growers fields from 1970—1971 were single 10-metre rows. Each treatment was replicated four or five times.

Treatments were applied two, three or four times during the flowering period (cf. Powelson 1960 and Jarvis & Borecka 1968): at early, full and late flowering stages. These treatments were applied on the average, at 8 day intervals. The fourth treatment, when used, was applied at least one week before picking when fungisides with a week's waiting time or less were used.

In the 1950's, treatments were carried out with a hand-operated hydraulic knapsack sprayer (Ginge M 37) and later with an atomizing motor sprayer (Solo Combi 423). 2 000 l of 0.25 % dichlofluanid spray liquid per hectare (20 l per 100 metres of row), were applied with the former 400 l at 5 × concentration per hectare with the latter. In a trial conducted in 1967 (Table 4), the effectiveness of dichlofluanid applied by these two spraying methods was studied. In a 1971 trial (no. VI, Table 3), a tractordriven motor sprayer was used. It had a five metres' spray width with three nozzles per row. The sprayed areas each contained five 100-metre rows. Four 10-metre sections were cut for four respective plots from these five rows.

In the experiments at Tikkurila, the healthy and mouldy berries were both counted and weighed separately. In the other trials, they were only weighed at picking time. There were six to eight pickings in the various trials.

Results

The effects of various fungicides

The field trials conducted in the 1950's mostly involved study of the relative effectiveness of captan and thiram. The results varied in different experiments (Tapio 1958), but on the average captan was more effective than thiram (cf. Glaeser 1963). Captan was, however, found to give an off-flavour both to strawberry preserves and to bottled fruit, but this was not definite in fresh and deep frozen berries (cf. Kirby et al. 1967 and Grishner et al. 1970). The treatments also reduced *Rhizopus* infection in thawing berries (Tapio 1958).

Table 2. Effect of various fungicides on yields of healthy strawberries in trials at Tikkurila in 1965—1969

Fungicide applied	Yields of disease-free strawberries relative to those from non-treated plots				
	1965	1966	1967	1968	1969
Benomyl	—	—	—	104	107
Captan	101	79	112	103	83
Dichlofluanid ...	120	110	111	142	104
Dichl.+thiram ..	—	111	111	121	—
Folpet	—	84	95	117	103
Thiram	129	92	89	116	—
Control	100	100	100	100	100

The effect of dichlofluanid on strawberry grey mould has been examined since 1965. In trials conducted at the Department of Horticulture in Piikkiö, the increase in yield and decrease in grey mould strawberries treated with dichlofluanid were significantly better than on those treated with thiram. This was especially the case with the susceptible cultivar Senga Sengana (Table 1). Dichlofluanid was also most effective in the trials performed at the Department of Plant Pathology at Tikkurila from 1965—1969 (Table 2). The effects of captan, folpet and thiram were very variable and in some years decreased yields, especially in 1966 when a double strength spray was applied in the first of the three treatments. The reduction in yield is probably caused by the phytotoxicity of these fungicides (cf. EATON and CHEN 1969). It was particularly apparent when the *Botrytis* infection was slight. The differences within these trials were not significant.

Benomyl is the only systemic fungicide which has been examined by us for strawberry disease control. It has been compared mostly with dichlofluanid (Table 3) since 1968. Benomyl was usually applied three times, but the third treatment of dichlofluanid was usually replaced by thiram owing to the higher toxicity and the longer waiting period recuired following dichlofluanid application. Three dichlofluanid applications were not, on the average, any more effective than two of dichlofluanid + one of thiram. The increase in yield and decrease in grey mould were slightly better in plots treated with dichlofluanid than in those treated with benomyl, especially in years of heavy *Botrytis* infection. The differences were not, however, significant in any single trial, thus benomyl and dichlofluanid must be considered to be equally effective for the control of *Botrytis* rot on field grown strawberries. Thiram used alone was less effective than the above two.

Number of treatments

The significance of a fourth application of fungicide was examined in two trials in 1971

Table 3. Effects of several fungicides on *Botrytis* rot and yields of strawberry fruits in trials conducted in growers fields from 1968—1971

Treatment	No. of applications	Rate per applicat. g a.i./a =100 m²	Ratio of healthy strawberry yields in trials no. I	II	III	IV	V	VI	VII	*Botrytis* infection in % in trials no. I	II	III	IV	V	VI	VII
Benomyl	3	4	—	154	110	—	—	—	—	—	4.6	1.2	—	—	—	—
Benomyl	3	6	—	—	—	121	111	183	126	—	—	—	5.5	0.7	6.2	9.8
Benomyl	4	4	—	—	—	126	119	—	—	—	—	—	8.1	1.0	—	—
Benomyl	2	4														
+Thiram	1	32	178	—	—	—	—	—	—	9.2	—	—	—	—	—	—
Dichlofluanid	3	25	—	163	111	140	109	—	—	—	3.6	0.4	2.7	0.4	—	—
Dichlofluanid	2	25														
+Thiram	1	32	182	—	116	128	108	183	134	8.2	—	0.6	3.6	0.6	7.7	7.3
Dichlofluanid	2	25														
+Thiram	2	32	—	—	—	137	115	—	—	—	—	—	3.8	0.6	—	—
Thiram	3	30	—	—	110	—	—	149	—	—	—	1.2	—	—	15.7	—
Control	—		100	100	100	100	100	100	100	12.8	5.4	3.3	14.5	2.9	26.8	23.8
Control yield kg/a			60.4	77.1	154.8	122.6	143.3	53.8	85.5							
F-value			7.92*	55.4***	1.2	3.48*	1.45	22.56***	2.9	—	—	8.4***	10.3***	8.7***	30.2***	13.9***
LSD			15	27	—	23	—	26	—	—	—	0.9	4.1	1.0	5.5	7.1

Table 4. Comparison of methods of applying dichlofluanid on strawberry yields and *Botrytis* control 1967

Treatment	Rate per applic. per a (= 100 m²) g a.i.	litres of water	Ratio of healthy yields	% disease berries
Hand-operated hydraulic knapsack sprayer	25	20	159	1.4
Atomizing motor sprayer	25	4	154	1.2
Control	—	—	100[1])	7.7
F-value			20.5***	
LSD			9	

[1]) 105.2 kg/a.

(Table 3, no. IV and V). In both trials a fourth application of benomyl or a second of thiram following two applications of dichlofluanid increased the yield to some extent, but did not decrease grey mould noticeably. The differences in yield were not significant. Rainfall was, however, only half of normal at flowering time in 1971.

Spray method

The influences of the type of sprayer used and the amount of spray liquid on the effectiveness of dichlofluanid were examined in an experiment conducted at the South Savo Agricultural Experiment Station. 2.5 kg of active ingredient were applied per hectare (kg a.i./ha), either in 2 000 litres water with a hand operated hydraulic knapsack sprayer or in 400 litres with an atomizing motor-sprayer. The increase in yield of healthy berries and the decreass in diseased berries was of the same order with both methods (Table 4, cf. NORDBY 1969).

The size of berries

Of the fungicides, examined only captan reduced the size of strawberry fruits (Table 5). Dichlofluanid, contrary to the results of some other studies (FREEMAN 1966, FREEMAN and PEPIN 1968), increased fruit size slightly (Tables 1 and 5) as BORECKA (1971) has observed. The slight effectes of benomyl and thiram in reducing berry size were not significant.

The development of fruits and of Botrytis rot in treated and control plots during the picking period

The total strawberry yield from control plots was greater in the two first pickings than from benomyl-treated plots and sometimes greater than that from dichlofluanid-treated plots (Fig. 1 and 2 b). It was not, however, greater than the yield from thiram-treated plots. BORECKA (1971) likewise noticed that berries from plots sprayed with benomyl ripened nearly one week later than those from other treatment plots. The amount of diseased fruit was greatest in the middle of the picking period. This maximum occurred some days after the only heavy rainfall during the very dry midsummer of 1971. In the middle, and especially at the end of the picking season, the yield from the control plots was

Table 5. Effects of several fungicides on the size of strawberry fruits in trials at Tikkurila from 1968—1971

Treatment	No. of appl.	Rate per appl. g a.i./a	Pocahontas 1965	Size of strawberry fruits in various years (grammes) Senga Sengana: 1965	1968	1969	1970 (open)	1970 (cloche)	1971 (open)	1971 (cloche)	1968—1971 aver.
Benomyl	3	4	—	—	7.5	7.1	7.4	7.1	7.7	6.2	7.17
Dichlofluanid	2	25	11.2	13.9	8.1	7.5	7.9	7.5	8.4	6.5	7.65
Thiram	3	32	11.5	12.8	7.7	7.2	7.4	7.3	7.8	6.2	7.27
Captan	3	25	—	—	7.8	7.0	7.1	6.9	7.6	5.9	7.05
Control	—	—	11.8	12.8	7.7	7.1	7.3	7.5	8.5	6.4	7.42
F-value							37.08***				6.88***
LSD g							0.29				0.26

considerably lower than that from the treated ones. It is therefore probably that many of the flowers infected at flowering time did not develop into fruits. It has already been demonstrated in the investigations of many research workers (POWELSON 1960, JARVIS 1962 and BORECKA 1967) that *Botrytis* infection occurs mainly during flowering time, and that a wet ripening season will only aggravate the already latent infection.

A comparison of cloche and open cultivation

In trials conducted at Tikkurila in 1970 and 1971, the development of *Botrytis* infection and yielding capacity of strawberries were compared using two treatments. In the first, strawberries were kept covered with plastic cloches for a month before flowering. The plastic was removed at the time of the first spray. In the second, the stawberries were open-cultivated. Flowering and ripening began in the cloches about one week earlier than in the open. However, total yield was lower under the cloche culture (Fig. 2 a and 2 b). *Botrytis* infection was noticeably less on strawberries which had been under cloches than on those under open-cultivation. This was attributed to differences in temperature between the two treatments. In spite of ventilation, maximum temperatures in the cloches were, on the average, 10°C higher than in the open. This is shown below.

No. days when temp. attained indicated range

Degrees °C	in cloche	in open
40—45	13	0
30—39	8	10 (max. 37°C)
20—29	3	9
10—19	0	4
<10	0	1 (8°C)
mean	37.7°C	26.1°C

Differences between minimum temperatures for the two treatments were small. Minima under cloches averaged 5.96°C (2—11°C) and in the open 5.61°C (1—11°C). The optimum temperature for *Botrytis cinerea* is 15—20°C, according to HENNEBERT and GILLES (1958) and 20—25°C, according to BORECKA et al. (1969).

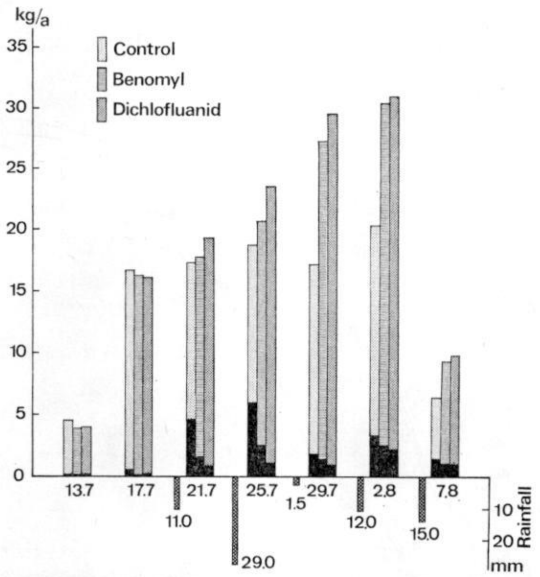

Fig. 1. The development of fruits and *Botrytis* rot on treated and control plots during the picking period. —(Average of trials nr. IV. VI and VII in 1971, cf. table 3.) Columns = total yield, dark parts = diseased berries.

It can thus be taken as about 20°C. Growth is inhibited at temperatures over 30°C. Therefore development of the fungus may be inhibited under the cloches, whereas it could grow vigorously on debris in the open. Infective spores were probably more abundant in the open at flowering time than under cloches. Relative humidity averaged, about 10 % higher under the cloches than in the open: 77.8 % (40—100 %) as opposed to 65.9 % (25—95 %). The high humidity in the cloches might have promoted the growth of the fungus (JARVIS 1964) if the high temperatures had not prevented this.

The total yield of starwberries grown under cloches was less than that of those grown in the open (Fig. 2, Table 6). In both trials benomyl and captan considerably reduced the yield of strawberries grown for one month under cloches relative to untreated strawberries (Table 6). In 1970 dichlofluanid and thiram had the same yield depressing effect when applied to cloche-grown plants. Obviously the strawberries under cloches became in some way susceptible to the phytotoxic effects of the fungicides, especially benomyl.

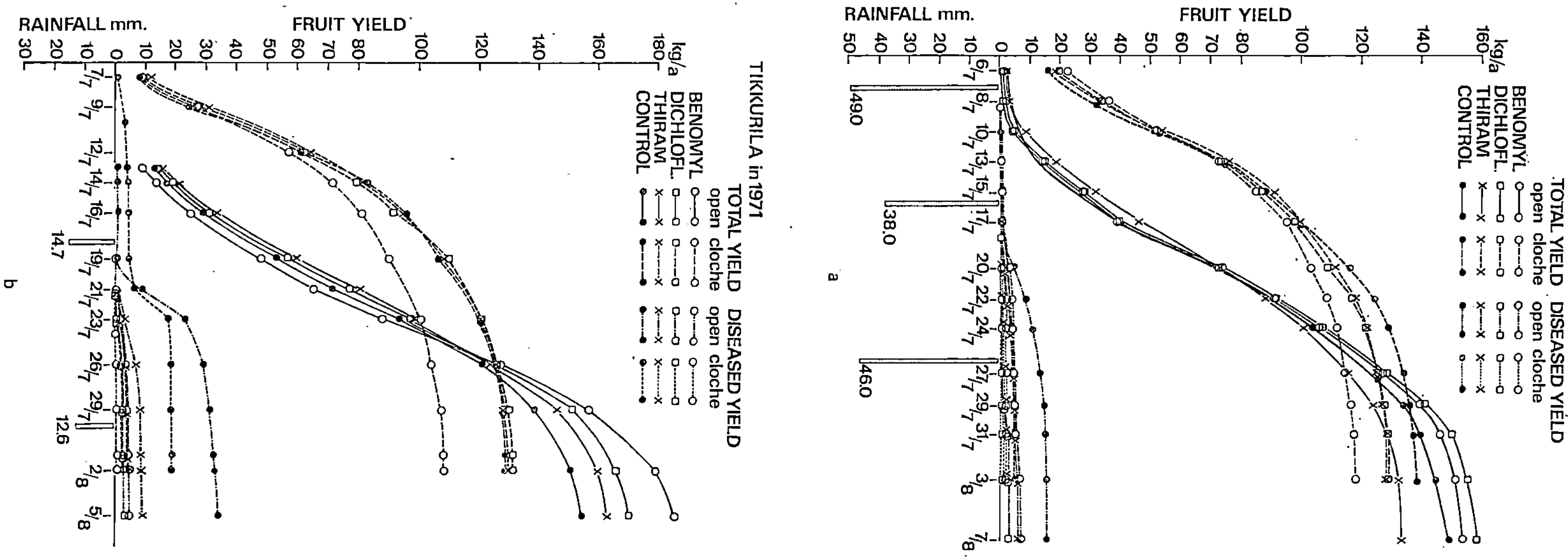

Fig. 2. Effect of various fungicides on *Botrytis* rot and yield of fruits from open-grown and cloche-grown strawberries at Tikkurila a) in 1970, b) in 1971.

Table 6. Effects of several fungicides on Botrytis rot and yields of strawberry fruits under open and cloche cultivation at Tikkurila in 1970 and 1971

Treatment	No. of appli-cations	Rate of appl. g a.i./a	Yields of healthy berries kg/a (ratio)						% of diseased berries					
			in open cultivation			in cloche cultivation			in open cult.			in cloche cult.		
			1970	1971	mean	1970	1971	mean	1970	1971	mean	1970	1971	mean.
Benomyl	3	4	145.7	181.0	163.4(130)	115.2	105.5	110.4(91)	4.7	2.8	3.8	2.1	2.9	2.5
Dichlofluanid spr.	2	25	147.6	163.8	155.7(124)	120.1	121.0	120.5(95)	1.8	2.3	2.1	0.8	2.9	1.9
Dichlofl. dust +	2	15												
Thiram spr.	1	32	162.3	167.7	165.0(132)	136.2	134.9	135.5(107)	2.9	3.3	3.1	1.2	2.5	1.9
Thiram	3	30	130.6	159.0	144.8(115)	120.9	127.2	124.1(98)	4.9	4.4	4.7	2.9	3.3	3.1
Captan	3	25	138.3	145.7	142.0(113)	118.7	111.9	115.3(91)	5.4	5.9	5.7	2.7	2.6	2.7
Ave. of fungicide — treated	—	—	144.9	163.4	154.3(123)	122.2	120.1	121.2(96)	3.9	3.7	3.8	1.9	2.8	2.4
Control	—	—	131.4	119.4	125.4(100)	132.5	121.2	126.9(100)	11.3	23.2	17.3	4.0	5.7	4.9
Treatments:														
F-value			1.8	5.6**		1.2	2.6*		6.28**	8.77***		10.71***	5.19***	
LSD kg/a and %			—	24.5		—	17.2		3.6	7.3		1.0	1.4%	
Open/cloche F-value						13.7**						(4.39°)		
LSD kg/a						16.4 kg/a						(3.8%)		

Table 7. Effect of several fungicides used in *Botrytis* control on strawberry leaf spot diseases

Treatment	No. of applications	Rate per g a.i./a =100 m²	% leaf spots on strawberry foliage in trial				
			I	II	III	IV	V
Benomyl	3	6	4.4	1.8	10.5	11.0	11.2
Captan	3	25	19.2	22.0	—	—	—
Dichlofluanid	3	25	13.2	16.0	26.0	—	—
Dichlofluanid	2	25					
+Thiram	1	32	17.6	19.3	13.0	15.5	11.6
Thiram	3	30	25.6	23.0	—	70.0	—
Control	—	—	46.4	60.8	37.0	85.5	24.8
F-value			14.7***	51.8***	10.7***	276.4***	15.1***
LSD %			10.0	7.3	8.9	7.2	6.1

Table 8. Residue analyses of strawberry fruits sprayed for *Botrytis* control

Treatment	No. of applications	Rate per applic. g a.i./a = 100 m²	Interval treatm.-analysis days	Berries washed or unwashed	Residue ppm	Highest residue allowed ppm
1967, 1968 Dichlofluanid spray	2	25	26—14	washed	0.02— 0.2	4.0
» » » »	2	25	26—14	unwash.	0.03— 0.6	4.0
1966 » »	3	25	14	unwash. with calyx	1.3	4.0
1971 » »	2	25	15	unwash.	1.5	4.0
» » »	3	25	8	unwash.	18.0	4.0
1967, 1968 Dichlofluanid dust	2	15	26—14	washed	0.01— 0.15	4.0
» » » »	2	15	26—14	unwash.	0.01— 0.5	4.0
1966 » »	3	15	14	unwash with calyx	0.45	4.0
1969 Benomyl [1])	3	4	11	washed	n.d.—0.4	2.0
» »	3	4	11	unwash.	n.d.—0.4	2.0
1971 »	3	6	8	unwash.	0.6	2.0
1966 Captan	3	25	18	unwash.	2.9	10.0
1965 »	3	25	14	unwash.	4.2	10.0
1971 »	4	25	4	unwash.	9.0	10.0
1965, 1966 Thiram	3	32	18—14	unwash.	0	3.0
1971 »	3	32	8	unwash.	1.3	3.0

[1]) In the analyses of benomyl residues, the hydrolysis of benomyl (methyl 1(butylcarbomyl)-2-benzimidazolecarbamate) to the product methyl 2-benzimidazolecarbamate was taken into account (Sims et al. 1969).

Leaf spot diseases

Lessening of leaf spot symptoms resulted when treatments for the control of strawberry grey mould also had a controlling effect upon leaf spot diseases. These were caused mainly by *Mycosphaerella fragariae* (Tul.) Lindau, and partly by *Diplocarpon earliana* (Ellis & Everh.) Wolf. Benomyl proved to be very effective in their control preventing the appearance of leaf spots almost entirely (Table 7). This is contrary to the results obtained by Bolay (1971) in the French part of Switzerland with the variety Souvenir de Ch. Machirone. Benomyl had no effect upon strawberry leaf spot disease in Bolay's experiments. He found dichlofluanid rather effective. Captan, and especially thiram, were less effective than benomyl, contrary to the results of Gourley (1963). However, in the present studies even these, gave significantly better results than the control (Table 7).

Residues

Fungicide residue analyses have been made on strawberries since 1965. In all the 1965—1970 experiments, the residues found both in washed and unwashed berries were within the tolerance limits (Table 8). In these experiments the berries analysed had been sprayed mostly with a hand-operated hydraulic sprayer. In 1971 treatments were applied with an atomizing motor sprayer (Solo Combi 423), which gives greater fungicidal penetration than a hand operated sprayer (cf. GILLES et al. 1962). The residues found in the 1971 investigations were greater. They exceeded the tolerance limit in berries sprayed with dichlofluanid 8 days before picking (Table 8). Therefore the waiting time for dichlofluanid (Euparen) will not be shortened in Finland from 14 to 7 days, as has been done in some countries.

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SELOSTUS

Mansikan harmaahomeen kemiallinen torjunta koetulosten valossa

Eeva Tapio

Maatalouden tutkimuskeskus, Kasvitautien tutkimuslaitos, Tikkurila

Kasvitautien tutkimuslaitoksessa useiden vuosien aikana suoritettujen mansikan harmaahomeen torjuntakokeiden tulokset ovat yhdenmukaisia useissa muissa maissa saatujen tulosten kanssa. Parhaat sadonlisäykset on saatu ruiskuttamalla mansikkakasvustot kolme kertaa kukinnan aikana joko diklofluanidilla (Euparen) tai benomyylillä (Benlate). Neljäs kukinnan jälkeinen ruiskutus ei merkitsevästi lisännyt satoa ja vähentänyt harmaahomeisuutta. Kolmas diklofluanidi- (varoaika 14 vrk) ruiskutus voidaan korvata benomyylillä, folpetilla, kaptaanilla tai tiraamilla, joilla on lyhyempi varoaika. Benomyyli torjui samalla erittäin hyvin ja diklofluanidi hyvin mansikan lehtilaikkutauteja. Varoaikoja noudatettaessa ei edellä mainituista fungisideista jäänyt marjoihin toleranssirajoja ylittäviä jäämämääriä.

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RIBES LEAF SPOT DISEASES AND THEIR CONTROL

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The currant leaf spot diseases leaf spot, *Drepanopeziza ribis* Kleb. and grey leaf speck, *Mycosphaerella ribis* Desm. are very common in Finland, especially on red and white currants. The first of these is of greater economic significance. The most important treatment times are just before and immediately after flowering. Spraying with fungicides in the autumn after harvest did not affect the following year's yield nor degree of leaf spot diseases. Although the ascospore dissemination of both the leaf spot fungi continues from May to July, coincing with rainy periods, bushes cannot be sprayed at the green fruit stage as the fruits then accumulate large residues of fungicides. Of the various fungicides, benomyl, mancozeb and maneb are best suited to the control of leaf spot diseases.

Introduction

Soft fruit cultivation has increased greatly in Finland recently. The black currant is the most important and most cultivated of the currants. Also, the cultivation of red and white currants has increased and shifted from household to commercial production over the years. At the same time, currant diseases and their control have become a present-day problem. Of these, black currant leaf spot, caused by *Drepanopeziza ribis* Kleb. (syn. *Pseudopeziza ribis* (Kleb.) Höhn.) with its conidial stage *Gloeosporidiella ribis* (Lib.) Petr. (syn. *Gloeposporium ribis* (Lib.) Mont. & Desm.) causes the most damage. Grey leaf speck caused by *Mycosphaerella ribis* Desm. occurs along with it even on the same bushes.

Drepanopeziza ribis, called black currant leaf spot by English authors (CORKE 1954) and anthracnose by American authors (BLODGETT 1936) is known to be destructive especially on black currants (CORKE 1954, 1962, Ó RÍOARDÁIN 1968 and GJAERUM 1970). In Finland, its control has been found necessary, particularly on red and white currants.

The leaf spot diseases of currants were formerly controlled with copper preparations. More recently, good results have been obtained with organic fungicides in many countries (CORKE 1962, Ó RÍORDÁIN et al. 1966, GJAERUM 1970). The effectiveness of various fungicides in the control of leaf spot diseases, and the effects upon currant yields under Finnish conditions were compared in experiments made from 1969—1971.

Materials and methods

The occurrence of both Pseudopeziza and Mycosphaerella leaf spot diseases on various currant varieties was examined in currant variety trials in 1969 and 1970. These were made at three experimental sites, the Department of Horticulture at Piikkiö, the South Savo Agricultural Experiment Station at Mikkeli and the Häme Agricultural Experiment Station at Pälkäne. The degree of speckling was determined using a 0—10 scale (0 = healthy, 10 = leaves completely covered with spots, or leaves shed). Fungi isolated from the spots were identified microscopically from leaves of all the varieties.

To determine time of infection, late spring dissemination of spores from leaves which had overwintered in the soil was studied. This was done by setting up slides which were examined regularly under the microscope.

The effectiveness of various fungicides against leaf spot diseases was studied in two 2-year experiments. The first was made at Ristiina, South Savo in 1969 and 1970, the other in Muurikkala in South Karelia in 1970 and 1971. The variety Red Dutch, which had proved rather resistant in variety trials, was used at both station. At Ristiina the large bushes, planted in 1962 at 2 × 2.5 m formed a dense stand. There were 4 bushes in each treatment and 4 replicates. The spacing at Muurikkala was 2 × 3 m, and the inter-row spaces were well-defined. There were 5 bushes in each treatment, and 4 replicates. When fungicides were applied, the adjacent bushes were screened with a movable plastic sheet. Maneb was applied in a time-of-spraying experiment in which there were 7 bushes in a treatment and 4 replicates.

In the experiments conducted to compare different fungicides, three applications were made at each site in the first experimental year and two in the second. The spraying times were just before flowering (24.—30. 5.), soon after flowering (8.—15. 6.) and about ten days later. In the time-of-spraying experiment, the effectiveness an autumn spray applied at the end of August immediately after harvest on leaf spot diseases and yields the following year was compared with a post-harvest plus following spring spray and with two spring sprays. The spraying was done with a Solo atomizing motor sprayer, using a spray 5 times the normal concentration. Each bush was given about 3 dl of spray.

Analyses of fungicide residues on some fruit samples were carried out by the State Agricultural Chemistry Department in Helsinki. They were made on berries from Red Lake bushes sprayed three times in succession at Tikkurila and from Red Dutch bushes sprayed twice at Ristiina.

Table 1. Degree of severity of leaf spot diseases at Piikkiö, at Mikkeli and at Pälkäne in 1968 and 1969

Variety	Degree of severity of leaf spot [1])		
	Piikkiö	Mikkeli	Pälkäne
Red currants			
Heinemanns Spätläse	1.7	1.6	1.7
Red Dutch	4.4	2.2	2.4
Laxtons Perfection	4.0	4.9	2.5
Heros	4.0	5.9	2.2
Erstling aus Vierlanden	5.1	3.9	4.8
Jonkheer van Tets	5.6	3.2	5.7
Laxtons nr. 1	4.7	6.8	3.8
Rondom	6.5	2.9	6.5
Maarses Prominent	5.8	6.0	4.8
Red Lake	5.8	7.4	4.7
White currants			
Weisse Jüterboger	3.5	3.2	2.2
White Dutch	3.3	3.9	2.8
White Imperial	3.5	—	—
Black currants			
'Karila' (Östersund?)	—	1.2	—
Lepaan musta	0.7	1.3	1.5
Brödtorp	1.2	1.5	2.1
Wellington XXX	1.5	3.2	1.5
Neapel black	—	3.2	—
Seabrooks black	—	3.9	—

[1]) Scale of severity: 0 = healthy, 10 = leaves completely covered with spots, or leaves shed.

Specific and varietal susceptibility

The susceptibility of different currant varieties to leaf spot diseases varied considerably from site to site (Table 1). The sprawling black currant varieties Brödtorp, widely cultivated in Finland at the moment, and Lepaan musta (Lepaa black), were the most resistant. The erect-growing North Swedish »Karila» (Östersund?), which was the highest yielding in South Savo trials, was also one of the most resistant. Black currant varieties more susceptible than those just mentioned are little cultivated in Finland. Red and White Dutch, the most widely grown red and white currant varieties, are rather resistant. In spite of this, however,

Table 2. Effects of several fungicides on leaf spot diseases and yields of red currant in South Savo in 1969 and 1970

Treatment	No. of applications		Rate per application			Fruit yields kg/a [1])		Ratio of yields			Per cent disease specks on foliage	
	1969	1970	product %	g/a[1])	act.ingr. g/a [1])	1969	1970	1969	1970	Average	18. 8. 69.	26. 8. 70.
Benomyl	3	2	0.04	12	6.0	215.4	118.4	261	154	218	11	11.7
Copper+zineb	3	2	0.5	150	97.5+15.0	176.9	149.0	214	194	204	13	3.5
Dichlofluanid	3	2	0.25	75	37.5	148.6	114.0	180	148	164	15	1.2
Dithianon	3	2	0.1	30	22.5	145.4	102.1	176	133	155	34	17.9
Mancozeb	3	2	0.2	60	48.0	191.3	130.0	232	169	201	9	10.7
Maneb	3	2	0.2	60	48.0	185.3	130.9	225	170	198	9	4.6
Dodin+dinocap	2[2])	—	0.4	120	1.8+3.6	117.5	—	142	—	—	40	—
Dodin	—	2	0.1	30	19.5	—	112.0	—	146	—	—	15.4
Control	—	—	—	—	—	82.5	76.9	100	100	100	76	55.3
F-value						34.7***	3.05*	34.7***	3.05*		27.3***	18.3***
LSD						42.6 kg	36.1 kg	65	47		13%	12.1%

[1]) 20 bushes/a, spacing of bushes 2 × 2.5 m
[2]) third spraying not given on account of severe damage caused by product

Table 3. Effects of several fungicides on leaf spot diseases and yields of red currant in South Karelia in 1970 and 1971

Treatment	No. of applications		Rate per application		Fruit yields kg/a [1])		Ratio of yields			Per cent disease specks on foliage	
	1969	1970	product %	act.ingr. g/a[1])	1970	1971	1970	1971	Average	28. 7. 70.	25. 8. 71.
Benomyl	3	—	0.04	5.0	206.6	—	133	—		24	—
Benomyl	—	2	0.06	7.5	—	190.8	—	235	184	—	16.1
Copper oxychl.	3	2	0.5	106.5	183.8	—	118	—	—	20	—
Dichlofluanid	3	2	0.25	31.3	183.3	—	118	—	—	26	—
Mancozeb	3	—	0.2	40.0	212.2	—	137	—	—	25	—
Maneb	3	2	0.2	40.0	206.9	181.0	133	223	178	23	40.4
Control	—	—	—	—	155.2	81.1	100	100	100	55	75.3
F-value					6.05**	25.56**	6.05**	25.56**			179.2***
LSD					26.4 kg	104.1 kg	17	13			7.7%

[1]) spacing of bushes 2 × 3 m
16.7 bushes/a

these varieties become so badly infected in large plantings after a few years that their cultivation is not economically worthwhile without chemical control. The cultivation of Red Lake came to an early halt owing to a severe outbreak of the disease. In addition to *Drepanopeziza*, the fungus *Mycosphaerella* has been found in particular on Brödtorp, Red Dutch and Red Lake. On the red currants Maarses Prominent, Red Dutch and Red Lake, there were also specks caused by the fungus *Cercospora* sp., though to a lesser extent.

The dimension (μ) of spores and conidia isolated from red currant leaves were as follows:

Drepanopeziza ribis — ascospores 14.5 × 4.4
(2—21) × (3—6.3)

Gloeosporium ribis — conidia 17.3 × 5.5
(13—28) × (4—6)

Gloeosporium ribis — microconidia 6.5 × 2.2
(4—12) × (1.2—2.9)

Mycosphaerella ribis — ascospores 29.8 × 3.1
(19—40) × (2.5—3.4)

Septoria ribis — conidia 56.0 × 2.6
(34—90) × (1.5—3.4)

Infection time

In 1970, ascospores of both *Drepanopeziza* and *Mycosphaerella* were found to develop and disseminate from May to July, according to observations made from the 22.5—4.7. Dissemination was most prolific in the middle of June

Table 4. The effect of spraying time on the control of leaf spot diseases on red currant in South Savo in 1970 and 1971

Spraying time	No. of applications	maned sprayer per application g/a [1])	Fruit yields kg/a[1]) 1970	Fruit yields kg/a[1]) 1971	Ratio 1970	Ratio 1971	Aver	Per cent disease specks on foliage 26. 8. 70.	Per cent disease specks on foliage 25. 8. 71.
After harvest 18. 8. 69 and 28. 8. 70.	1	40	113.9	157.9	106	101	103.5	23.8	38.1
After harvest and before flowering .	2	40	122.1	171.4	113	110	11.5	2.3	12.9
Before and after flowering	2	40	133.2	188.5	122	121	121.5	1.3	9.8
Control	—	—	109.0	155.7	100	100	100	22.8	37.6
F-value			3.02	0.8				9.47**	24.08**
LSD			—	—				11.5%	10.0%

[1]) spacing of bushes 2 × 3 m
16.7 bushes/a

especially during rainy spells or immediately after them. Asexual conidia of the fungi were found from mid July to September after which time no further observations were made.

Effectiveness of the various fungicides

On the average, benomyl gave the best yield increase in two 2-year, experiments (Tables 2 and 3) (cf. Ó Ríordáin 1969, Nøddegaard et al. 1970). It was not, however significantly better than mancozed or maneb which, according to some authors (Vukovits 1964, Nøddegaard et al. 1968, Ó Ríordáin 1968, Gjaerum 1970) are the most effective fungicides against leaf spot. In the South Savo experiment, a combination of copper oxychloride and zineb (Miltox) was more effective than other preparations during the second experimental year. Also, copper oxychloride or dichlofluanid applied singly significantly improved yields and reduced the degree of speckling. With copper, slight phytotoxicity appeared as scorch speckling on the leaves, which Gjaerum (1970) also found occurred on black currant. Dithianon increased the yield significantly in only one experimental year, though according to Nøddegaard et al. (1968) and Ó Ríordáin (1968) it is nearly as effective as mancozed or maneb. The yield increase brought about by dodine-containing preparations was not significant in the South Savo experiments. This could be partly due to severe damage to the bushes caused by two sprays of a mixture of dodine and dinocap (Bilobran) in the first year. Ó Ríordóin et al. (1966) found dodine to be as effective as mancozeb in leaf spot control experiments on gooseberries but less effectives, on black currants due to phytotoxicity (Ó Ríordáin 1968).

Time-of-spraying experiments

Maneb sprayed only after harvest did not bring about any reduction in the degree of leaf spot or any increase in yield the following growing season (Table 4). When sprayings were also made the following spring just before flowering, the degree of leaf spot decreased significantly and yields improved somewhat, but not significantly. Two spring sprayings gave the best result. The spraying made after harvesting thus had no or little effect as Corke (1967) has found previously. Since spore dispersal continues throughout June, in the first experimental years the third spraying was made about 10 days after the second when there was a period of rain in between. This green fruit third spraying was discontinued because the berries retained fungicide residues from it (cf. p. 98). Instead attempts were made during the first two sprayings to restrict the dispersal of spores by directing the spray partly onto old leaves on the ground. Ascospore infection starts from these old leaves.

Fungicide residues on red currants

In preliminary studies made in 1970, surprisingly large mancozeb residues (Table 5) were found on red currants sprayed at the green fruit stage. Similarly, benomyl, copper oxychloride and maneb residues found on Red Lake red currants in the summer of 1971 exceeded the permitted tolerance limits (Table 5). The bushes were sprayed three times in early summer. The last treatment was given at the green fruit stage. Berries of Red Lake ripened a full week earlier than those of Red Dutch, the variety most cultivated in Finland. The berries were picked 35 days after the last treatment. At this time there was exceptionally little rain in Tikkurila — 34 mm instead of the usual 85 mm (30 year average). For purposes of comparison, analyses were made on berries of Red Dutch sprayed twice with maneb. The berries were picked 67 days after the second treatment, given after flowering. No residues were found (Table 5). The bushes were grown in South Savo, where the rainfall of 139 mm was nearly average (normal 152 mm).

In some countries, 3—4 sprayings before harvesting and 1—2 after are recommended (NØDDEGAARD et al. 1965, Ó RÍORDÁIN et al. 1966, GJAERUM 1970). Results of preliminary residue studies made in Finland, however, do not advocate the use of this type of spraying programme.

Discussion

The currant leaf spot diseases leaf spot, *Drepanopeziza ribis* and grey leaf speck, *Mycosphaerella ribis* are very common in Finland, especially in red and white currant plantings. The first of these is of greater economic significance. Considerable varietal differences in susceptibility to this disease have been found. The black currant varieties Lepaan musta and Brödtorp grown in Finland, and the promising North Swedish variety »Karila» (Östersund?) proved the most resistant in comparisons made in variety trials. The most important red and white currant varieties, Red and White Dutch, and the increasingly cultivated Weisse Jüterboger were also rather resistant, but become infected with leaf spot so badly in their most important production area in Southeast Finland that chemical control is necessary.

Ascospore dissemination of both the leaf spot fungi continues from May to July, coinciding with rainy periods. Bushes cannot, however, be sprayed at the green fruit stage as large residues remain on the fruit at harvest. It is obvious that the waxy layer of currants retains controlling agents very strongly indeed (cf. MARTIN et al. 1953). The matter warrants through investigation for black currants as well as for red and white currants.

Autumn spraying after harvest was not found to have any effect upon the following year's yield nor on severity of leaf spot diseases. The most important treatment times are just before and immediately after flowering.

Of the various fungicides, benomyl, mancozeb and maneb were best suited to the control of the leaf spot diseases studied. Copper oxyxhloride, and especially a mixture of it and zineb, were found to be effective, but caused phytotoxic symptoms on certain currant varieties. Dichlofluanid reduced significantly the degree of speckling of leaves, but yield increases were not of the same order as with the first-mentioned fungicides.

Table 5. Residue analyses of red currant fruits sprayed for control of leaf spot diseases

Year, location, variety, treatment	No. of applications	Rate per applic g a.i./a	Interval treatment-analyses days	Residue ppm	Highest residue permitted ppm
1970					
Tikkurila					
Red-Lake					
copperoxychloride	3	127.5	20	14.2	15.0
mancozeb	3	48.0	20	30.0	3.0
1971					
Tikkurila					
Red-Lake					
benomyl	3	9.0	35	10.0	2.0
copperoxychloride	3	127.5	35	40.5	15.0
maneb	3	48.0	35	5.0	3.0
1971					
Ristiina					
Red Dutch					
maneb	2	48.0	67	0.15	3.0

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SELOSTUS

Ribes-pensaiden lehtilaikkutaudit ja niiden torjunta

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Herukoiden laikkutaudit, sekä varistetauti (*Drepanopeziza ribis* Kleb.) että harmaalaikkutauti (*Mycosphaerella ribis* Desm.), ovat sangen yleisiä Suomessa etenkin puna- ja valkoherukkaviljelyksillä. Ensiksi mainittu on taloudellisesti merkittävämpi. Fungisideista soveltuvat benomyyli, mankozebi ja manebi parhaiten laikkutautien torjuntaan. Kuparioksikloridin ja varsinkin sen ja zinebin seoksen on myös todettu olevan tehokkaita, mutta vaikuttavan fytotoksisesti eräisiin herukkalajikkeisiin. Tärkeimmät käsittelyajat ovat juuri ennen kukintaa ja heti sen jälkeen. Vaikka itiölento jatkuu sateiden yhteydessä heinäkuun alkuun, ei pensaita voida enää raakileasteella ruiskuttaa torjunta-aineilla marjoissa todettujen jäämien vuoksi. Sadonkorjuun jälkeisellä syysruiskutuksella ei koetulosten mukaan ole merkitystä.

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WEED COLONIZATION OF CULTIVATED FIELDS IN FINLAND

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Composition of the weed flora and their population densities were studied in Finland in the years 1961—64 on 153 cultivated fields of various ages (mostly under 100 years) which at the time of the survey were under spring cereals. Data were collected from 22 rural parishes, most of which were situated in Central Finland. Numbers of weed seeds in the cultivated (top 20 cm) layer were also determined from soil samples taken from 47 fields.

The native perennial flora of a virgin site usually disappeared within a few years after the land is cleared, but certain species persisted as weeds. The characteristic weeds arrived on the fields over a span of a few years. At the outset the vegetation was patchy. After 20—30 years of cultivation a field had acquired a fairly typical composition of taxa and vegetation. At that time the number of weed seeds in the cultivated layer was about 40 000/m^2 and the number of individuals of annuals + shoots of perennials about 700—800/m^2.

Colonization by weeds was faster on mineral soils than on humus or peat soils. As the age of the fields increased, the weed florae and vegetation on the two types of soil became more and more similar to each other.

The weeds of cultivated fields were classified into five groups according to their time of arrival. It was apparent that most of the typical weed species arrived in farmyard manure or in contaminated seed of cultivated crops.

The purpose of this study is to describe the main features of weed colonization of fields having cultivation ages ranging from young (1—5 yrs.) to old (71+yrs.). In 1961—64 when the study was carried out, the area of cultivated fields in Finland was 2.7 million hectares or 9 % of the total surface area of the country. Between 1900 and 1960 new land was cleared for cultivation at an approximate rate of 18 000 hectares per annum. Land clearance activity was at its highest just after the turn of the century and in the 1930's and early 1950's when the highest yearly total was 41 000 hectares (PÄLIKKÖ 1960). Land clearing has decreased since then, and since 1969 as a result of the new land reservation act the cultivated area has been reduced by 138 000 ha in just two years. On 10 000 ha of this area reforestation has been authorized.

Weed infestation of cultivated fields has long been combatted in Finland but the phenomenon itself has been relatively little investigated (e.g. MUKULA et al. 1969). Surveys were carried out by LINKOLA (1921, 1922) in areas immediately east of the Finnish-Russian border, where conditions in the 1910's much resembled those in Central Finland at that time, i.e. weeds grow-

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ing on first and second-year burn-beaten forest clearings and on fields of various ages. In all Europe, to our knowledge, investigations on this subject are few, although ELLENBERG (1950), for example, has described the process of weed colonization of a young field. In many old civilized countries the cultivated fields are hundreds, even thousands of years old, thus presenting for investigation plant successions much farther advanced than those in Central Finland. On such study was carried out by TÜXEN (1958).

The present work is part of a series of studies dealing with the development and composition of weed flora and pest fauna on cultivated fields in Finland.

Material and methods

Main localities

Five rural parishes in Central Finland were chosen as localities for the survey: Laihia (Locality 1), Alajärvi (2), Kälviä (3), Viitasaari (4) and Keitele (5) (Fig. 1). Field husbandry was already quite common in these regions in the mid-1800's but was greatly expanded in the 1900's. In the early 1960's land was still being cleared both on individual farms and newly settled areas. Old land-clearing methods have been described in a publication by SIMOLA (1921) and contemporary methods by PÄLIKKÖ (1960).

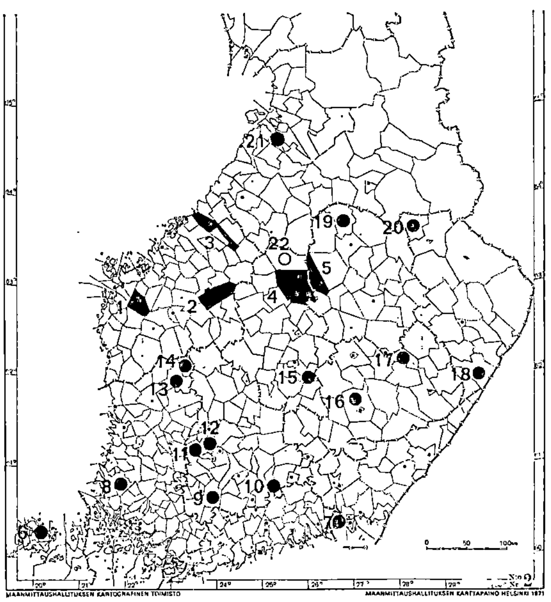

Fig. 1. Main localities (1—5) and other localities (6—21) surveyed and the locality for weed colonization observations (22).

At Viitasaari and Keitele many of the oldest fields on mineral soils originated from burn-beaten woodland or meadows. Decomposed peat had been commonly used for soil improvement. The younger fields had been cleared mostly by mechanical methods, and no peat had been added after the clearance burning of brushwood and twigs. The main fertilizer was farmyard manure still in common use today despite a steady increase in the use of artificial fertilizers during this century.

The peatland fields had been cleared during the latter half of the 19th century. The method of clearing was hand-hoeing or ploughing. After clearance burning, mineral soil had been applied to improve the soil quality; this was usually done in several successive winters while the field was already under cultivation. At Laihia it was customary to burn the top layer of peat, and in many instances this burned to such a depth that a high proportion of mineral material from the subsoil became intermixed with the cultivated layer (VESIKIVI 1922, RAATIKAINEN and RAATIKAINEN 1964). At Keitele and Viitasaari most of the fields reclaimed from bog lie adjacent to the other cultivated fields of the farm in the same forest glade to form an uniform open area; in the western regions they usually lie separated from the rest of the fields and at a considerable distance from the farm buildings. Farmyard manure is used on peatland to a less extent than on fields of mineral soil; yet nearly every one of the oldest peatland fields had at some time or other received farmyard manure.

The material for this investigation was collected from the spring cereal fields referred to in the study of MUKULA, RAATIKAINEN, LALLUKKA and RAATIKAINEN (1969). Sampling was carried out in the summers of 1961—64 during the period between June 25 and July 15. In choosing the fields to be sampled it was considered important that all age groups of fields were available as near as possible to each other on similar soil types. Fields of all age groups were most numerous in the Viitasaari—Keitele area where a total of 71 fields were examined. At Kälviä the number of fields examined was 37, at Laihia 8 and at Alajärvi 5. Of these, 48 % were on mineral soil and 52 % on humus or peat soil. All species of vascular plants growing in the fields were noted with the exclusion of those in border strips 1 m wide. The numbers of annual weeds and aerial shoots from underground branches of perennial weeds were counted within four randomly placed sampling circles of 0.25 m^2 area.

At Kälviä two soil samples were taken from each of the 0.25 m^2 sampling areas examined in the 37 fields. An »Oiva»-type soil auger was used for this purpose. The soil cores had a cross-sectional area of approx. 6 cm^2 and extended from the soil surface to the boundary of the subsoil. The eight soil samples thus obtained from each field were mixed together in a polythene bag. From this, a sample of 6 dl was taken for determination of the number of weed seeds, which was made under the supervision of Prof. J. Paatela. The seed content is expressed as number of seeds per m^2 of cultivated layer, taken to be 20 cm deep. Treated in a different manner, this data has already been published elsewhere (PAATELA and ERVIÖ 1971).

Other localities

Fields with a cultivation age of not more than five years were studied at Valtimo (Locality 20; number of fields examined 7), Mikkeli (16; 4), Vieremä (19; 4), Kärkölä (10; 2), Lempäälä (12; 2), Kangaslampi (17; 2) and Parkano (13; 2). One field was examined at each of the following localities: Finström (Locality 6), Pyhtää (7), Laitila (8), Tammela (9), Vesilahti (11), Kihniö (14), Toivakka (15), Kitee (18) and Liminka (21) (Fig. 1). Of all these fields, 15 were located on sandy soil, 9 on humus or peat and 8 on clay. The species of vascular plants were noted and the numbers of individuals or shoots of 41 taxa characteristic of spring cereal fields were counted. The study was carried out simultaneously with the main survey but by different persons whose names are given in the publication of MUKULA, RAATIKAINEN, LALLUKKA and RAATIKAINEN (1969). In the same paper are also listed the 41 taxa studied in detail. Soil samples taken from ten fields at Vieremä, Kärkölä, Lempäälä, Vesilahti and Toivakka were treated and examined in the same way as those from the main localities. Furthermore, observations on weed colonization of fields had been made since the early 1950's in the Central Finnish parish of Pihtipudas (Locality 22 and Fig. 1) where land clearing was very activitely pursued in the late 1940's and early 1950's.

Results

Changes in species composition

Table 1 shows the weed species and their percentage frequencies in fields of various age groups at the main localities. The first columns (A) show the results obtained from the one to five-year-old fields of the other localities studied. According to these data the following species in particular decreased in frequency with ageing of the field: *Betula pubescens*, *Carex canescens*, *Chamaenerion angustifolium*, *Epilobium palustre*, *Equisetum fluviatile*, *Juncus filiformis*, *Menyanthes trifoliata*, *Salix* spp. and *S. phylicifolia*. Data in Table 1 also support the observations made at Pihtipudas

Table 1. Frequency percentages and plant or shoot numbers/m² of weed taxa found in fields of different ages at the main localities and in the 1 to 5-year-old fields of the other localities (A).

Taxon	Frequency %							Number of plants or shoots/m²						
	A	Main localities						A	Main localities					
Age of fields, years / No. of fields	1—5 32	1—5 14	6—10 15	11—30 15	31—50 24	51—70 20	71— 33	1—5 32	1—5 14	6—10 15	11—30 15	31—50 24	51—70 20	71— 33
Achillea millefolium	53	50	53	67	71	90	76	3.8	0.9	1.4	0.5	4.8	5.2	6.2
A. ptarmica	16	14	47	53	63	70	52	0.5	—	3.1	4.2	11.3	12.9	12.6
Agropyron repens	9	21	27	33	50	65	64	0.2	16.4	3.9	3.4	21.0	35.7	38.5
Agrostis spp.	—	21	27	47	33	30	36	—	17.5	6.7	9.3	6.8	2.1	56.0
A. canina	—	—	13	7	—	5	3	—	—	—	—	—	1.0	0.6
A. tenuis	41	36	33	47	29	30	21	..	11.7	0.3	15.5	7.5	2.1	6.0
Alchemilla vulgaris coll.	6	7	7	—	8	35	3	..	0.1	0.8	—	0.0	0.2	—
Alisma plantago-aquatica	—	7	—	—	4	—	—	—	0.1	—	—	—	—	—
Alnus incana	3	14	—	—	4	—	—	..	—	—	—	—	—	—
Alopecurus aequalis	—	7	—	7	4	—	6	—	—	—	—	—	—	2.5
A. geniculatus	—	—	7	—	17	—	3	—	—	—	—	0.9	—	—
A. pratensis	—	—	20	7	—	5	3	—	—	—	0.2	—	—	—
Angelica silvestris	6	7	—	7	—	10	—	..	—	—	—	—	—	—
Anthoxanthum odoratum	6	7	7	7	13	20	9	..	—	—	0.3	—	—	0.3
Anthriscus silvestris	6	7	7	—	—	15	12	..	—	0.1	—	—	—	—
Avena fatua	—	7	—	—	—	—	3	—	—	—	—	—	—	0.1
Barbarea vulgaris	—	7	13	7	—	5	6	—	—	—	—	—	—	0.1
Betula spp. (excl. *B. nana*)	—	14	13	7	—	—	—	—	0.1	—	—	—	—	—
B. nana	—	7	7	—	—	—	—	—	—	0.1	—	—	—	—
B. pubescens	6	14	20	—	4	—	—	..	0.2	—	—	—	—	—
Brassica spp.	6	—	—	7	—	—	6	..	—	—	—	—	—	—
B. rapa	—	—	—	—	4	—	3	—	—	—	—	—	—	—
Bromus secalinus	—	—	—	—	4	10	—	—	—	—	—	—	—	—
Calluna vulgaris	—	7	—	—	—	—	3	—	—	—	—	—	—	0.0
Campanula patula	6	—	—	7	—	30	15	..	—	—	—	—	0.1	—
C. rotundifolia	3	—	7	7	4	—	3	..	—	0.1	0.1	0.0	—	0.1
Capsella bursa-pastoris	6	21	7	13	33	65	52	0.2	3.2	—	2.8	5.3	4.9	5.4
Carex spp.	13	7	27	7	4	10	3	..	0.1	15.3	1.0	0.6	1.2	0.9
C. canescens	—	29	40	—	8	10	—	—	6.1	13.7	—	2.4	0.6	—
C. leporina	—	—	7	—	4	—	—	—	—	—	—	—	—	—
C. limosa	—	7	7	—	—	—	—	—	—	—	—	—	—	—
C. nigra	—	—	13	7	8	5	—	—	—	—	8.2	0.6	1.2	—
C. pallescens	—	7	—	—	4	—	—	—	—	—	—	—	—	—
Carum carvi	—	—	7	7	—	—	3	—	—	—	—	—	—	—
Centaurea cyanus	—	21	—	—	4	5	21	—	1.3	—	—	0.3	0.1	2.0
Cerastium caespitosum	38	36	53	47	75	70	48	..	1.2	2.7	4.1	5.6	4.7	3.0
Chamaenerion angustifolium	75	64	73	47	13	30	42	0.6	0.3	4.3	1.2	0.0	0.6	0.2
Chenopodium album s. lat.	59	64	67	93	92	100	97	1.8	4.5	16.5	54.7	43.6	49.1	98.2
Crysanthemum leucanthemum	6	14	—	—	4	30	6	..	—	—	—	0.0	0.2	0.1
C. vulgare	3	—	7	—	—	—	—	..	—	—	—	—	—	—
Cirsium arvense	9	—	—	13	4	10	24	—	—	—	0.1	1.7	0.6	0.5
C. heterophyllum	6	7	7	13	8	25	9	..	0.1	0.1	—	—	—	—
C. palustre	6	7	13	—	13	15	3	..	—	0.1	—	0.1	0.1	0.0
Comarum palustre	—	—	7	7	4	—	3	—	—	—	0.1	—	—	—
Deschampsia caespitosa	41	43	80	93	67	75	48	..	14.3	2.2	48.8	14.3	10.6	9.3
D. flexuosa	6	—	7	—	4	5	3	..	—	—	—	0.2	—	0.0
Dryopteris linnaeana	—	—	—	—	4	—	3	—	—	—	—	—	—	—
D. spinulosa	3	—	—	—	4	5	6	..	—	—	—	—	—	—
Epilobium palustre	6	29	27	27	17	5	0	..	0.7	90.7	0.4	0.2	0.5	—
Equisetum arvense	31	—	20	13	13	65	45	0.7	—	1.0	0.7	3.1	7.8	4.9
E. fluviatile	—	7	13	—	—	5	—	—	—	0.5	—	—	—	—
E. palustre	6	7	13	13	8	10	3	—	8.9	0.1	4.7	0.3	1.2	—
E. silvaticum	25	21	20	—	13	45	33	0.5	—	—	—	—	2.1	0.3
Eriophorum angustifolium	—	7	7	—	—	—	—	—	—	—	—	—	—	—
Erysimum cheiranthoides	31	29	20	47	58	70	76	1.6	1.0	0.2	1.7	25.0	17.1	37.1
Festuca spp.	3	—	—	—	4	—	—	..	—	—	—	0.4	—	—
F. ovina	3	7	—	—	4	—	3	..	—	—	—	—	—	—
F. pratensis	—	—	—	—	—	5	6	—	—	—	—	—	—	—
F. rubra	13	—	27	20	13	30	30	..	—	1.8	4.9	0.1	13.0	2.9
Filipendula ulmaria	3	7	27	7	13	30	9	..	1.6	0.1	0.1	—	—	—
Fumaria officinalis	6	14	7	—	8	35	39	—	—	—	—	0.2	3.7	8.2

Taxon — Age of fields, years / No. of fields	Frequency % A	Frequency % Main localities						Number of plants or shoots/m² A	Number of plants or shoots/m² Main localities					
	1—5 32	1—5 14	6—10 15	11—30 15	31—50 24	51—70 20	71— 33	1—5 32	1—5 14	6—10 15	11—30 15	31—50 24	51—70 20	71— 33
Galeopsis spp.	84	57	67	100	92	100	97	24.7	8.1	13.3	7.9	58.2	126.4	102.4
Galium palustre	3	14	13	20	38	5	9	..	0.2	0.8	1.6	3.4	0.9	0.1
G. uliginosum	6	29	27	40	29	15	18	..	1.1	2.9	2.1	0.9	0.5	3.1
G. vaillantii	13	—	13	20	17	5	9	3.3	—	1.4	0.2	0.1	0.4	0.8
Geranium silvaticum	22	—	—	—	—	5	3	..	—	—	—	—	—	—
Geum rivale	—	7	7	—	—	5	6	—	0.1	0.1	—	—	—	—
Gnaphalium uliginosum	9	7	33	27	46	45	55	0.2	0.4	4.9	1.1	45.6	33.0	13.0
Graminae	—	14	—	—	13	5	3	—	0.1	—	—	3.4	2.0	0.1
Hieracium pilosella s. lat.	6	14	7	—	8	20	15	..	0.4	—	—	—	0.2	0.1
H. umbellatum	13	—	—	—	—	20	12	..	—	—	—	—	0.1	0.1
Hypericum maculatum	3	—	7	—	—	—	—	..	—	0.1	—	—	—	—
Juncus spp.	3	—	—	—	—	5	9	..	—	—	—	—	0.3	0.8
J. bufonius	—	14	13	13	13	25	36	—	0.1	1.5	140.1	17.9	4.6	3.9
J. filiformis	—	—	20	13	—	—	3	—	—	—	0.2	—	—	—
Lamium spp.	—	—	—	7	—	5	—	—	—	—	0.1	—	0.6	—
Lapsana communis	16	21	13	13	—	10	21	1.7	0.1	0.1	0.3	—	0.3	5.7
Lathyrus pratensis	3	7	—	13	13	15	9	0.1	0.1	—	0.1	0.6	0.1	0.2
Leontodon autumnalis	22	29	40	33	46	70	36	0.7	0.3	0.3	0.3	0.9	2.8	1.2
Luzula spp.	—	7	27	27	25	15	9	—	0.3	1.0	2.2	1.5	0.3	3.9
L. multiflora	9	14	—	13	4	—	3	..	—	—	—	—	—	0.2
L. pallescens	—	—	7	7	—	5	—	—	—	—	0.1	—	0.1	—
Lysimachia vulgaris	3	—	7	—	—	—	—	..	—	—	—	—	—	—
Matricaria matricarioides	—	14	27	33	33	30	33	—	1.3	0.3	0.3	17.7	1.5	4.4
Mentha arvensis	6	—	—	—	4	—	—	..	—	—	—	0.4	—	—
Menyanthes trifoliata	—	7	13	—	—	—	—	—	—	0.5	—	—	—	—
Myosotis spp.	31	7	20	33	33	65	76	1.4	1.0	0.5	1.1	14.7	11.9	44.8
Peucedanum palustre	—	—	7	7	4	—	—	—	—	—	—	—	—	—
Phleum pratense	22	50	73	87	50	90	64	..	3.4	2.1	23.3	2.3	2.5	5.6
Picea abies	3	14	—	—	—	—	—	..	0.2	—	—	—	—	—
Pimpinella saxifraga	3	—	—	—	—	—	3	..	—	—	—	—	—	—
Plantago major	31	21	27	33	25	50	33	0.1	0.3	0.5	0.3	0.5	0.6	0.2
Poa spp.	9	36	27	33	46	60	45	..	3.7	3.3	10.2	6.6	12.0	5.7
P. annua	3	—	—	7	8	15	—	..	—	—	0.2	0.4	—	—
P. pratensis s. lat.	31	43	60	53	42	55	52	..	1.8	2.8	7.9	4.4	8.3	4.1
P. trivialis	3	—	—	7	—	5	6	..	—	—	—	—	0.2	—
Polygonum amphibium	—	7	—	—	—	5	—	—	5.2	—	—	—	0.5	—
P. aviculare	13	36	47	73	79	70	82	0.0	0.3	1.1	2.1	10.1	2.2	5.1
P. convolvulus	19	14	27	67	58	75	73	0.6	0.1	0.5	1.1	1.2	2.5	6.2
P. lapathifolium s. lat.	34	29	80	93	96	80	85	0.6	1.1	3.7	37.9	32.0	23.5	21.3
P. viviparum	6	7	—	—	4	—	—	..	0.3	—	—	—	—	—
Populus tremula	3	—	7	—	—	—	3	..	—	—	—	—	—	—
Potentilla spp.	25	7	27	27	25	10	12	0.5	3.8	0.6	0.7	0.9	0.1	3.9
Prunella vulgaris	6	7	13	—	4	20	12	..	0.4	—	—	—	0.1	0.0
Ranunculus acris s. lat.	22	21	27	7	8	20	15	..	0.2	—	—	—	—	0.3
R. auricomus s. lat.	3	7	7	13	4	10	—	..	0.8	—	—	—	—	—
R. repens	81	57	80	100	100	90	88	3.8	5.8	10.3	5.6	39.3	19.7	26.4
Raphanus raphanistrum	13	29	20	33	17	40	52	0.3	0.6	—	—	6.3	0.5	9.5
Rhinanthus minor	—	—	7	—	—	15	3	—	—	0.1	—	—	—	0.2
Rorippa palustris	6	7	20	27	25	—	6	..	0.1	0.1	0.2	1.3	—	0.2
Rubus articus	41	7	20	—	8	15	12	..	—	0.1	—	0.1	0.2	0.2
R. chamaemorus	6	7	7	—	—	—	—	..	—	—	—	—	—	—
R. idaeus	9	—	—	—	4	—	3	..	—	—	—	—	—	—
R. saxatilis	6	—	—	—	—	5	3	..	—	—	—	—	—	—
Rumex spp. sorrels	84	93	100	100	100	95	76	30.1	73.5	41.9	159.4	39.7	21.6	14.5
Rumex spp. docks	31	36	40	33	38	30	42	1.1	—	0.1	0.1	0.1	0.1	0.1
Sagina procumbens	6	7	13	20	29	50	30	..	1.3	8.3	5.8	2.9	8.8	8.3
Salix spp.	9	7	7	—	—	—	3	..	—	—	—	—	—	—
S. caprea	—	—	7	—	4	—	—	—	—	0.1	—	—	—	—
S. phylicifolia	—	29	27	7	8	5	—	—	—	—	—	—	—	—
Secale cereale	3	21	27	—	4	20	6	..	1.1	0.8	—	—	—	—
Senecio vulgaris	16	—	—	—	—	—	3	..	—	—	—	—	—	0.1
Solanum tuberosum	6	7	7	—	4	5	12	..	—	—	—	—	0.1	—
Solidago virgaurea	9	—	—	7	—	—	—	..	—	—	—	—	—	—
Sonchus arvensis s. lat.	25	7	—	—	13	10	12	1.3	—	—	—	0.8	1.2	0.1

Taxon / Age of fields, years / No. of fields	Frequency % A 1—5 32	Frequency % Main localities 1—5 14	6—10 15	11—30 15	31—50 24	51—70 20	71— 33	Number of plants or shoots/m² A 1—5 32	Number of plants or shoots/m² Main localities 1—5 14	6—10 15	11—30 15	31—50 24	51—70 20	71— 33
Spergula arvensis	59	71	73	87	83	100	88	5.4	10.7	79.7	174.5	152.1	229.6	94.2
Stellaria graminea	13	14	7	33	17	20	12	..	0.1	2.7	0.5	0.0	0.2	0.4
S. media	78	79	87	93	92	90	88	57.2	161.6	21.0	64.7	90.1	46.8	46.9
Taraxacum spp.	34	14	27	13	21	35	48	0.3	—	0.7	0.3	0.1	0.3	0.8
Thlaspi spp.	3	7	7	—	17	20	18	—	—	—	—	1.1	3.8	3.4
Trifolium pratense	13	50	60	73	58	70	52	—	0.2	—	0.4	0.2	0.1	0.2
T. others	22	21	47	47	67	65	67	0.8	3.9	0.7	2.7	2.0	3.0	1.6
Tripleurospermum inodorum	19	43	33	47	50	65	61	1.9	2.4	0.5	1.5	1.8	13.0	7.3
Tussilago farfara	25	—	7	7	—	—	—	1.5	—	—	—	—	—	—
Urtica dioica	3	—	7	20	4	30	12	..	—	—	0.3	—	0.4	0.1
Vaccinium myrtillus	6	—	—	—	4	—	—	..	—	—	—	—	—	—
Veronica chamaedrys	16	7	13	7	—	30	12	..	—	0.2	0.1	—	—	—
V. officinalis	—	7	—	—	4	—	3	—	0.1	—	—	—	—	0.1
V. serpyllifolia	9	21	27	33	25	60	42	..	1.4	3.4	1.2	7.5	6.4	3.8
Vicia cracca	9	7	—	20	13	20	27	0.3	—	—	—	0.1	0.3	0.4
V. hirsuta	6	—	13	—	29	45	55	0.2	—	0.1	0.1	1.2	1.6	0.6
V. sepium	3	—	—	7	4	—	3	..	—	—	—	—	—	0.0
Viola arvensis	34	21	13	27	63	65	85	5.8	10.5	—	0.9	33.7	20.9	51.3
V. canina	—	—	7	—	—	5	—	—	—	0.1	—	—	—	—
V. epipsila	—	—	7	13	—	—	—	—	—	—	1.4	—	—	—
V. palustris	25	21	67	93	58	30	21	..	2.3	2.4	6.0	1.4	1.7	0.5
Total taxa or plants	102	91	98	81	98	96	104	153.8	401.6	372.7	964.1	761.6	796.0	805.0

Frequencies and numbers of plants or shoots/m² of the species found in one field age group ( ) only:

(1) *Antennaria dioica* 3, ..; *Calamagrostis arundinacea* 3, ..; *Chenopodium polyspermum* 3, ..; *Cornus suecica* 3, ..; *Crepis* spp. 3, ..; *Epilobium montanum* 3, ..; *Filices* 3, ..; *Hieracium* spp. 6, ..; *Knautia arvensis* 3, ..; *Linaria vulgaris* 3, ..; *Luzula pilosa* 3, ..; *Majanthemum bifolium* 6, ..; *Paris quadrifolia* 3, ..; *Poa nemoralis* 3, ..; *Pteridium aquilinum* 6, ..; *Pyrola* spp. 3, ..; *Stachys palustris* 3, —; *Trientalis europaea* 16, ..; *Vaccinium vitis-idaea* 3, ..;
(2) *Andromeda polifolia* 7, —; *Chamaedaphne calyculata* 7, —; *Ribes rubrum* 7, 0.1; *Vaccinium uliginosum* 7, —;
(3) *Calamagrostis canescens* 7, 0.9; *Eriophorum vaginatum* 7, —; *Oxycoccus quadripetalus* 7, 0.3; *Petasites frigidus* 7, —; *Pinus silvestris* 7, —; *Salix lapponum* 7, 0.1; *S. repens* 7, —; *Sparganium* spp. 7, —;
(4) *Calamagrostis purpurea* 7, —; *Rhinanthus serotinus* 7, —; *Scutellaria galericulata* 7, —; *Stellaria palustris* 7, —; *Valeriana sambucifolia* 7, —;
(5) *Athyrium filix-femina* 4, —;
(6) *Salix myrsinifolia* 5, —;
(7) *Apera spica-venti* 6, 0.1; *Artemisia vulgaris* 6, —; *Brassica napus* 9, 0.5; *Glechoma hederacea* 3, 0.2; *Heracleum sphondylium* 3, 0.1; *Lolium perenne* 3, —; *Melandrium rubrum* 3, 0.4; *Myosurus minimus* 3, 0.1; *Scleranthus annuus* 3, 0.1; *Urtica urens* 3, 0.0; *Viola montana* 3, 0.1.

which showed that frequencies of *Alnus incana*, *Andromeda polifolia*, *Betula nana*, *Carex limorosa*, *Chamaedaphne calyculata*, *Eriophorum angustifolium*, *E. vaginatum*, *Oxycoccus quadripetalus*, *Picea abies*, *Pteridium aquilinum*, *Rubus chamaemorus* and *Trientalis europaea* decreased with increasing age of the field.

Frequencies of the following taxa increased with cropping age of the fields: *Agropyron repens*, *Capsella bursa-pastoris*, *Cirsium arvense*, *Equisetum arvense*, *Erysimum cheiranthoides*, *Fumaria officinalis*, *Gnaphalium uliginosum*, *Myosotis arvensis*, *Polygonum convolvulus*, *Sagina procumbens*, *Urtica dioica*, *Vicia cracca*, *V. hirsuta* and *Viola arvensis*. According to the present data and the observations at Pihtipudas, the following species appeared to increase as well: *Achillea millefolium*, *A. ptarmica*, *Chenopodium album*, *Galeopsis bifida*, *G. speciosa*, *Lamium hybridum*, *L. purpureum*, *Lathyrus pratensis*, *Matricaria matricarioides*, *Phleum pratense*, *Plantago major*, *Poa* spp., *Polygonum aviculare*, *P. lapathifolium*, *Raphanus raphanistrum*, *Spergula arvensis*, *Stellaria media*, *Thlaspi arvense* and *Trifolium repens*.

It appeared as a general feature that on fields of all age groups the numbers of perennial

Table 2. Numbers of species and numbers of plants or shoots/m² of vascular plants growing on fields of different ages.

Age of fields, years	No. of fields	Perennials		Annuals		Total	
		No. of species	No. of shoots	No. of species	No. of plants	No. of species	No. of plants or shoots
1—5	14	14.1	191	6.2	211	20.4	402
6—10	15	19.3	219	7.3	153	26.6	373
11—30	15	17.7	396	9.3	568	27.1	964
31—50	24	16.6	209	10.2	552	26.8	762
51—70	20	21.1	190	12.9	605	34.0	796
71—	33	17.3	229	13.4	576	30.6	805

species were approximately equal and generally quite high. Certain perennials like *Agrostis* spp., *Deschampsia caespitosa* and *Equisetum palustre* carried over from the native wild vegetation to become part of the weed flora. Many native species disappeared in the course of time but simultaneously several other perennial weeds spread onto the field filling the gaps thus created, so that the total number of taxa in the community remained about the same (Table 2). Only those very young fields in areas remote from farmstoods and other cultivated fields showed very low numbers of perennial species a few years after having been cleared.

Virgin soil usually contained very few annual species, which therefore were also scarce in newly-cleared fields. The number of annual species first increased rapidly, then more slowly in the course of several decades (Table 2). Yet even after more than 70 years of cultivation the number of annual species did not reach that of perennials, even though spring cereals were grown which are known to favour annual weeds. With the arrival of the annuals the total number of species in the field increased considerably.

Changes in weed density

The percentage frequency and abundance of a given taxon were usually positively correlated but sometimes the correlation was weak or undistinguishable. Densities of receding species were mostly low but densities of those on the increase (weeds proper) were very high in some young fields (Table 1). Propagules of certain perennial species such as *Agrostis tenuis*, *Agropyron repens*, *Deschampsia caespitosa* and sorrels (*Rumex* spp.) persisted in the soil from the period prior to clearing and even increased with increasing age of the field. The numbers of individuals or shoots increased as the age of the field increased but seemed to reach a maximum of fields over 30 years of age.

The increase in density was caused especially by the increase in numbers of individuals of annual weeds. In some instances, e.g. on fields situated on peatland, the density of perennials was found to be increasing as well, but many of these fields were in fact developed from land containing propagules of this group in abundance, thus the perennials were already numerous in the first year.

Changes in occurrence and number of weed seeds in soil

The numbers of seeds in the soil were clearly lower in the young fields than in the old ones (Table 3). The cultivated layer of young fields initially contained seeds of the species already present, whose numbers decreased with increasing age of the field. This was quite evident e.g. in the genus *Carex* (Table 3). This genus was fairly abundant in the areas to be cleared, but the cleared fields contained very few *Carex* plants. The seeds found most frequently in young fields were those of *Brassica*, but in places *Rumex* spp., *Stellaria media*, *Chenopodium album*, *Spergula arvensis*, *Viola* spp. and *Ranunculus* spp. were fairly numerous as well. The high number of *Brassica* seeds encountered was somewhat surprising. The seeds were of low viability since young emerged seedlings of *Brassica* were

Table 3. Frequency percentages and numbers/m² of seeds of weed taxa found in the cultivated layer of fields of different ages at localities 10—12, 15 and 19 (A) and locality 3.

Taxon / Age of field, years No. of fields examinated	Frequency %				Number of seeds/m²			
	A	Locality 3			A	Locality 3		
	1—5 10	1—30 14	31—50 14	51—100 9	1—5 10	1—30 14	31—50 14	51—100 9
Agropyron repens	—	—	—	11	—	—	—	33
Alchemilla spp.	30	7	7	—	264	198	33	—
Alopecurus geniculatus	—	21	7	22	—	429	33	990
Anthoxanthum odoratum	—	—	7	11	—	—	33	33
Brassica spp.	90	86	64	89	9 372	3 861	3 762	5 808
Carex spp.	50	64	86	33	2 178	3 003	2 178	858
Centaurea cyanus	10	—	—	—	33	—	—	—
Chenopodium album s. lat.	60	86	86	89	627	2 244	2 508	11 682
C. glaucum	—	7	—	—	—	33	—	—
Galeopsis spp.	30	50	86	78	165	363	1 353	2 310
Galium spp.	10	7	—	22	33	990	—	132
Geranium spp.	—	7	—	—	—	33	—	—
Lathyrus pratensis	10	14	29	11	33	198	231	99
Leontodon autumnalis	—	—	—	22	—	—	—	66
Myosotis spp.	10	29	29	22	231	297	726	198
Pedicularis palustris	—	14	—	—	—	33	—	—
Polygonum aviculare	—	29	36	44	—	363	759	528
P. convolvulus	20	21	36	22	264	462	627	99
P. hydropiper	—	—	—	11	—	—	—	33
P. lapathifolium	10	36	57	89	33	396	627	1 452
Ranunculus spp.	40	93	86	100	462	4 257	2 211	5 280
Raphanus raphanistrum	—	14	7	—	—	66	33	—
Rumex spp.	—	7	14	—	—	2 178	3 762	—
R. acetosa	40	7	7	—	363	99	33	—
R. acetosella s. lat.	50	79	71	89	231	2 112	2 937	1 518
R. longifolius	30	14	14	—	1 386	132	198	—
Spergula arvensis	50	57	93	89	264	12 144	8 877	8 514
Stellaria media	60	29	64	67	1 122	297	2 442	429
Thlaspi arvense	—	7	—	11	—	66	—	33
Trifolium spp.	10	—	—	—	66	—	—	—
Tripleurospermun inodorum	—	7	14	—	—	33	231	—
Vicia spp.	—	14	7	11	—	561	363	132
Viola spp.	30	50	36	44	363	891	297	396
Other species	40	50	71	56	462	2 013	3 861	2 739
Total no. of seeds					17 952	37 752	38 115	43 362

extremely rare. It is possible that many of these fields were former burnt-over forest clearings where turnips had been sown as the first crop and the seeds may have persisted in the soil ever since. Seeds of *Chenopodium album*, *Galeopsis* spp., *Polygonum aviculare* and *P. lapathifolium* increased in numbers with increasing age of the field. The cultivated layer of the oldest fields contained in particular seeds of *Chenopodium album*, *Spergula arvensis*, *Brassica* spp., *Ranunculus* spp. and *Galeopsis* spp.

Changes in weed taxa on different types of soil

To obtain a general picture of the influence of soil type on the weed taxa changes the soils were grouped roughly into mineral soils and humus or peat soils. Even then, dependable material for comparison was only obtained from the Viitasaari—Keitele area where 52 fields studied were adjacent to each other. The mineral soils had in almost every instance received farmyard manure both as an initial basic dressing and on other occasions in later years, while the humus soils had almost exclusively been given artificial fertilizers. The young fields on mineral soil were usually situated closer to other farmland than were those on humus soil, and were consequently subject to more active spread of weeds by several means. It was found at least for certain

Table 4. Numbers of weeds/m² in fields of different ages and soil types in the Viitasaari—Keitele (4—5) area.

Taxon \ No. of fields	Numbers of weeds/m² in fields of indicated age groups and soil types			
	1—20 years		21—80 years	
	Mineral soils	Humus & peat soils	Mineral soils	Humus & peat soils
	10	12	22	8
Chenopodium album s. lat.	24.8	6.4	25.9	10.3
Capsella bursa-pastoris ..	4.5	0.0	5.3	1.9
Agropyron repens	27.4	0.7	58.5	28.1
Galeopsis spp.	34.0	5.3	117.5	80.0
Galium vaillantii	2.3	0.0	0.1	0.0
Myosotis spp.	2.1	0.0	26.5	4.0
Spergula arvensis	54.1	4.9	202.2	278.3
Stellaria media	309.3	0.5	30.8	47.6
Equisetum palustre	—	16.4	—	4.0
Ranunculus repens	4.2	14.1	21.1	111.5
Rumex spp. (sorrels) ..	20.9	104.1	16.0	20.8
Agrostis spp.	0.2	32.5	22.9	34.1
Deschampsia caespitosa ...	9.2	38.7	22.7	12.5
Viola palustris	0.3	5.3	0.3	6.1

species common to both soils that their rates of arrival and increase in particular were clearly different on the two different soil types. In young fields the numbers and frequency percentages of species normally present in abundance in farmyard manure were clearly lower on the humus soils than on the mineral soils, but these differences later diminished or even disappeared (Table 4). Occasionally a species disseminated in farmyard manure, e.g. *Stellaria media*, would occupy the growing space almost totally. Those species spreading through contaminated crop seed, on the other hand, were quickest to invade the humus soils, but certain plants typical of the virgin peat, e.g. *Equisetum palustre* and *Viola palustris*, stayed on for at least a century after cropping of the site began. The development of a characteristic weed flora thus takes longer on humus soils than on mineral soils, but in the end the species compositions on both will gradually approach each other as the habitats become more and more alike in regard to soil and general growing conditions.

Changes in vegetation

On fields less than 10 years old the number of taxa was small and in years when spring cereals were grown many perennials seldom encountered in arable fields were predominant. The frequencies and abundances of certain taxa characteristic for spring cereals were rather low. The vegetation was mostly patchy. Thus, for instance, some fields displayed patches of *Agropyron repens*, *Chenopodium album*, *Galeopsis bifida*, *Spergula arvensis*, *Stellaria media*, *Rumex acetosella*, *R. acetosa* or *Viola arvensis* consisting of hundreds or even thousands of plants per square metre, while other fields or even different parts of the same field had none at all. The numbers and especially densities of the other species typical in spring cereals were lower on young fields than on the old ones. Weed vegetation became much more homogeneous after the field had been under cultivation for more than 10 years, but the change was rather slow. The dispersal of the most common and most abundant species of a field was fairly uniform after 20—30 years of cultivation, while that of the rarer species was still patchy. Apparently the formation of a typical plant community takes somewhat less time on mineral soils than on peat soils. The vegetation development of a weed in a cultivated field is, however, a continuing process, and it appears that plant compositions on mineral and humus soils tend to grow more and more alike as the fields become more and more similar the longer they are cultivated. The whole process is, however, extremely slow.

Discussion

The weeds of cultivated fields can be classified into five groups according to their time of arrival on the site. A given species can, nevertheless, come under more than one group.

1. Species that arrived before the site was cleared for cultivation. These are, in general, perennial plants of forest and peatland, such as *Alnus incana*, *Betula* spp., *Vaccinium myrtillus*,

Deschampsia flexuosa, *Equisetum silvaticum*, *E. palustre*, *Eriophorum angustifolium*, *Carex canescens* and *Viola palustris*. Many of these disappear after a number of years but e.g. *Equisetum palustre* will persist in the field. Sites infested by this very persistent species should no longer be cleared for cultivation. In the Välijoki settlement of Rovaniemi rural commune already this weed has made both field and livestock husbandry unprofitable (e.g. BORG 1971). Perennial species of forest habitats were quite common on ancient burnt-over clearings (LINKOLA 1921).

2. Species that arrive at the time of land clearance. When the original vegetation is removed, some perennials especially favouring open places are likely to gain foothold, e.g. *Agrostis tenuis*, *Chamaenerion angustifolium*, *Rumex acetosella* and *Deschampsia caespitosa*. Their dissemination into the field occurs through wind, man, his tools, animals and their feeds. Many such arrivals will thrive well especially when the field is under ley.

3. Species that arrive with the first application of farmyard manure and soil improvement materials. The number of such species is very high; they all are characteristic of cultivated fields and leys. Farmyard manure is known to contain huge amounts of weed seeds (see e.g. KORSMO 1925), and it was established that many fields in the present investigation had received manure containing high numbers of most of the species listed in Table 4.

4. Species that arrive in seed of the first crop sown. Seed lots of oats, rye, turnip, timothy and clover, the most frequent first crops, carry seeds of scores of typical weeds (see JOKELA 1965, 1966). It was common for newly-reclaimed land to be sown with home-grown seed much more contaminated than commercial seed (see HILLI 1961). This provided the field with large numbers of weed seeds from the very beginning. Common or typical species transported in cereal seed are, among others, *Galeopsis bifida*, *G. speciosa*, *Polygonum* spp., *Raphanus raphanistrum*, *Chenopodium album*, *Centaurea cyanus*, *Bromus secalinus* and *Avena fatua;* species transported in herbage seed are e.g. *Rumex acetosella*, *Deschampsia caespitosa*, *Achillea ptarmica*, *A. millefolium*, *Tripleurospermum inodorum* and *Spergula arvensis*.

5. Species that arrive after the field has been under cultivation for many years. Weeds of this group were still infrequent in our sample areas at the time of the survey, but some of them were encountered in densely populated areas especially on the oldest fields. One of the earliest arrivals in this group is *Agropyron repens* followed by *Cirsium arvense*, *Sonchus arvensis*, *Lamium* spp. and *Avena fatua*.

The weed flora of cultivated fields is, however, subject to continuous change (cf. MUKULA et al. 1969, RAATIKAINEN and RAATIKAINEN 1970). Although it is presently possible to reduce the numbers of weed seeds in soil to a minimum by repeated herbicide treatments, the weed content will return to its previous level in a few years' time unless really effective measures are taken to control the spread of propagules.

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SELOSTUS

Peltojen rikkaruohottumisesta Suomessa

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Vuosina 1961—1964 tutkittiin peltojen rikkakasvilajiston suuruus ja rikkakasvien määrä/m² 153 eri ikäisellä, yleensä alle 100 vuotta viljeltynä olleella ja tutkimusaikana kevätviljaa kasvavalla pellolla. Aineisto kerättiin etupäässä Viitasaarelta, Keiteleeltä, Kälviältä, Laihialta ja Alajärveltä, mutta aineistoa koottiin myös 17 muusta pitäjästä (kuva 1). Muokkauskerroksessa olevien rikkasiementen määrät tutkittiin 47 pellolta otetuista näytteistä.

Paikan alkuperäinen monivuotinen lajisto hävisi muutamassa vuodessa, mutta jotkut lajit, mm. suokorte jäivät pysyvästi peltojen rikkaruohoiksi (taul. 1). Peltojen tyypilliset yksi- ja monivuotiset rikkakasvit levisivät viljelyksille muutamassa vuodessa (taul. 2). Aluksi kasvillisuus oli hyvin laikuittaista, mutta muuttui vähitellen homogeenisemmaksi. Noin 20—30 vuoden kuluttua pellolla oli jo melko tyypillinen rikkakasvikoostumus. Muokkauskerroksessa oli silloin noin 40 000 rikkasiementä/m² (taul. 3), ja yksivuotisten rikkakasvien+monivuotisten kasvien versojen määrä oli noin 700—800 kpl/m².

Kivennäismailla rikkakasvittuminen oli yleensä nopeampaa kuin multamailla, joilla käytettiin huomattavasti vähemmän rikkasiemenpitoista karjanlantaa (taul. 4). Kivennäismailla ja multamailla olevien peltojen rikkakasvikoostumus muuttui pellon vanhentuessa yhä enemmän toistensa kaltaiseksi.

Peltojen rikkakasvilajit jaettiin saapumisajan perusteella viiteen ryhmään. Karjanlannan ja kylvösiemenen mukana näyttivät tulleen useimmat tyypilliset rikkakasvilajit.

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SCLEROTINIA DISEASE OF STOCKS (MATTHIOLA INCANA R. BROWN)

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A *Sclerotinia* fungus isolated from stocks (*Matthiola incana*) was identified as *S. matthiolae* Lendner. Apothecia, asci ($8.1 \times 120.3\ \mu$) and ascopores ($4.2 \times 9.3\ \mu$) produced by the fungus were somewhat smaller than those of *S. sclerotiorum*. *S. matthiolae* differed from the latter particularly in its pathogenicity. It infected stocks very severly, withering them completely; *S. sclerotiorum* caused only mild infection in wounded plants.

Of the fungicides tested, tecnazene was most effective against both *Sclerotinia* fungi, inhibiting both the mycelium and the formation of sclerotia. Also the quintozenes, phenylmercury acetate and cycloheximide prevented the formation of sclerotia and decreased the degree of severity of the disease in inoculated plants.

Introduction

In our country, the area of stocks (*Matthiola incana* R. Brown) under glass is rather small. This plant is, however regularly grown in some glasshouses as a spring rotational crop. For the stock to succeed, it must be grown in light and spacious greenhouses with not too high a humidity. In spring 1956, a stand of stocks badly infected with Sclerotinia disease was found in a rather low greenhouse in Kerava. About 60 % of the 200 m^2 stand had been destroyed. The flowers and leaves had withered and the plants were completely covered with a white fungal mycelium. Black sclerotia typical of the *Sclerotinia* fungi were found on the stems. The fungus was isolated, and studies were conducted in the Department of Plant Pathology to investigate its taxonomy, pathogenecity and control.

Material and methods

The *Sclerotinia* fungus isolated from stocks was grown on glucose- and on oat agar. Some of the sclerotia which had developed on the nutrient medium were placed on moistened sand in Petri-dishes at room temperature to grow apothecia. For the infection experiments, the *Sclerotinia* fungus of stocks, and also for purposes of comparison MUKULA's (1957) *Sclerotinia sclerotiorum* (Lib.) de Bary isolated from carrots, were grown in Erlenmeyer flasks on pieces of white bread moistened with 1 % sucrose solution. The infection was initiated by three methods, using mycelial and sclerotial material from fungus grown for 21 days, as follows:

a) the plant was treated with a fungal suspension containing 5 g of crushed mycelial and sclerotial material/dl of water/plant.

b) 5 g of mycelial and sclerotial material were placed at the base of the plant.

c) the crown of the plant was sprayed with a mycelial-sclerotial suspension.

The effect of the fungicides on *Sclerotinia* fungi in vitro was studied in laboratory experiments by the diffusion method as described by TAPIO (1966) and YLIMÄKI (1969). The fungus was transferred to the centre of a dish of glucose

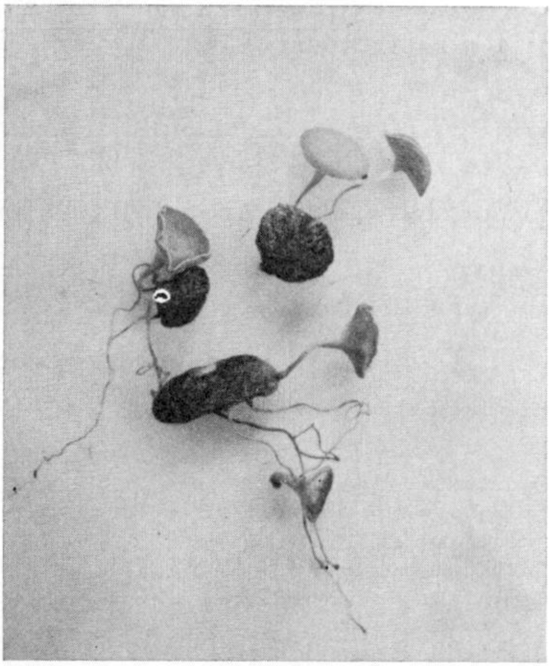

Fig. 1. Apothecia grown from sclerotia of the fungus *Sclerotinia matthiolae* on quartz sand.

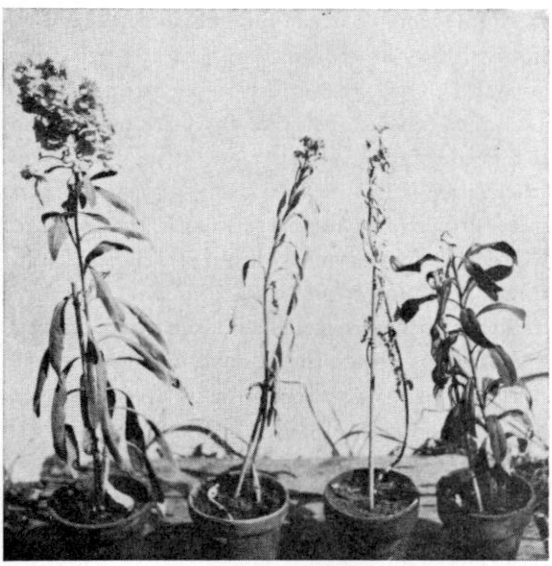

Fig. 2. Stocks infected with *Sclerotinia matthiolae*. From left a) control, b) watered with mycelial and sclerotial suspension, c) sclerotial material applied to base, d) crown sprayed with sclerotial suspension.

agar, and weighed quantities of fungicide were placed on 10 mm diameter filter-papers on various parts of the dish. Growth of the mycelium was measured daily and the sclerotia which developed were counted.

The effects of the fungicides in vivo were studied on stocks infected with *S. matthiolae* and on dahlias and hydrangeas infected with *S. sclerotiorum*. The base of plants and soil inoculated with fungal suspension (method a) were treated or dusted 6 days later with the fungicide to be studied.

Results

Morphology and pathogenicity

The *Sclerotinia* fungus isolated from stocks grew vigorously both on glucose- and on oat agar. The mycelium was white and cotton-like, and abundant microconidia formed on it. Appressoria developed on the surface of the glass. The 9—14 sclerotia which developed in each dish were oval to roundish, 3.3 × 5.3 mm in size (2—4.5 × 3.5—8 mm). After a year, apothecia grew from the sclerotia on quartz sand. The apothecia were convex or slightly concave over their 3—8 mm diameter (Fig. 1). On the inner surface of the cup, large numbers of asci, 8.1 × 120.3 μ (6.5—9.5 × 98—136 μ) formed. Each of which contained 8 oval, colourless ascospores 4.2 × 9.3 μ (3.8—5 × 6—12 μ), or a little smaller than those of *S. sclerotiorum* (Mukula 1957). The characteristics of the fungus studied agree with those described by Lendner (1929) for *S. matthiolae* which, according to him, infects stocks in spring causing symptoms similar to those described above.

In the infection experiments, *S. matthiolae* was found to infect stocks severely by all three inoculation methods. As early as two weeks following inoculation, plants infected via the soil and base had withered completely, and those spraying with fungal suspension had withered from the crown (Fig. 2).

On the other hand, stocks inoculated with *S. sclerotiorum* using the same methods did not

Table 1. Effect of various fungicides on *Sclerotinia matthiolae* and *S. sclerotiorum* in laboratory trials

Preparation	Active ingredients	Prepar. mg/dish	Mycelial growth (mm) of *Sclerotinia*-fungi after days indicated						No. of sclerotia per dish	
			S. matthiolae			*S. sclerotiorum*			*S. matth.*	*S. scl.*
			2	6	12	2	6	12		
Inorganic compounds										
Atiran	methoxyethylmercury chloride 4.6 %	10	13.5	50.0	70.5	14.0	55.5	85.0	8	10
Ceresan Nb.	methoxymercury acetate 2.4 %	15	9.5	34.5	54.5	11.0	14.0	24.5	11	3
Verdasan	phenylmercury acetate 5 %	10	8.5	33.0	34.0	17.5	42.5	46.0	0	0
Organic compounds										
Avicol dust	quintozene (PCNB) 20 % .	20	14.0	100	100	0	100	100	0	0
Avicol wp.	» 50 % .	10	14.0	100	100	10.5	67.5	82.5	3	1
Botrilex	» » 50 % .	10	15.0	100	100	5.5	81.5	100	0	0
Folosan	tecnazene (TCNB) 5 % ...	80	0	12.5	16.0	0	10.5	13.5	0	0
Orthocide 75 ...	captan 75 %	5	25.0	100	100	16.0	79.5	86.5	9	4
Duphar ferbam .	ferbam 95 %	5	13.5	78.0	100	12.5	79.5	80.0	12	13
Duphar TMTD .	thiram 50 %	10	22.0	91.0	100	13.5	84.5	100	12	19
Pomarsol forte ..	» 80 %	5	18.5	92.5	100	18.5	66.5	78.5	13	15
Antibiotics										
Agrimycin	streptomycin 15 % + oxytetracycline 1.5 %	2	17.0	100	100	17.5	91.0	92.5	10	13
U-4527	cycloheximide	2	14.5	27.0	28.0	13.5	23.5	24.5	0	0
Control		—	24.0	100	100	33.0	100	100	10	7

contract the disease at all (Fig. 3). Only when the base of the stock was wounded, sclerotia inserted in the wound and the stem bound with cotton at this point did some individuals become diseased. The fungal mycelium did not grow throughout the stock plant as did that of *S. matthiolae*, but only caused partial withering.

S. sclerotiorum has been mentioned (ANON. 1948) as having infected *Matthiola incana* in New South Wales, Australia, in cool, moist conditions in late autumn and winter.

Effects of the fungicides

All of the mercury-containing substances slowed down the growth of the mycelium, but only phenylmercury acetate inhibited the formation of sclerotia (Table 1). The chloronitro-

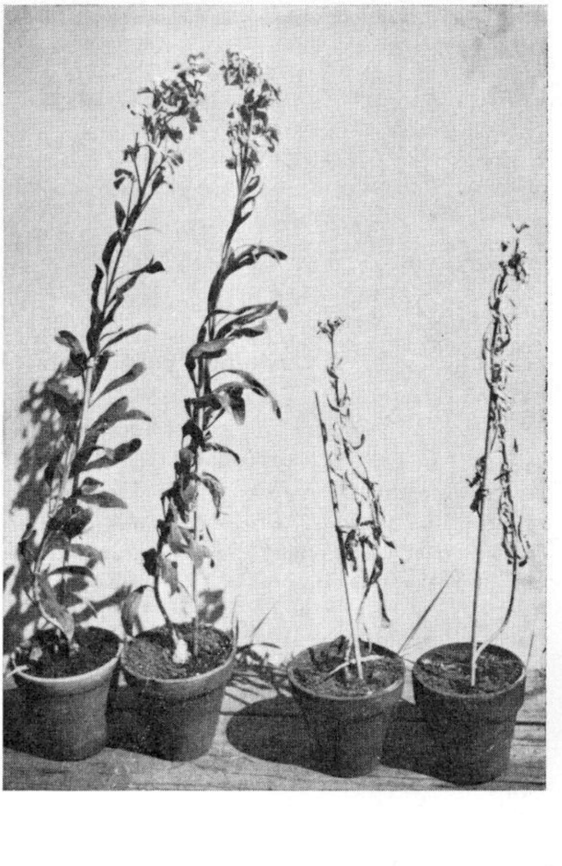

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Fig. 3. Stocks infected with *Sclerotinia* fungi. Left pair with *S. sclerotiorum*, right with *S. matthiolae*.

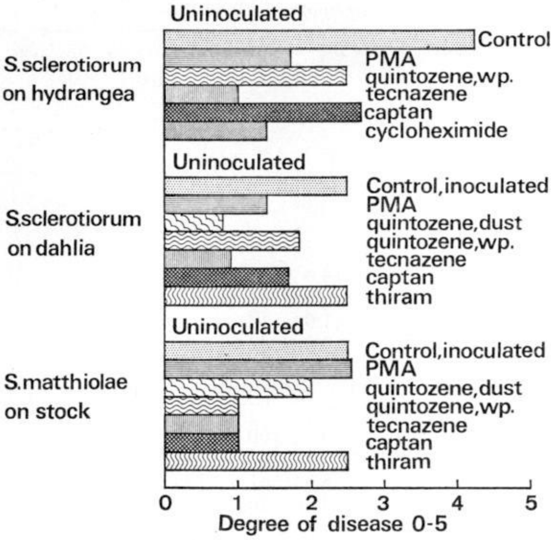

Fig. 4. Effect of various fungicides on *S. matthiolae* on stock and *S. sclerotiorum* on dahlia and hydrangea.

benzenes inhibited almost entirely the development of sclerotia, and tecnazene also inhibited mycelial growth. The other organic preparations, captan, ferbam and thiram somewhat slowed down the growth of *S. sclerotiorum* in particular, but did not prevent the formation of sclerotia. Of the antibiotics, agrimycin did not affect the growth of the fungi, but cycloheximide slowed down mycelial growth greatly and prevented the formation of sclerotia. None of the substances studied inhibited the formation of microconidia.

In the experiments carried out on plants, tecnazene and cycloheximide (Actidione), which was used in only one experiment, were most effective against *Sclerotinia* fungi, while quintozenes were rather effective (Fig. 4). In some of the experiments, captan and phenylmercury acetate had an inhibitory effect on the fungus. Thiram was not effective at all against *Sclerotinia* fungi. The results are in agreement with those of MUKULA (1957) for *S. sclerotiorum* and of YLIMÄKI (1955, 1969) for *S. trifoliorum*.

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SELOSTUS

Leukoijan pahkahome (Sclerotinia matthiolae Lend.)

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Leukoijasta (*Matthiola incana* R. Brown) eristetty *Sclerotinia*-sieni identifioitiin *S. matthiolae* Lendner -lajiksi. Sienen kehittämät apoteekiot (3—8 mm), itiökotelot (8.1 × 120.3 μ) ja itiöt (4.2 × 9.3 μ) olivat jonkin verran pienemmät kuin *S. sclerotiorum*in vastaavat. *S. matthiolae* poikkesi jälkimmäisestä erityisesti patogeenisuutensa vuoksi. Se saastutti voimakkaasti leukoijaa kuihduttaen sen kokonaan. *S. sclerotiorum* aiheutti vain haavoitetun leukoijan lievää sairastumista.

Fungisideista tehosi teknatseeni parhaiten molempiin *Sclerotinia* -sieniin ehkäisten sekä rihmaston kasvun että pahkojen muodostumisen. Myös kvintotseenit, fenylimerkuriasetaatti ja cycloheksimidi estivät pahkojen kehittymisen ja vähensivät inokuloitujen kasvien pahkahomeisuutta.

ANNALES AGRICULTURAE FENNIAE, VOL. 11: 115—118 (1972)
Seria PHYTOPATHOLOGIA N. 38 — Sarja KASVITAUDIT n:o 38

VIRUS-FREE CLONES OF THE POTATO VARIETIES PITO AND TAMMISTON AIKAINEN

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TAPIO, EEVA 1971. **Virus-free clones of the potato varieties Pito and Tammiston aikainen.** Ann. Agric. Fenn. 11: 115—118.

The potato variety Pito, released by the Department of Plant Breeding at Jokioinen in 1964 for commercial production and the variety Tammiston aikainen, released by the Plant Breeding Institute of Hankkija in 1930 were used as experimental subjects. The former is completely infected with S and partially with X virus, the latter completely with S and Y, and partially with X virus. Both these potato varieties were freed from viruses by apical meristem culture alone or by meristem culture combined with heat treatment.

Introduction

More than three quarters of the potatoes cultivated in Finland are virotic (SEPPÄNEN 1966). In particular, the viruses S and X occur in all varieties throughout the country. Virus-free seed of several varieties cannot be found at all. In early spring of 1971, attempts were started to free certain potato varieties from viruses according to a method used by several workers (MOREL and MARTIN 1955, KASSANIS 1957, KASSANIS and VARMA 1966, CHRISTENSEN 1968).

Materials and methods

The potato variety Pito, released by the Department of Plant Breeding at Jokioinen in 1964 for commercial production, was used as an experimental subject. This variety is completely infected with S and partially infected with X virus. The once popular early variety Tammiston aikainen released by the Plant Breeding Institute of Hankkija in 1930 was used as the second subject. Its cultivation has been largely given up on account of severe virosis and because of its susceptibility to potato wart. As well as being completely infected with viruses S and Y, it is partially infected with X.

The tubers were sprouted in half light in a bed of peat for about two weeks before apical meristem culture was begun. After this time, sprouts were 3—5 cm long. For culturing the apical meristems MURASHIGE and SKOOG's (1962) nutrient solution was mostly used as the growth medium, either as an 0.8 % agar or as a solution. Five ml of nutrient agar or solution were put into 19 mm × 150 mm large test tubes or 15 ml into 50 ml large Erlenmeyer flasks (Fig. 1). In the solution cultures, a filter paper, previously rolled around a cylindrical object, was half immersed in the solution (Fig. 2) (cf. HELLER 1949). In addition to these, a nutrient solution according to MOREL and MULLER (1964) was used both with and without yeast-extract. The apical meristems were excised in a small disinfected laboratory, where U.V. lamps were switched on at regular intervals. The work was done under the microscope using 25 × magnification. The test tubes were sealed either with an aluminium or cotton stopper with parafilm stretched over these. They were then put into a growth cabinet at a temperature of 22 ± 3°C and illuminated at 2 500 lux with fluorescent tubes.

The potatoes to be heat-treated were sprouted in peat and planted in soil in clay pots. When the young plants were 10—15 cm tall they were placed into a thermotherapy cabinet whose internal measurements were 70 × 140 × 170 cm. The cabinet had 14 × 40 W fluorescent tubes which gave a light intensity of about 6 000 lux. The temperature was 37 ± 1°C and the relative humidity 65—85 % during the treatment. Plants of Pito were subjected to heat therapy for 21 days, after which meristems were excised from them. Tammiston aikainen did not withstand the long heat treatment, so its meristems were excised as soon as the plants showed signs of suffering, about 9—15 days after the treatment was begun. Meristems from heat-treated plants were then cultured in the Murashige-Skoog media.

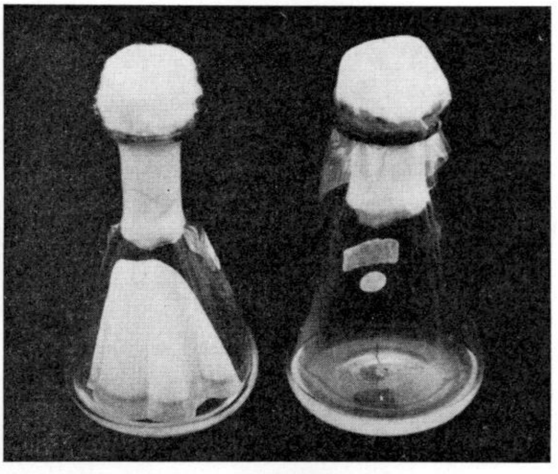

Fig. 1. Potato meristem culture in 50 ml Erlenmeyer flasks in Murashige and Skoog's nutrient medium. Left: on filter paper partly immersed in solution, right: on 0.8 % agar.

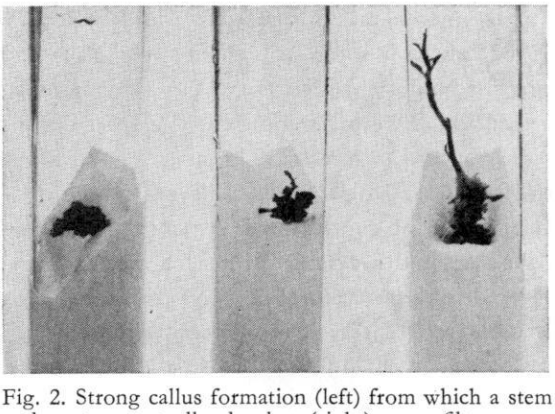

Fig. 2. Strong callus formation (left) from which a stem and roots eventually develop (right) on a filter paper immersed in Murashige and Skoog's solution.

When 4—6 cm stems and good roots had developed from the meristems, they were planted in steamed soil in small 6 cm diam. pots. They were kept in the growth cabinets for 1—2 weeks before they were transferred to the greenhouse. The young plants were later transplanted to larger pots.

When the plants had grown to about 15 cm, the first test was made. Viruses S and X were determined serologically and Y by inoculating leaves of A6 and plants of *Nicotiana tabacum* var. Samsun. A second serological and inoculation test was made 1—2 months later to confirm the earlier test. Tissues from all plants were examined under the electron microscope. Tubers developed from potato plants which had proved virus-free were removed in October—November for storage at +2—+5°C for few months, and the stems were divided into cuttings. These were inserted in a rooting mixture of peat and sand. Clones from single meristems were grown in isolation for a time. This allows comparisons to be made during the growing season to identify possible harmful mutations before clones will be combined and finally propagated for seed potato production.

Results

Apical meristems developed into young plants much better in Murashige and Skoog's growth

Table 1. The performance of virus-free potato plants produced by heat treatment and meristem culture

Variety	Virus present	Thermo-therapy 37°C days	Culture medium	No of excised meri-stems	Plants producted		Virus-free plants		Days from meristem excision — potting up
					No.	%	No.	%	
Pito	S	0	M. — Sk.-sol.[1])	30	6	20	3		138 (85—204)
»	»	0	M. — Sk.-agar	19	7	37	} 12	} 71	105 (69—168)
»	»	0	M. — Sk.-ag.to sol.	9	8	89			
»	»	0	M. — M.-sol.[2])	24	0	0	0	0	0
»	»	0	M. — M.-agar	71	1	1	1	(100)	253
Tamm. Aik.	S, Y	0	M. — Sk.-sol.	35	18	51	14	} 85	56 (35—75)
»	»	0	M. — Sk.-agar	41	9	22	9		56 (35—190)
Pito	S, X	21	M. — Sk.-sol.	12	6	50	4	} 84	55 (41—93)
»	S, X	21	M. — Sk.-agar	35	13	37	12		74 (42—146)
Tamm. Aik.	S, X, Y	9—15	M. — Sk.-sol.	65	6	9	5	83	99 (77—106)
»	S, Y	9—15	M. — Sk.-agar	86	0	0	0	0	—

[1]) Murashige and Skoog's solution
[2]) Morel and Muller's solution

medium than in Morel and Muller's. In the latter, only 1 plant developed from 95 meristems (Table 1; cf. CHRISTENSEN 1970). When the solution-filter paper growth medium is compared with the agar, the former — with certain exceptions — gave somewhat better results. STONE (1963) obtained similar results with carnations. For Pito potatoes, the development of non-heat-treated meristems to the potting stage took an average of 122 days, and for Tammiston aikainen 56 days (Fig. 3). This difference could have been due to the time of culture, and not only to varietal characteristics. Meristems of Pito were put into the test tubes during February—March, those of Tammiston aikainen during April—May. On the other hand, Pito withstood heat treatment better than Tammiston aikainen. With a 21 day heat treatment, 44 % of the meristems taken from Pito potato sprouts developed into plants. Only 5 % of Tammiston aikainen meristems subjected to a 9—15 day heat treatment developed successfully, however (Table 1).

About 80 % of the plants grown apical meristems were certainly virus-free. In serological tests, some gave a clear agglutination reaction with S and/or X antisera. Those which gave an unclear reaction were rejected as possibly virotic. Whereas all the mother plants were infected, none of the individuals grown from meristems of Tammiston aikainen were found to have Y virus. This virus can thus be eliminated by simple apical meristem culture without thermotherapy, as CHRISTENSEN (1970) and some others have found. About two months after potting up, 5.2 tubers per potato plant had developed on the average, and the stems could be divided into 14 cuttings, of which most rooted in a peat-sand mixture.

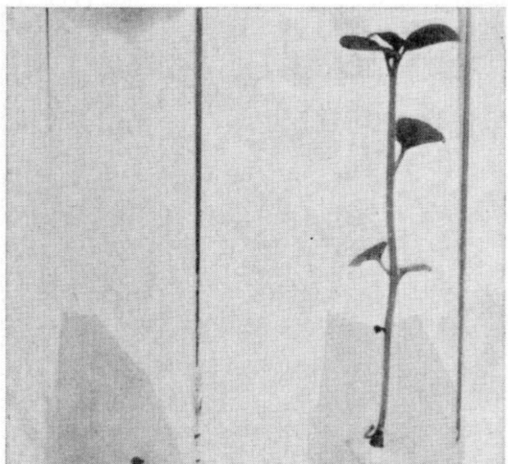

Fig. 3. The rapid development of a young Pito potato plant (right) on a filter paper immersed in Murashige and Skoog's solution after slight callus formation (left).

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SELOSTUS

Viruksettomia klooneja Pito- ja Tammiston aikainen-perunoista

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Solukkoviljelyä (kasvupisteviljelyä) tai lisäksi sitä edeltävää lämpökäsittelyä apuna käyttäen on viroottisesta Pito-perunasta saatu tuotetuksi taimia, joissa ei ole S- ja X-virusta ja Tammiston aikaisesta sellaisia, joissa ei ole S-, X- ja Y-virusta, kuten lähtöaineistossa. Viruksettomien kloonien lisäysviljely on käynnistetty.

ANNALES AGRICULTURAE FENNIAE, VOL. 11: 119—134 (1972)
Seria PHYTOPATHOLOGIA N. 39 — Sarja KASVITAUDIT n:o 39

ON THE EXTERNAL QUALITY OF TABLE POTATOES IN FINLAND AND FACTORS INFLUENCING IT

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SEPPÄNEN, E. 1972. **On the external quality of table potatoes in Finland and factors influencing it.** Ann. Agric. Fenn. 11: 119—134.

In 1967—71 the external quality of 320 lots of packaged table potatoes was studied. The quality varied greatly. The most common defect was mechanical damage followed by green, scabby, and decayed tubers. Some fungi were detected as new pathogens of the potato in Finland.

Introduction

In Finland, potatoes are an essential part of the daily food. In recent years the consumption of potatoes has decreased rapidly. Because poor quality has been mentioned as one factor which has contributed to this decline, the question of quality has been under lively discussion.

As to the definition of high quality of table potatoes, the matter is not unambiguous because the taste and food habits of people differ. Some properties of potato tubers such as size and freedom from defects are, however, possible to determine fairly objectively. Samples of table potatoes were obtained from retail stores by the Department of Plant Pathology and examined as to their external and internal defects with the objective of determining their severity in table potatoes. In this study »external quality» includes all properties other than nutritional values, cooking quality, and flavor characteristics (cf. VARIS 1970). In addition to the quality investigation a further objective was to get information about the incidence and importance of tuber diseases of potatoes in Finland. Naturally the results of a limited study like this are not conclusive but help to reveal the variations in quality of table potatoes and the most important factors contributing to low quality.

Materials and methods

Samples of potatoes were purchased at random in retail stores starting in October 1967 and continuing to May, 1968. The same procedure was used during the following two years. In 1967—68, in addition to the purchase and examination of 47 samples of ordinary table potatoes, 37 samples of so-called »choice» potatoes, the only quality-graded potato (voluntary control) at that time, were examined. During the three first years most of the samples were bought in Helsinki or its vicinity. In 1971 the sampling was different. In September 1970

Table 1. Distribution of varieties among the choice class lots in 1967—68 and among I class lots in 1971

Taulukko 1. Lajikejakautuma herkkuperunanäytteissä v. 1967—68 ja I luokan näytteissä v. 1971

Variety *Lajike*	Choice potatoes *Herkkuperunanäytteet* (no. of lots)	I class *I luokka* (no. of lots)
Record	14	16
Eigenheimer	11	6
Pito	1	32
Bintje	0	11
Others — Muut	11	18
Total — *Yhteensä*	37	83

a statute concerning the quality of table potatoes came into force and the Finnish Potato Association arranged to obtain samples from 9 towns in different parts of the country. All the samples were collected in January and analyzed and classified immediately in accordance with the new grade regulations.

A great number of wholesale dealers is a typical feature of Finnish potato marketing. Thus, the samples collected and analysed may have been packed by farmers, retailers or by small or large wholesale dealers.

In the lots analyzed, the name of the variety was mentioned only in samples belonging to the choice class in 1967—68 and to I class in 1971. The distribution of the varieties among these lots is presented in Table 1. The Finnish variety Pito (Manner and Ravantti 1969) has rapidly become one of the most common table potatoes in our country, and at the same time Eigenheimer particularly has decreased in importance. Bintje first grown for processing has gotten a foothold also as a table potato. The varieties named in Table 1 were most common also among the other lots examined although detailed classification as to variety was not carried out for these lots.

The tubers were washed with care, dried, and weighed and analyzed individually. All the observations were made visually.

Variation in tuber size is not a defect. However, tubers smaller than 35 mm (20 g) were considered too small. Deformed tubers were so uncommon that they could be disregarded as a defect. In Finland growers will grade potatoes into one of five size classes: 35—50, 40—55, 45—60, 50—65, and 55—70 mm, the first number indicating the hole of the lower and the latter number the hole of the upper riddle. Because the shape of the tubers varies there are no clear limits between classes, and tubers of the same weight but having a different shape may be riddled into different size classes. An attempt was made to classify the tubers by weight. The system used is presented in Fig. 1. The numbers in the tables indicating the percentages of tubers of same size are based on this system.

Varietal mixture in a potato sample was determined by comparing the characteristic features of each tuber such as shape, skin and flesh color and, in some cases, sprout color with those of the principal variety in the sample.

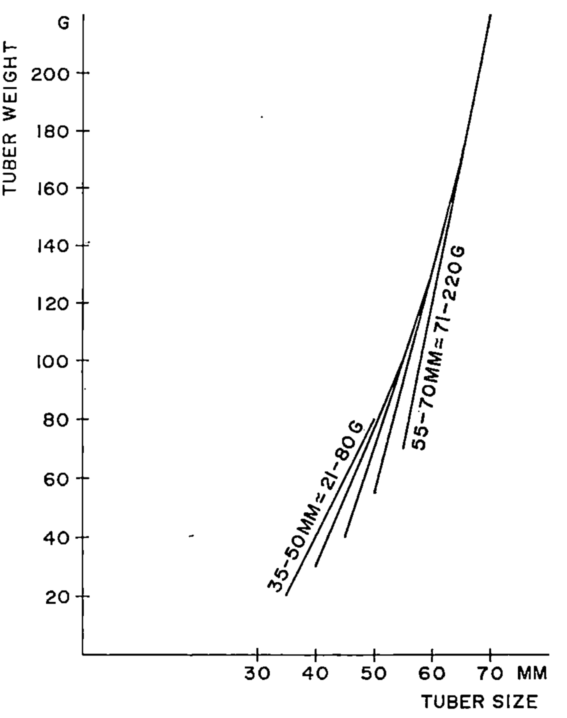

Fig. 1. The relation of tuber size to tuber weight in each of five size classes.

Kuva 1. Mukuloiden koon määrittäminen painon perusteella.

Table 2. Classification of tubers in 1967—70 and the types and severity of defects used to classify each lot.

Taulukko 2. Vuosien 1967—70 aineistoja käsiteltäessä käytetyt laatuvaatimusnormit

Kind of defect	Good *Hyvät*	Usable *Käyttökelpoiset*	Unusable *Käyttökelvottomat*
Size — *Koko*	> 35 mm	> 35 mm	< 35 mm
Hollow heart — *Onttous*	0	0	if present — *kaikki*
Rust spots — *Ruskolaikut*	0	0	if present — *kaikki*
Green tubers — *Vihertyneet*	0	slight — *lievä*	severe — *paha*
Mechanical damage — *Mekaaniset viat*			
periderm — *kuori* *)	0—10 %	11—20 %	> 20 %
flesh (cuts and black spots) — *malto (haavat ja mustelmat)* **)	< 2 mm	2—5 mm	> 5 mm
Diseases — *Tarttuvat taudit*			
common scab and powdery scab — *tavallinen perunarupi ja kuorirokko* *)	0—10 %	11—20 %	> 20 %
skin spot — *känsärupi*	»	»	»
black scurf — *seittirupi*	»	»	»
russeting — *kuoriroso*	»	»	»
silver scurf — *harmaa hilse* *)	0—20 %	21—100 %	
tuber rot — *mukulamätä ja -laho*	0	0	if present — *kaikki*
wet rot — *märkämätä*	0	0	if present — *kaikki*
Pest damages — *Tuhoeläinten vioitukset* **)	<2 mm	2—5 mm	> 5 mm

*) per cent of skin removed — *vioituksen laajuus*
**) depth of injury — *vioituksen syvyys*

In the analyses carried out in 1971 part of the determinations were verified by means of ultraviolet lamp by Mr. O. Ulvinen of the State Seed Testing Station. Because the tubers of some varieties cannot be distinguished visually, the number of varietal mixtures found may be too low.

To determine the incidence of hollow heart, rust spot and black tubers were halved through the largest diameter. To determine the depth of visible mechanical and pest injuries and the degree of greening the tubers were cut as needed. Hesen and Kroesbergen (1960) have divided mechanical damages into 5 groups: skinning, cuts, flesh wounds, splits and internal injuries, in this paper cuts, flesh wounds and splits are called cuts and internal injuries are called black spots. Cuts and black spots were classified according to the depth of the defect. This differs from the method used by Lööw (1964) and used in West Germany grade regulations (Anon. 1970).

Diseases such as black scurf, skin spot, tuber blight and wet rot were easy to determine. However, tuber blight, gangrene and dry rot were grouped together as »tuber rots» because the same tuber often was infected with more than one of these diseases. In addition, the symptoms of gangrene and dry rot are often rather similar and thus difficult to distinguish visually. Powdery scab occurred uncommonly and because its symptoms are often rather similar to those of common scab the two were classified into one group. Black dot occurred commonly with silver scurf, and this disease, which is of little or no importance, was grouped together with silver scurf.

Wet rots made up one group. It included tubers which apparently were infected with one or more species of bacteria and/or *Pythium ultimum* and *Phytophthora erythroseptica*.

Numerous isolations were made from the tubers with symptoms of fungus diseases to identify the pathogens.

Injuries caused by other pests were handled as one group. It is probable that most of them were caused by wireworms.

During the first three years the tubers of each lot were classified into three quality classes: *good*, in which small defects were allowed; *usable*, in which more defects were allowed; and *unusable* tubers. This classification and the allowable percentages of various kinds of defects in each of the classes are shown in Table 2.

In 1971 the standards of judgment differed somewhat from those used earlier, and tubers were classed into two groups: *usable* and *unusable*. Class I potatoes were restricted to certain varieties but class II potatoes could be of any variety. According to the new regulations, class I potatoes could not contain more than 20 % of tubers of other varieties. No tolerance was allowed for badly-deformed, hollow-hearted or rust-spotted tubers. Greening was a defect if it could not be removed by peeling. Class I and II tubers could not exceed 25 % skin injury due to scab (common scab, powdery scab, black scurf and skin spot). Furthermore tubers with any injury in the flesh which, when removed with a knife, caused a loss in tuber weight of more than 10 % was not suitable for classes I and II.

The maximum of unusable tubers tolerated in class I potatoes was 5 % and in class II, 10 %. Further, the maximum tolerances for decayed tubers were 2 and 5 % for class I and class II potatoes, respectively.

Results

Size of tubers

In Finland consumers prefer table potatoes 40—55 mm in size. This size was most common also in the lots examined in this study. Fig. 2 shows the weight distribution of tubers examined during 1967—70. The curves for each of the four years are very similar and show that more than half of all tubers occurred in the 40—55 mm. size range (31—100 g).

The mean weights of all tubers and the range in mean weights of tubers in the lots examined each year are given in Table 3. They were fairly similar in different years. Only in the lots

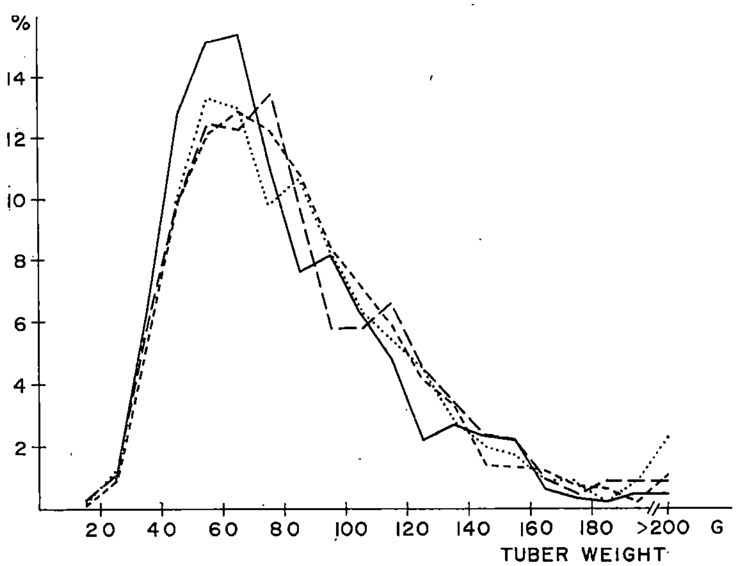

Fig. 2. Distribution of tuber weights in the lots examined in 1967—70. Solid line is choice 1967—68, — —, - - - - and ..... ordinary 1967—68, 1968—69 and 1969—70, respectively.

Kuva 2. Mukuloiden kokojakautuma v. 1967—70 kootuissa aineistoissa. Yhtenäinen viiva on herkkuperuna 1967—68 ja pilkkuviivat — —, - - - - ja ... tavallinen ruokaperuna vastaavasti 1967—68, 1968—69 ja 1969—70.

Table 3. Size of tubers, incidence of varietial mixtures, incidence of green tubers and incidence of tubers with hollow heart and/or rust spot in lots of potatoes examined in each of 4 years

Taulukko 3. Tietoja mukuloiden koosta, vieraiden lajikkeiden, vihertyneiden mukuloiden sekä onttojen ja ruskolaikkuisten mukuloiden esiintymisestä

Quality class *Laatuluokka*	Period *Jakso*	Number of samples *Näytteitä kpl*	Mean wt. of tubers and range in mean wts. of tubers in individual samples *Yksittäisten näytteiden keskimääräiset mukulapainot² keskiarvo ja vaihtelun laajuus*	Percentage of tubers within one size class; mean and range of indivisual samples *Mukuloiden tasakokoisuusprosentti yksittäisissä näytteissä² keskiarvo ja vaihtelun laajuus*	Incidence of varietal mixtures *Vieraiden lajikkeiden esiintyminen*		Green tubers *Mukuloiden vihertyminen* Slight *lievä*		Severe *paha*		Incidence of hollow heart and/or rust spot *Onttous ja ruskolaikkuisuus*	
					1.	2.	1.	2.	1.	2.	1.	2.
Choise — *Herkkuperuna*	1967—68	37	74 (42—160)	97 (84—100)	16	2	59	3	35	4	16	1
Ordinary — *Ruokaperuna*	1967—68	47	76 (42—133)	89 (63—100)	9	2	72	6	66	6	23	2
Ordinary — *Ruokaperuna*	1968—69	57	75 (32—145)	90 (66—100)	12	1	44	5	35	3	65	6
Ordinary — *Ruokaperuna*	1969—70	66	75 (41—130)	91 (61—100)	3	0.2	62	7	47	8	26	2
I class — *luokka*	1971	83	82 (45—152)	91 (60—100)	39	23 *)	—	—	10	0.4	14	1
II class — *luokka*	1971	30	95 (55—188)	83 (52—100)	—	—	—	—	7	0.3	7	1

1. = Percent of samples — *Tapausten lukumäärä (% näytteistä)*
2. = Average of all lots — *Keskiarvo (% mukuloista)*
*) The numbers obtained in 1971 are not comparable with those for 1967—70
Vuoden 1971 arvot eivät ole vertailukelpoisia aikaisempien vuosien tulosten kanssa

collected in January 1971 was the average weight of tubers higher. This was due to the good potato yield in the 1970 season.

The lack of uniformity in size of tubers should be noted. The size classes used were not narrow for in a given class the largest tubers could be about three times larger than the smallest ones. Despite this, the data in Table 3 indicate that in many samples only slightly over one-half of the tubers fell within a given size class. Even the mean values of these lots varied from 83 to 97.

Varietal mixtures

It was mentioned earlier that the identification of other varieties in a lot was done conservatively, thus the numbers presented in Table 3 may indicate less varietal mixture than was actually the case. In 1971, when potatoes belonging to I class were examined, the determination of trueness to variety was more accurate and the results obtained indicated considerable varietal mixture, some samples were wrongly named, and in only two out of three samples, on the average, was trueness to variety very good.

Physiogenic defects

Green tubers

Considering that the potatoes had been graded by hand the numbers of green tubers found were very high (Table 3). On the average, green tubers were detected in the majority of the samples and severe greening in one out of three. The average per cent of greened tubers (by weight) was as high as 8 % in 1969—70. In the lots collected in 1971 the presence of green tubers was infrequent.

Hollow heart and rust spots

These defects are grouped together although they are quite different phenomena and have different causal agents. The incidence of the former varies with variety and with conditions of the growing season (Braun 1961, Braun and Niehaus 1962). The latter may be caused by *Rhizoctonia solani* (Schomburg 1965) and also is

Table 4. Incidence of mechanical injuries in tubers of lots examined
Taulukko 4. Mekaanisten vioitusten esiintyminen

Quality class *Laatuluokka*	Period *Jakso*	Number of lots *Näytteitä kpl*	Periderm injuries — *Pintaviat*				Cuts and black spot *Haavat ja mustelmat*			
			Slight — *lievä* (11—20 %)		Severe — *paha* (> 20 %)		Slight — *lievä* (2—5 mm)		Severe — *paha* (> 5 mm)	
			1.	2.	1.	2.	1.	2.	1.	2.
Choice — *Herkkuperuna*	1967—68	37	86	12	32	2	100	14	72	10
Ordinary — *Ruokaperuna*	1967—68	47	79	11	19	2	98	18	75	13
Ordinary — *Ruokaperuna*	1968—69	57	19	1	7	0	100	25	95	25
Ordinary — *Ruokaperuna*	1969—70	66	74	7	33	7	100	31	97	18
I class — *luokka*	1971	83	—	—	—	—	93	9	80	2
II class — *luokka*	1971	30	—	—	—	—	77	7	77	5

1. = Percent of lots having defects — *Tapausten lukumäärä (% näytteistä)*
2. = Average percent of damaged tubers (by wt.) — *Vioittuneita keskimäärin (% mukuloista)*

one symptom of tobacco rattle virus (Harrison 1968).

In the present study, rust spot was of little importance and as a matter of fact all the defects detected in this group were due to hollow heart (Table 3). Except in the 1968—69 samples, these defects were of little importance. Most of the hollow heart found was in the variety Record, which seems to be rather susceptible.

Mechanical injuries

Periderm injury was examined only during the first three years, because it was not considered a defect in the official regulations provided in 1970. The observations of cuts and black spots were made according to both the old and new methods but the results presented here (Table 4) are based on the old method.

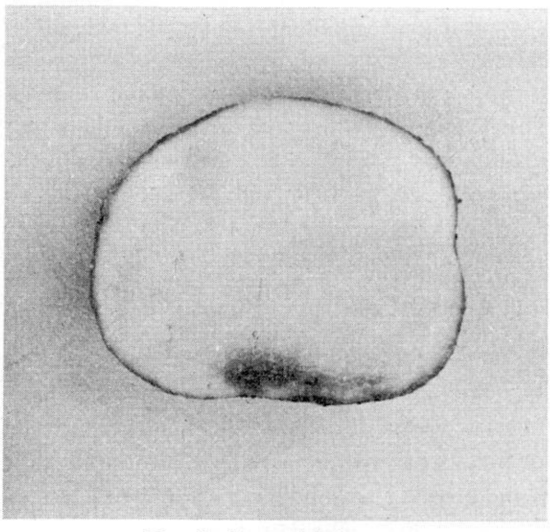

Fig. 3. Severe black spot.
Kuva 3. Pahasti mustelmoitunut mukula.

Skinning of tubers (periderm injury) was quite common in the 1967—68 and 1969—70 lots when about three samples out of four showed slight damage, and nearly one out of three severe damage. In a few lots the amount of damage was high, but the mean values were low compared with those for cuts and black spot. In the lots collected in 1968—69 damage due to skinning was less than normal, probably a consequence of better maturity of tubers at harvest.

Cuts and black spots were grouped together. Most of the flesh injuries observed were cuts because the tubers were not cut into slices but only into two halves. In every instance cuts were of greater importance than black spots. Actually, slight damage due to cuts and/or black spot was detected in every sample, and severe damage was present in most of the samples. Also the mean values, excluding the samples of 1971, are alarmingly high. Even in the 1971 lots cuts and black spots were the most important factors decreasing the quality of the tubers. While some of defects might be difficult to detect, probably their large incidence was primarily due to poor grading.

Common scab and powdery scab

The only data on the incidence of the pathogen of common scab, *Streptomyces scabies* (Thaxt.) Waksman and Henrici, in Finland are those reported by HEINÄMIES and SEPPÄNEN (1971) obtained during the course of the present study. Some isolations were made also from the lots examined.

There is no detailed information about the occurrence of powdery scab caused by *Spongospora subterranea* (Wallr.) Johns. in Finland. POHJAKALLIO (1962) mentioned that the disease had been detected but that it was of minor importance. In this study the causal agent of the disease (Fig. 4) was detected on potatoes grown in different parts of the country, but its occurrence compared with that of common scab was of little importance. It is probable that in the results presented in Table 5 the contribution due to powdery scab is less than 10 %.

Common scab is a common potato disease in Finland. In the present survey hardly a sample was free of it. The potatoes analyzed were graded ones and part of the scabby tubers had probably been discarded during grading. Thus the results presented in Table 5 do not give a true picture of the real importance of the disease. In 1967 and 1969 in nearly half of the samples there were severely scabbed tubers, and about 4 % of all the tubers had severe scab. In potatoes grown in 1968 and 1970 the occurrence of scab was less than half of that in 1967 and 1969. There was a similar difference between the years if the figures for moderate damage and for the scab index are compared. In extreme cases scab index were as high as 21.5 and 20.2 indicating the great importance of scab in individual cases. In 1971 the incidence of skin spot was also included in the numbers presented, but it was of little importance because the analyses were made in January and February before skin spot had developed much in storage.

Skin spot

Injuries due to skin spot caused by *Oospora pustulans* (Owen & Wakef.) are restricted to the skin and the flesh just below it. Thus the defect is considered primarily as one affecting appearance, but sometimes the spots may be deeper ones (BOYD and LENNARD 1962). In Great Britain skin spot is of great importance (e.g.

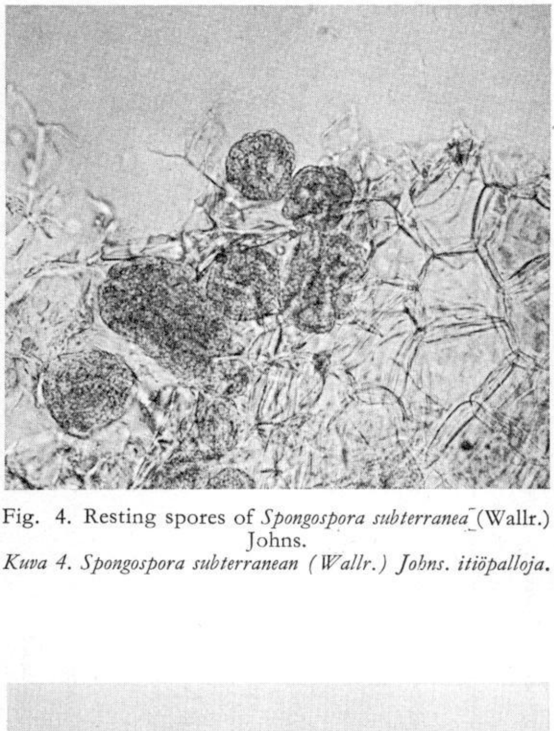

Fig. 4. Resting spores of *Spongospora subterranea* (Wallr.) Johns.
Kuva 4. Spongospora subterranean (Wallr.) Johns. itiöpalloja.

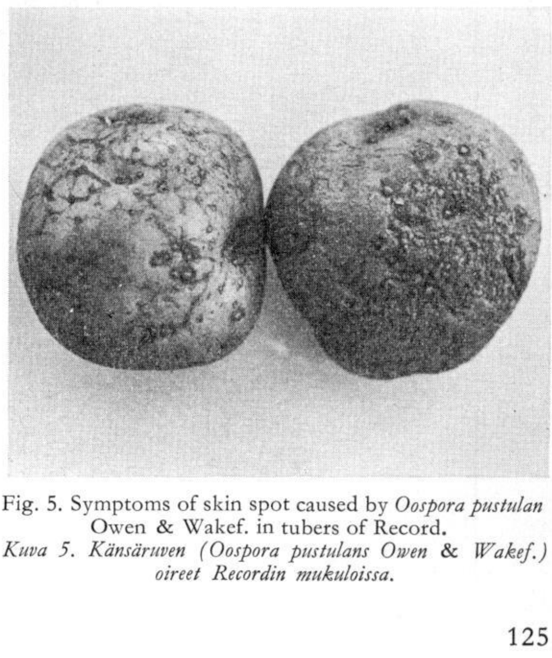

Fig. 5. Symptoms of skin spot caused by *Oospora pustulan* Owen & Wakef. in tubers of Record.
Kuva 5. Känsäruven (Oospora pustulans Owen & Wakef.) oireet Recordin mukuloissa.

Table 5. Incidence of defects due to diseases present on the periderm of tubers

Taulukko 5. Mukulan pinnassa esiintyvien tautien aiheuttamat vioitukset

Quality class *Laatuluokka*	Period *Jakso*	Numbers of samples *Näytteitä kpl*	Common scab and powdery scab *Tavallinen perunarupi ja kuorirokko* — Degree of infection, (percent of periderm covered with scab) *Viitusaste, mukulan pinnasta ruven peitossa %* 1—5		6—10		11—20		21—50		51—100		Scab index *Keskim. rupisuus*		Skin spot *Känsärupi* (1—10%)		Silver scurf *Harmaa hilse* (1—20%)		Silver scurf (21—100%)		Black scurf *Seittirupi* (1—10%)		Black scurf (11—20%)		Russeting *Kuoriroso* (1-10%)		Russeting (11—20%)	
			1.	2.	1.	2.	1.	2.	1.	2.	1.	2.	3.	4.	1.	2.	1.	2.	1.	2.	1.	2.	1.	2.	1.	2.	1.	2.
Choice — *Herkkuperuna*	1967—68	37	97	40	78	8	57	4	43	3	3	0	3.2	11.6	49	10	78	21	54	19	62	6	0	0	97	29	65	4
Ordinary — *Ruokaperuna*	1967—68	47	100	36	68	7	53	5	40	4	21	1	4.7	21.5	45	11	74	21	56	18	53	6	4	0	91	23	40	3
Ordinary — *Ruokaperuna*	1968—69	57	88	18	54	4	37	3	18	1	5	0	1.7	14.0	70	21	68	19	13	1	72	12	16	1	89	10	68	3
Ordinary — *Ruokaperuna*	1969—70	66	97	24	76	8	65	7	42	3	21	1	4.1	20.2	43	12	67	21	28	4	53	8	18	3	54	7	35	4
							11—25%		26—100%																			
I class — *luokka*	1971	83					18	1	11	1			—	—	7	—	47	—	8	—	—	—	—	—	—	—	—	—
II class — *luokka*	1971	30					30	3	17	2			—	—	0	—	30	—	0	—	—	—	—	—	—	—	—	—

1. = Percentage of samples infected — *Tapausten lukumäärä (% näytteistä)*
2. = Average percent of damaged tubers (by wt.) — *Vioittuneita mukuloita keskimäärin paino-%*
3. = Average index (%) — *Keskiarvo (%)*
4. = Index (%) of the most scabby lot — *Rupisimmassa näytteessä*

Boyd and Lennard 1962, Hirst 1967) and it has been studied extensively there. The disease has also been studied in Norway (Försund 1966, Bjor 1970) and in the Soviet Union (Kharkova and Krudenko 1957, Khaleeva 1968, Nikolaeva 1968). It is quite natural that the disease occurs also in Finland, although there is no earlier information on it. The pathogen was isolated from tubers showing different symptoms (Fig. 5), but the isolates obtained were identified to be the same fungus, *Oospora pustulans*, described by Fuchs (1954).

Skin spot proved to be quite common in the lots examined. In the spring, after storage, nearly all of the samples were contaminated and in the worst cases nearly every tuber. On the average, more than 10 % of the tubers were infected. However, most of the samples were bought in autumn and thus the results presented do not give an absolutely correct picture. As to the impact of skin spot on the external quality of tubers the disease was not of great significance. At the highest degree of infection the area covered by pustules rarely exceeded 10 % of the tuber surface. It is probable that the disease has greater effect on the growth of potatoes than on the appearance of tubers.

Silver scurf and black dot

These diseases, caused by *Spondylocladium attrovirens* Harz. and *Colletotrichum atramentarium* (Berk. & Br.) Taubenh., respectively, were usually found together and because the observations could not be made separately they were treated as one group. Usually only the former was detected and the results presented in Table 5 indicate mainly the occurrence of silver scurf. These diseases injure only the periderm of tubers, and usually they do not affect table quality but only external appearence. The causal agents of silver scurf and black dot (Fig. 6) were isolated and identified to be the same organisms described by Hoffmann (1962). Neither of these diseases have been studied in Finland.

Silver scurf turned out to be one of the most

Fig. 6. Spores and mycelium of *Colletotrichum atramentarium* (Berk. & Br.) Taubenh. × 1075.
Kuva 6. Colletotrichum atramentariumin (Berk. & Br.) Taubenh. itiöitä ja rihmastoa. × 1075.

common diseases of potato tubers in Finland. During the first month after harvest, i.e. to the end of October, the disease is of little or no importance. But from November on, particularly if potato tubers are kept in warm storage, its presence becomes more noticeable and its significance as a defect increases. By spring, silver scurf was observed in nearly all the samples and, in some samples, on almost every tuber. The Finnish variety Pito is more susceptible than, for example, Record and Bintje and thus the symptoms on it are more severe.

Black scurf

One of the diseases caused by *Rhizoctonia solani* Kühn is black scurf. It is quite common in Europe and was also common on the potato samples studied here. More than a half of the samples contained infected tubers, but less than one out of ten of the tubers, on the average, showed symptoms. Only on a few tubers was more than 10 % of the skin covered with sclerotia (Table 5). Thus, as a factor in reducing tuber appearance, the disease was of minor importance

Russeting

In this study russeting was not considered af a separate disease but rather as a group os

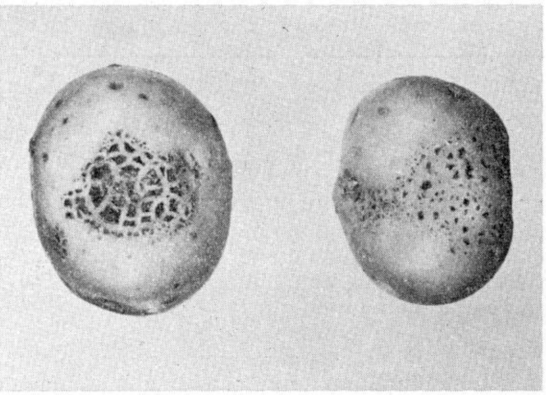

Fig. 7. Russeting.
Kuva 7. Kuoriroso.

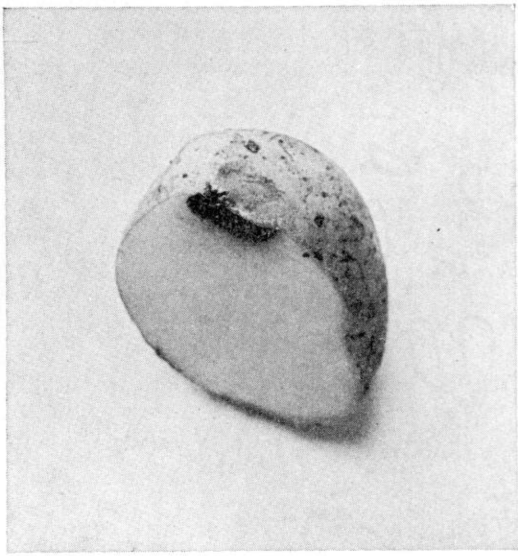

Fig. 8. Gangrene caused by *Phoma foveata* Foister in tuber of Bintje.
Kuva 8. Phoma-mätä (Phoma foveata Foister) Bintjen mukulassa.

symptoms which usually are caused by *Rhizoctonia solani* (e.g. SALZMANN and KELLER 1969). According to TODD (1967) they can be caused by potato mop top virus, too. In the lots studied russeting may have been due to *Rhizoctonia solani*, which as a causal agent of black scurf was common (Fig. 7). On the other hand, no tubers with spraing (caused by potato mop top virus) were detected.

Russeting was rather common and tubers with moderate defects were detected in about half the lots and on 3 to 4 % of the tubers. In lots having most of this defect, nearly half of the tubers had moderately severe russeting.

Tuber rots

Tuber rots include a group of diseases which affect the flesh of tubers. The most common and important of them, tuber blight caused by *Phytophthora infestans* [(Mont.) de Bary] has been under study since the first potato variety trials were carried out in Finland. Most investigations were, however, conducted to determine varietal resistance. OLLILA (1947) made the first attempt to identify the pathogens causing tuber rot during storage. She concluded that tuber blight disease was of greatest importance. Besides tuber blight she isolated a number of *Fusarium*- and *Cylindrocarpon*-species, but not *Phoma*-species which earlier had been identified as causal agents of gangrene (e.g. ALCOCK and FOISTER 1936). JAMALAINEN (1943) isolated and identified *F. coeruleum* and *F. sambucinum*.

Tuber blight was easily recognized by its symptoms, thus the main attention was paid to tubers with symptoms differing from those of tuber blight. Numerous isolations were made from tubers with symptoms like those of gangrene and dry rot as described by SALZMANN and KELLER (1969). Two types of *Phoma* were isolated and, using the description of MALCOLMSON (1958), they were considered to be *Phoma foveata*

Table 6. The incidence of the defects caused by tuber rot, wet rots and pest damages
Taulukko 6. Mukulamädän, märkämädän ja tuhoeläinten aiheuttamat vioitukset

Quality class *Laatuluokka*	Period *Jakso*	Number of samples *Näytteitä kpl*	Tuber rots *Mukulamätä*		Wet rots *Märkämätä*		Pest damages *Tuhoeläinten aiheuttamat vioitukset*			
							Slight *Lievä*		Severe *Paha*	
			1.	2.	1.	2.	1.	2.	1.	2.
Choice — *Herkkuperuna*	1967—68	37	30	2	3	0	41	4	3	1
Ordinary — *Ruokaperuna*	1967—68	47	49	3	15	1	72	9	15	2
Ordinary — *Ruokaperuna*	1968—69	57	4	0	40	5	40	2	72	5
Ordinary — *Ruokaperuna*	1969—70	66	0	0	32	2	39	2	44	3
I class — *luokka*	1971	83	46	5	10	1	—	—	39	2
II class — *luokka*	1971	30	27	2	7	0	—	—	33	2

1. = Percentage of samples infected — *Vioitusten esiintyminen (% näytteistä)*
2. = Average percent of damaged tubers (by wt.) — *Vioittuneita mukuloita keskimäärin paino-%.*

Foister and *P. solanicola* Prill. et Dell. The only differences between them were that the latter was not capable of producing pigment in its mycelium and was a weaker pathogen. *Phoma foveata* may be a new pathogen in our country, because gangrene to the present had been undescribed in Finland, and it was detected only in samples of the variety Bintje (Fig. 8) originating from recently imported stocks. *P. solanicola* was isolated from a few varieties including Pito and Record. Gangrene, caused by this organism, has been of relatively little importance in our country. During the course of this work *Fusarium coeruleum* (Lib.) Sacc., *F. sambucinum* Fuck. and *F. oxysporum* Schl. as described by GORDON (1952, 1959) were also isolated and identified.

The high incidence of tuber rots in Table 6 reveals defective grading. In the lots examined from the crop years 1967 and 1970 more than one third of the lots, on the average, contained tuber rots, and in the worst sample 38 % of the tubers were diseased. The average of infected tubers in these samples varied from 2 to 5 %. It is obvious that the occurrence of tuber late blight is reflected in the figures presented, because in the lots grown in 1968 and 1969 years of low late blight in the field, tuber rots were of no importance. Furthermore, during inspection of the lots it was apparent that most of the observations concerning tuber rots were due to tuber blight. As to gangrene and dry rot, the only findings of any importance was the occurrence of gangrene in Bintje in 1971. In spite of the little importance of gangrene and dry rot compared with that of tuber blight greater attention has to be paid to these diseases as wound parasites of potato tubers.

Wet rots

This group as the name indicates, was composed of those rots which more or less lignified the tuber tissues. Because it was impossible in many cases to determine whether the infections containing bacteria were primarily or secondary, the causal agents of wet rots were not analyzed. In approximately nine cases out of ten, a pungent odor was associated with wet rots. However, during the last few years the incidence of black leg has increased alarmingly. On the basis of these observations bacteria belonging to the genus *Erwinia* might also be a causal agent of the wet rots reported here.

The incidence of wet rots (Table 6) again indicates careless grading. However, poor conditions in the retail stores may be of some importance also. Exclunding the samples from 1968—69 the incidence of wet rot was tolerable.

Pest damages

Most of the pest damage found appeared to be wireworm injury. As a rule, no attention has been paid to such injuries and only in a few exceptional instances have they been of some importance. Results in Table 6 indicate that more attention has to be paid to them. An average of 2—3 % of tubers examined were severely damaged.

Discussion

In Tables 3—6 the incidences of different defects or defect groups were presented. In Table 7 all these results are presented in accordance with the standards discussed earlier in this paper and as outlined in Table 2. These results were calculated so that e.g. a tuber with severe defects of two kinds was taken into consideration only once. Furthermore it must be remembered that the results obtained in 1971 are not quite comparable with those obtained earlier because they were inspected in accordance with new regulations that became effective in the fall of 1970.

The figures indicate that in the best years about 80—90 % of tubers fit for use but only half of these were classified as »good». In the

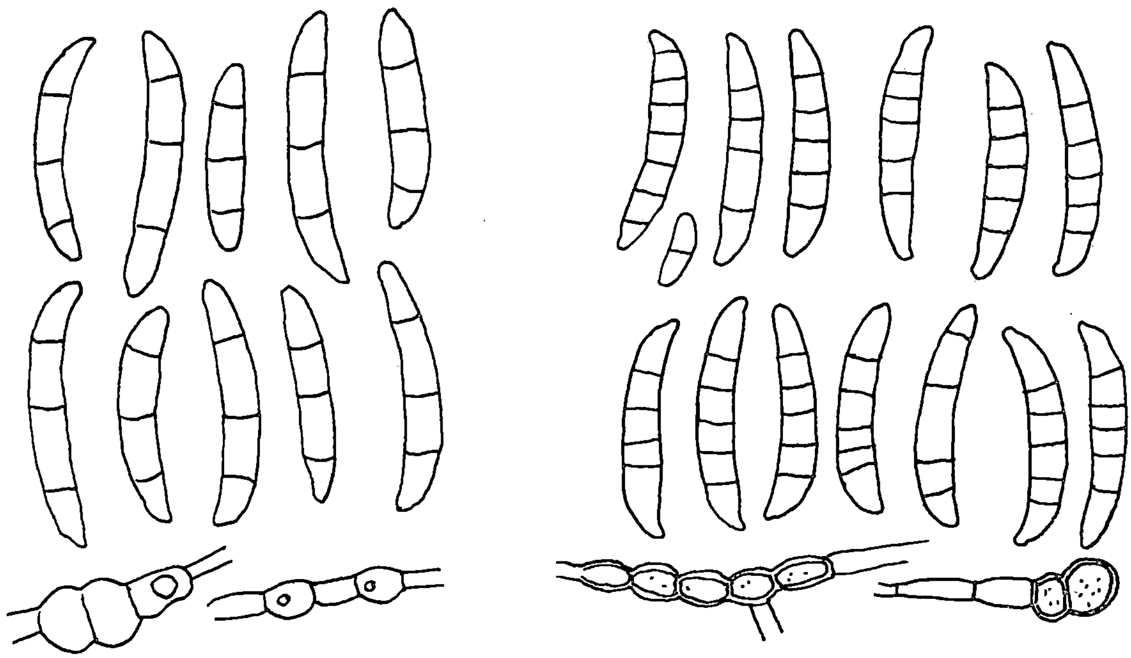

Fig. 9. Spores and chlamydospores of *Fusarium coeruleum* (Lib.) Sacc. (left) and *F. sambucinum* Fuck (right). × 800
Kuva 9. Fusarium coeruleumin (Lib.) Sacc. (vas.) ja F. sambucinumin Fuck (oik.) itiöitä ja clamydosporeja. × *800*

samples of 1968—69 and 1969—70 only 60—65 % of tubers were fit for use. If the results are scrutinized in the light of the new grade regulations of 1970, in which the maximum allowable percentages of tubers unfit for use were 5 % and 10 % for class I and class II potatoes, respectively, only a small part of the lots inspected were good enough for sale. These results unquestionably show that the average quality of table potatoes was not high and, considering the great variation, the quality of the worst samples was really poor. Thus the criticism of consumers regarding the lack of quality of market potatoes has not been unjustified. It is probable, however, that the new regulations of 1970 shall rapidly improve the quality of table potatoes. The superior quality of choice potatoes is due to the limited number of wholesale entitled to sell them.

The relative importance of the several defects discussed earlier are presented graphically in Fig. 10. Although the number or lots inspected each year was rather limited the similarity of the results between years justifies some conclusions about the significance of different factors. There is no doubt that mechanical injuries have contributed most to decreasing the quality of potatoes. About half of the tubers were unusable because of defects due to mechanical injuries. The problem is difficult indeed to resolve because

Table 7. The distribution of tubers among the usability classes

Table 7. Mukuloiden jakautuminen eri käyttökelpoisuusluokkiin

Materials *Aineistot*		Number of samples *Näytteitä kpl*	Percentage of tubers in each usability class *Käyttökelpoisuusluokat*		
			Good *Hyvät*	Usable *Käyttö-kelpoiset*	Unusable *Käyttö-kelvot-tomat*
Choice — *Herkkuperuna*	1967—68	37	43	49	8
Ordinary — *Ruokaperuna*	1967—68	47	40	44	16
Ordinary — *Ruokaperuna*	1968—69	57	33	29	38
Ordinary — *Ruokaperuna*	1969—70	66	25	38	37
I class — *luokka*	1971	83	82	—	18
II class — *luokka*	1971	30	77	—	23

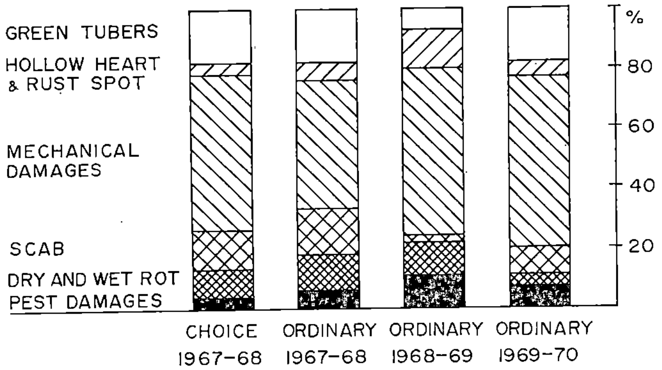

Fig. 10. The relative importance of the most common factors excluding varietal mixtures decreasing the external quality of table potatoes in 1967—70. Here dry rot includes tuber blight, gangrene, and dry rot.

Kuva 10. Yleisimpien ruokaperunan ulkoista laatua alentavien tekijöiden suhteellinen merkitys vuosien 1967—70 aineistoissa. Tekijät ylhäältä lukien: vihertyneet mukulat, ontot ja ruskolaikkuiset, mekaanisesti vioittuneet, rupiset, pilaantuneet ja tuhoeläinten vioittamat. Choice = herkkuperuna, ordinary = tavallinen ruokaperuna.

both growing and harvesting seasons are short and the latter is often rather cold. It is not uncommon that potatoes have to be harvested in temperatures of 4—5°C, when they are very susceptible to injury.

Of the other defects, greening, scab, and tuber rots were the most significant. The incidence of these defects varied greatly from year to year. This was particularly true for greening and scab which in 1968—69 were considerably less of a problem than in other years. Scab is less serious in years when rainfall is higher than normal during July.

Although many of the defects found in potato tubers can result from poor cultural techniques, the consequences of inadequate grading are very striking, because many defects in the harvested potatoes can be corrected, although with economic sacrifice, during grading.

Summary

The external quality of table potatoes bought from retail shops was studied during each of four years. At the same time, information about the incidence of tuber diseases was obtained.

The external quality of potatoes varied greatly. In the best lots all of the tubers were good and in the worst ones hardly a single tuber was usable. In the worst lots grown in 1968 and 1969 only two tubers out of three, on the average, were fit for use and in other years about four out of five.

Of the various factors which decreased external quality, mechanical injury was of greatest importance constituting about half of the defects found. Among the other non-disease defects, green tubers were rather common, but hollow hearth and rust spot were, except in occasional cases, of minor importance. Of the diseases common scab, skin spot, silver scurf, black dot, black scurf and russeting were quite common but only common scab was of major importance. The incidence of tuber rots and wet rots, although relatively less frequently found, is always of great significance. In the tuber lots examined,

late blight in tubers and bacterial rot were the most common. The occurrence of gangrene seems to be increasing as a wound parasite, whereas dry rot was of little importance.

Varietal mixtures and lack of uniformity in tuber size were common defects in many lots.

Although the incidence of many defects could be reduced by improvements in the techniques of cultivation, the quality level of table potatoes could be easily raised by more effective grading.

Some diseases which had not been previously studied in Finland were detected and their causal agents identified. Thus, powdery scab, skin spot, silver scurf, black dot, and gangrene were recognized and their causal agents *Spongospora subterranea* Wallr. (Johns.), *Oospora pustulans* Owen & Wakef., *Spondylocladium atrovirens* (Harz.), *Colletotrichum atramentarium* (Berk. & Br.) Taubenh., *Phoma foveata* Foister and *P. solanicola* Prill. & Dell., respectively, were identified.

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SELOSTUS

Kaupassa olevan ruokaperunan ulkoisesta laadusta ja siihen vaikuttaneista tekijöistä v. 1967—71

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Maatalouden tutkimuskeskus, Kasvitautien tutkimuslaitos, Tikkurila

Tutkimus perustuu v. 1967—70 Helsingistä ja sen ympäristöstä sekä osittain Tampereelta vähittäiskaupasta ostettuihin sekä tammikuussa 1971 Perunaseuran toimesta 9 paikkakunnalta eri puolilta maata hankittuihin perunanäytteisiin. Perunat pestiin ja analysoitiin mukulakohtaisesti. Niistä määritettiin aitous, mukulakoko ja sen tasaisuus, vihreiden ja maltovikaisten määrät, mekaanisten vioitusten määrä sekä tarttuvien tautien ja tuhoeläinten aiheuttamat vioitukset. Mukuloiden käyttökelpoisuus arvosteltiin taulukossa 2 esitettyihin normeihin ja v. 1971 hankittujen näytteiden osalta voimassaolleisiin laatuvaatimuksiin nojautuen. Laadun tutkimisen ohella pyrittiin selvittämään mukuloissa esiintyviä kasvitauteja ja niiden merkitystä perunan laatuun. Tautien määrittämiseksi näytteistä eristettiin sieniä, joista uusina maassamme esiintyvinä perunan patogeeneina määritettiin seuraavat: perunan kuorirokon aiheuttaja *Spongospora subterranea* Wallr. (Johns.), känsäruven aiheuttaja *Oospora pustulans* Owen & Wakef., harmaan hilseen aiheuttaja *Spondylocladium atrovirens* Harz., mustapilkun aiheuttaja *Colletotrichum atramentarium* (Berk. & Br.) sekä Phoma-mädän aiheuttajat *Phoma foveata* Foister ja *P. solanicola* Prill. & Dell.

Eri vioitusmuotojen yleisyys ja esiintymisrunsaus ilmenevät taulukoista 3—7.

Mukuloiden koko kolmen ensimmäisen vuoden aineistoissa ilmenee kuvasta 2, pääosa kaupan olevasta perunasta on kokoa 40—55 mm. Koon tasaisuus on laskettu mukuloiden painoon perustuvaan luokitukseen, joka on esitetty kuvassa 1. Koon tasaisuus vaihteli 83—97 prosenttiin (taul. 3).

Vieraiden mukuloiden osuus oli yleensä vähäinen, mutta niiden erottaminen pelkän ulkomuotoon ja kuoren sekä mallon väriin perustuvan määrityksen avulla on puutteellista ja näin ollen aitoutta osoittavat luvut lienevä liian hyviä. Vuoden 1971 I luokan aineiston heikko aitous johtuu siitä, että väärällä nimellä kulkeneiden näytteiden aitous on katsottu nollaksi.

Vihertyneitä ja maltovikaisia oli keskimäärin muutama prosentti, mutta muutamissa näytteissä hyvinkin paljon, pahasti vihertyneitä peräti 75 % ja maltovikaisia 25 % mukuloista.

Mekaaniset vioitukset olivat erittäin yleisiä. Kuorivikojen merkitys oli verraten vähäinen, pahoja vikoja oli vähiten v. 1968—69, vajaa prosentti, ja eniten 1969—70, peräti 7 %. Pahimmissa tapauksissa yli puolet mukuloista oli pahasti kuoriutuneita. Maltoon ulottuvat vioitukset, haavat ja mustelmat, on esitetty yhdessä. Pahoja vioituksia oli lähes joka näytteessä ja huonoimmissa näytteissä lähes joka mukulassa, niiden osuus vaihteli 2—25 prosenttiin. Koska mukulat halkaistiin vain kahteen osaan, eivät kaikki mustelmat saattaneet tulla todetuiksi ja osittain tästä syystä haavojen merkitys oli suurempi.

Tarttuvista taudeista oli yleisin tavallinen perunarupi. Sitä oli miltei jokaisessa näytteessä ja keskimäärin suunnilleen joka toisessa mukulassa. Pahasti rupisten mukuloiden osuus oli kuitenkin vain 1—5 %, joka sekin on merkittävä mukuloiden laatua alentava tekijä. Mukuloiden keskimääräinen rupisuus vaihteli 2—5 prosenttiin ja rupisimmissa näytteissä se oli yli 20 %. Perunan kuorirokkoa esiintyi melko vähän ja koska sitä toisinaan on vaikea erottaa tavallisesta perunaruvesta on sitä koskevat havainnot esitetty yhdessä perunaruven kanssa.

Känsärupi oli melko yleinen tammikuusta alkaen, mutta sillä ei ollut mainittavaa merkitystä mukuloiden laatuun.

Harmaa hilse, joka niinikään on tyypillinen varastotauti, esiintyi yleisesti jo joulukuusta alkaen. Muutamissa tapauksissa se huomattavasti heikensi mukuloiden ulkonäköä ja aiheutti jopa nahistumista.

Seittirupi oli yleinen, mutta vailla käytännöllistä merkitystä. Kuorirosoa, jota yleensä pidetään saman sienen aiheuttamana kuin seittirupeakin, esiintyi yleisesti, joskin senkin merkitys jäi vähäiseksi tavalliseen perunarupeen verrattuna.

Mukulamätää, johon sisältyy rutto, *Phoma*-mätä ja kuivamätä, todettiin mainittavasti vain vuosina 1967—68 ja 1971 kootuissa aineistoissa. Sitä todettiin tuolloin 27—49 prosentissa näytteistä, tautisten mukuloiden keskimääräinen osuus vaihteli 2—5 prosenttiin. Huonoimmassa näytteessä oli *Phoma*-mädän vioittamia mukuloita peräti 38 %. Mukulamätää aiheuttavista taudeista oli ruton merkitys suurin, *Phoma*-mätää todettiin mainittavasti vain Bintjessä ja *Fusarium*-sienten aiheuttama kuivamätä oli melko merkityksetön.

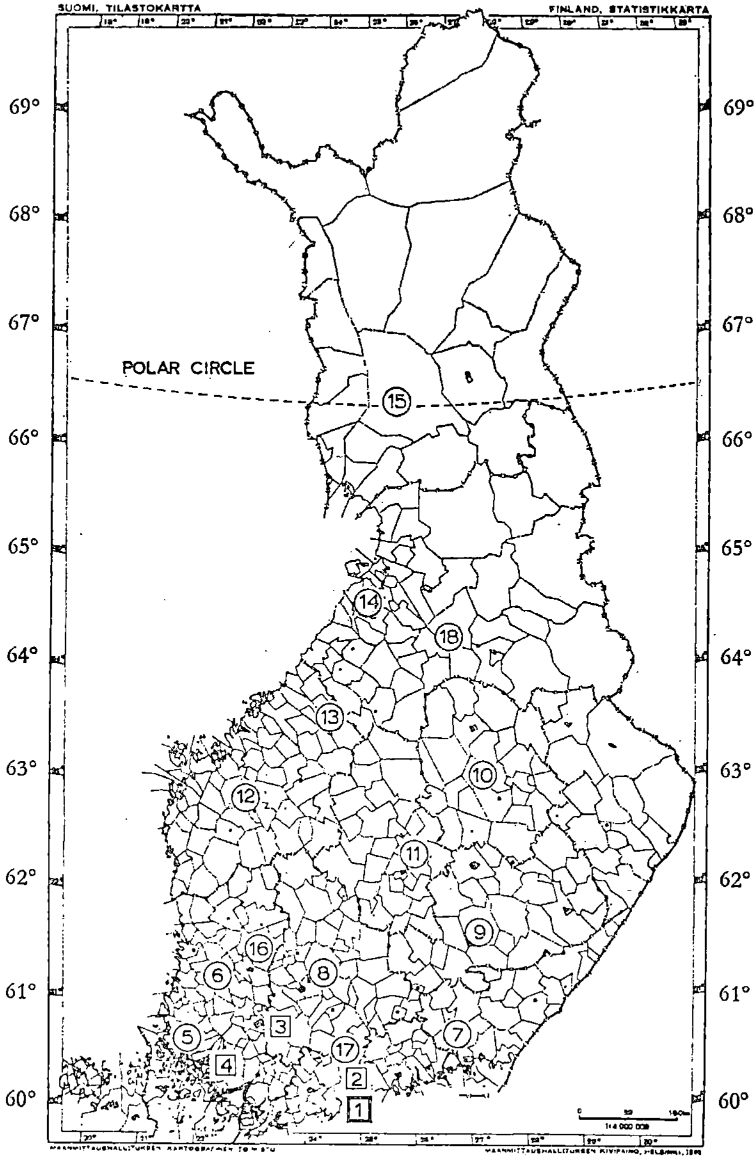
Märkämätää esiintyi vähemmän kuin mukulamätää. Vuosien 1968—69 aineistossa sitä oli kuitenkin runsaasti, 40 %:ssa näytteistä ja keskimäärin 5 % mukuloista oli sen saastuttamia.

Tuhoeläinten, pääasiassa juurimatojen, vioittamia mukuloita todettiin suunnilleen joka kolmannessa näytteessä, ja keskimäärin 1—5 %:ssa mukuloista. Joissakin näytteissä jopa yli 20 % mukuloista oli pahasti vioittuneita.

Taulukoissa 3—6 on esitetty analyysitulokset eri ominaisuuksien tai vioitusmuotojen mukaan. Yhdistettyinä ne on esitetty taulukossa 7. Tällöin mukula, jossa on esim. sekä paha mekaaninen vioitus että paha tautivioitus, on otettu huomioon vain kerran. Voidaan todeta, että parhaina vuosina keskimäärin 4/5 osaa mukuloista on ollut käyttökelpoisia ja niistä suunnilleen puolet hyviä. Satokautena 1967—68 pakattu herkkuperuna oli muita parempaa. Vuonna 1971 koottu aineisto on tutkittu osittain toisin perustein kuin aikaisemmat ja kerätty useammalta paikkakunnalta. Suurin piirtein sen voidaan katsoa vastaavan satokauden 1967—68 tavallista ruokaperunaa. Tarkasteltaessa tuloksia annetun peruna-asetuksen laatuvaatimusten valossa vain pienen osan näytteistä voidaan todeta läpäisevän vaatimukset.

Suurin syy hylkäämisiin on ollut mekaanisten vioitusten yleisyys. Kuvassa 10 on esitetty tulokset vuosien 1967—70 aineistoista jaettuna vioitusten suhteellisen merkityksen mukaan. Puolet hylätyistä mukuloista on ollut pahasti vioittuneita. Seuraavina ovat merkitykseltään vihertyneet, pahasti rupiset ja pilaantuneet mukulat. Näiden vuosittaiset esiintymismäärät vaihtelevat jonkin verran, mutta etenkin ruven ja ruton yleisyys heijastuu myös niiden esiintymiseen ruokaperunassa. Maltovikaisten ja tuhoeläinten vioittamien mukuloiden merkitys on pienempi, joskaan ei väheksyttävä.

Vaikka useimmat vioitukset viittaavat puutteelliseen viljelytekniikkaan, olisi perunan laatua mahdollista huomattavasti parantaa huolellisemmalla lajittelulla.



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