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RESEARCH NOTE

A FINNISH HIGHBUSH BLUEBERRY VARIETY 'ARON'

HEIMO HIIRSALMI and AARO LEHMUSHOVI

HIIRSALMI, H. & LEHMUSHOVI, A. 1982. **A Finnish highbush blueberry variety 'Aron'.** Ann. Agric. Fenn. 21: 151—154. (Agric. Res. Centre, Inst. Hortic., SF-21500 Piikkiö, Finland.)

The bog blueberry (*Vaccinium uliginosum* L.) has been successfully crossed with the highbush blueberry. On the basis of this interspecific breeding, the first Finnish highbush blueberry variety was released for general cultivation in spring 1982, under the name 'Aron'.

The 'Aron' was selected from the progeny of the back-cross 'Rancocas' × (bog blueberry × 'Rancocas') made in 1965. The cross bog blueberry × 'Rancocas' was made in 1961. 'Aron' resembles the foreign highbush blueberry varieties both as regards its vegetative and its cultural characteristics. Its winter hardiness and blueberry cancer resistance are, however, clearly better than those of the foreign varieties. The yield of the 'Aron' variety has proved satisfactory under the climatic conditions in Southern Finland. The berries are medium-sized and of good quality, suitable for use fresh and frozen.

Index words: highbush blueberry, bog blueberry, *Vaccinium uliginosum*, winter hardiness, blueberry cancer.

The results obtained in highbush blueberry trials in Finland, whatever varieties developed in America or Central Europe were used, have not been good enough to provide material for practical application (HIIRSALMI and SÄKÖ 1973, 1975). The main drawbacks are the rather poor winter hardiness and susceptibility of the varieties to the commonly encountered stem disease, blueberry cancer, caused by the fungus *Fusicoccum putrefaciens* Shear.

DEVELOPMENT OF THE SELECTIONS

In order to develop highbush blueberry varieties, which are better suited to the climatic conditions in these northern regions than the foreign ones and which are disease resistant and also produce good-quality yields, breeding work has been done at the Institute of Horticulture at Piikkiö attempting to cross native *Vaccinium* species with the highbush blueberry (HIIRSALMI 1968, 1969, 1973, 1977 a, 1977 b). Of the North-European species the bog blueberry, *V. uliginosum* L., which has the same tetraploid chromosome number, 2n = 48, as the highbush blueberry, has been successfully crossed with the latter. The first crosses between the highbush blueberry

varieties and the bog blueberry were made in the summer of 1961 (Rousi 1963). The bog blueberry used in the crossings comes from a wild population at Piikkiö close to the Institute of Horticulture. The highbush blueberry varieties employed are 'Rancocas', 'Pemberton' and 'Bluecrop'.

In the F_1 cross progenies of the bog blueberry and the highbush blueberry there are quite obviously the kind of unfavourable gene combinations that are typical of crosses between two widely separated species and which in time will cause disturbances. These appear in the form of a weakening of vigour resulting in, among other things, a decrease in winter hardiness and fruit yield. Hence it has been impossible to find a single individual among the F_1 cross progenies that would be of consequence to the berry growing in practice.

The course adopted for the utilization of the genes of the bog blueberry in the highbush blueberry breeding has been followed up by making successful back-crosses with the highbush blueberry varieties since the summer of 1965. This causes at least a partial break-up of the unfavourable gene combinations and it has produced a number of rather promising individuals.

Based on the assessment of the progenies of the 1965 back-crosses eight individuals with the most promising culture characteristics were chosen as selections. Their worth was determined both by comparing the seed-bushes and by running a special, comparative clone test.

CHARACTERISTICS OF THE BEST SELECTIONS

The selections chosen from among the progenies of the back-crosses of the bog blueberry and the highbush blueberry have many traits inherited from both parents even though the selections for the majority of their characteristics are closer to the highbush blueberry than to the bog blueberry. This has been established, among other things, when analysing stem and leaf characters (Hiirsalmi 1977 b). The same phenomenon can be seen when looking into the characteristics that are important from the cultural viewpoint. In determining the cultural value of the selections attention was paid to the following characters: earliness of crop; yield and berry weight; shape, colour, firmness and flavour of the berries and also the ripening for winter dormancy of the bushes, their winter hardiness, resistance to blueberry cancer, their vigour and height.

When comparing the seed-bushes with each other and also with the parents, selection 65011016, from the back-cross 'Bluecrop' × (bog blueberry × 'Rancocas'), seemed to have the incontestably best combination of characteristics. Due to its good winter hardiness and cancer resistance it has been vigorous and consequently also the fruit productivity has been high. Only with the 'Rancocas' variety has the yield per bush been greater. Said selection has even produced berries, whose quality too has proved to be nearly as good as that of the best varieties.

The selections were included in the comparative clone test. The results took a predominantly unfavourable turn from those obtained with the seedbushes and were especially poor as regards yield. Selection 65010003, from the back-cross 'Rancocas' × (bog blueberry × 'Rancocas'), however, was clearly better than the others. As a clone its winter hardiness and resistance to cancer, and consequently also its vigour and bush height, proved to be even better than for the seedbush. It was the only one among all the selections and varieties included in the different tests that survived the, from the highbush blueberry angle most disastrous winter 1979—80 almost undamaged. The yield was satisfactory for selection 65010003

and remained practically on the same level in the clone test as with the seedbush. Also the quality of the berry — size, colour, firmness and flavour — must be considered good enough.

The satisfactory results obtained with selection 65010003 in both tests, and above all its ability to survive even adverse winters, have been so encouraging that a decision has been made to the effect that this selection was released for general cultivation in spring 1982, under the variety name 'Aron'.

DESCRIPTION OF THE VARIETY 'ARON'

The highbush blueberry variety 'Aron' was chosen from among the progeny of the back-cross 'Rancocas' × (bog blueberry × 'Rancocas') made at the Institute of Horticulture at Piikkiö 1965. The cross bog blueberry (*Vaccinium uliginosum* L.) × 'Rancocas' was made at the Institute in 1961.

Regarding its vegetative characteristics the 'Aron' is more akin to the highbush blueberry than to the bog blueberry. Its growth habit as well as the shape of its stems, leaves and flowers resemble those of the highbush blueberry. — The bush reaches a height of approximately 1 m. It is made up of several cylindrical stems coming from the root, which as they become older branch out repeatedly. This makes the bush fairly thick. The unbranched shoots and the new branches are a pale green to begin with, but turn dark when they are lignified and in time take on a brownish colour. The oldest parts of the stems are a greyish brown. — The 2—6 cm long leaves, placed alternately and thickly on the stem, are simple, ovate with acute tips and have a fine-toothed margin. They are a shiny green on top, pale underneath. In the autumn the leaves turn russet, especially the top surface, after which the whole bush assumes the beautiful autumn shades. — The flowers, which have an off-white pot-like corolla, grow in cluster-like bunches.

Also as regards its culture characteristics 'Aron' resembles the highbush blueberry. Its winter hardiness and resistance to blueberry cancer are, however, clearly better than those of the foreign varieties (blueberry cancer is a disease attacking the stem and it is caused by the funcus *Fusicoccum putrefaciens*). Consequently the bushes are vigorous and give, at least under the climatic conditions in Southern Finland, a satisfactory yield, the reckoned yield has come to around 30 kg/100 m² per annum. — The berries are medium-sized, one hundred berries weigh 100—130 g. Qualitywise they are good, very tasty and firm. They are spherical in shape and are a darker colour on top than the bluish grey berries of the parents. The flesh of the berry is pale, without colour. — The sweet, aromatic berries are well suited for use fresh and frozen. When thawing out they retain their firmness and shape. — The 'Aron' variety flowers in early June in Southern Finland and the berries ripen in around a month, between the beginning of August and September 15th.

The cultivation of the highbush blueberry variety 'Aron' departs on some points from the cultivation of other berry species. It requires a light, sandy type of soil, which should be rather acid (the pH preferably below 5,5). The acidity can be achieved by adding unlimed peat to the soil or by using it as cover. In addition acid fertilizers should be used. The soil for growing the highbush blueberry should also be moist, but porous as well. Watering is most often necessary. — As planting distance for the 'Aron' variety we recommend about 100 bushes/100 m² with a space of 50—70 cm between the bushes in the row.

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SELOSTUS

Suomalainen pensasmustikkalajike 'Aron'

HEIMO HIIRSALMI ja AARO LEHMUSHOVI

Maatalouden tutkimuskeskus

Pensasmustikan viljely ei ole maassamme toistaiseksi onnistunut. Merkittävimmät haittatekijät ovat ulkomaisten lajikkeiden heikohko talvenkestävyys ja alttius yleisesti tavattavalle versotaudille, mustikkasyövälle, jonka aiheuttaa *Fusicoccum putrefaciens*-sieni. Haittatekijöiden merkityksen vähentämiseksi on puutarhantutkimuslaitoksessa Piikkiössä suoritettu vuodesta 1961 lähtien suunnitelmallista jalostustoimintaa pyrkimällä risteyttämään kotimaisia *Vaccinium*-lajeja pensasmustikan kanssa.

Juolukka, *V. uliginosum*, jolla on sama tetraploidinen kromosomiluku, 2n = 48, kuin pensasmustikallakin, on kyetty risteyttämään sen kanssa. Tähän puutarhantutkimuslaitoksessa suoritettuun lajinristeytysjalostukseen perustuen on keväällä 1982 laskettu yleiseen viljelyyn ensimmäinen suomalainen pensasmustikkalajike nimellä 'Aron'.

'Aron' on valittu vuonna 1965 tehdyn takaisinristeytyksen 'Rancocas' × (juolukka × 'Rancocas') jälkeläistöstä. Risteytys juolukka × 'Rancocas' tehtiin vuonna 1961. 'Aron' muistuttaa sekä kasvullisilta että viljelyllisiltä ominaisuuksiltaan ulkomaisia pensasmustikkalajikkeita. Sen talven- ja mustikkasyövänkestävyys ovat kuitenkin selvästi paremmat kuin niillä. 'Aron'-lajikkeen sato on Etelä-Suomessa osoittautunut tyydyttäväksi. Marjat ovat keskikokoisia ja laadultaan hyviä. Ne soveltuvat käytettäviksi tuoreina ja pakastettuina.

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Seria PHYTOPATHOLOGIA N. 90 — Sarja KASVITAUDIT n:o 90

FURTHER STUDIES ON VARIETAL DIFFERENCES IN RESISTANCE TO POTATO GANGRENE

ESKO SEPPÄNEN

SEPPÄNEN, E. 1982. **Further studies on varietal differences in resistance to potato gangrene.** Ann. Agric. Fenn. 21: 155—161. (Agric. Res. Centre, Inst. Pl. Path. SF-01300 Vantaa 30, Finland.)

The optimum growth temperature of *Phoma exigua* var. *foveata* and varietal resistance to gangrene was studied by infecting tubers artificially and incubating them under different environmental conditions for 20 days. The results are presented as fungal growth rates.

The optimum temperature of *Phoma exigua* var. *foveata* was studied in five cvs. The results of three tests indicated that the optimum in Saturna was less than 6 °C, in Bintje, Pito and Record about 10—11 °C (the Pito cv., however, having no peak between 6 and 18 °C) and in Sabina nearly 16 °C.

Ten tests for varietal resistance, seven with *P. e.* v. *foveata* and three with *P. e.* v. *exigua*, were carried out. The number of cvs. in each varied from 11 to 22. The resistance of the cvs. variedly greatly, and the values of resistance to var. *foveata* did not correlate with those to var. *exigua*. Eigenheimer and Hankkijan Tuomas proved to be the most resistant to var. *foveata*, and Eigenheimer to var. *exigua*.

Index words: potato, gangrene, *Phoma exigua* v. *exigua*, *P. e.* v. *foveata*, optimum temperature, varietal resistance.

In an earlier report (SEPPÄNEN 1980) on potato gangrene, the approximate growth optima of *Phoma exigua* var. *foveata* and *P. e.* var. *exigua* were determined and preliminary results on varietal resistance were presented. The earlier tests on growth optima were carried out with cv. Bintje. In the present study the tests were carried out with var. *foveata* but now the number of cultivars was increased to five to find out wheather there are any varietal differences which must be taken into consideration when testing cultivars for ranking. The literature contains no reports on varietal differences. The number of tests for varietal resistance was increased to permit comparisons between the results of different years.

MATERIAL AND METHODS

The growing of the cvs. to be tested, the growing of the fungi used as inoculum, and the infection and analytical methods were the same as used earlier (SEPPÄNEN 1980). This time, however, the results were treated with a computer. The mean values of radial and axial growth in three tests, each with 3 replications, were treated simultaneously, eliminating the influence of time between the tests. Regression curves with a pattern of 4th potency were calculated from the same material. They are presented in Fig. 1 with separate curves of radial and axial growth shown according to the conventional method.

The growth figures from separate tests for varietal resistance were mathematically derived onto a scale of 1 to 9. In each test the growth figure of the most susceptible cv. was given a score of 1 on the scale and 9 signified perfect resistance (growth figure = 0). The other cvs. were scored in relation to these. Only the means of the scores are presented, and the cvs. were ranked according to them. Not all of the cvs. were included in every test: they were ranked in order by comparing the scores of pairs which had undergone the same tests.

Correlation coefficients were calculated between all the separate tests for var. *foveata* and var. *exigua*, and also for 26 varietal tests carried out with a number of *Fusarium* species. The significances of the correlations were tested with the t-test.

RESULTS AND DISCUSSION

Optimum temperature for growth of *Phoma exigua* var. *foveata*

The results of three separate tests, 3 × 10 tubers of each cv. and each temperature, carried out during the period December—April, 1981—1982, showed great varietal differences in growth optima (Table 1, Fig. 1.). Saturna had the lowest optimum temperature (less than 6 °C) and Sabina the highest (about 16 °C). The optima of Bintje and Record were 10—11 °C whereas in Pito there was no clear optimum — the fungus grew equally well at 6, 12 and 18 °C. It is possible that with an incubation period longer than 20 days the fungus in Pito would increase its axial growth and give an optimum near 10—12 °C.

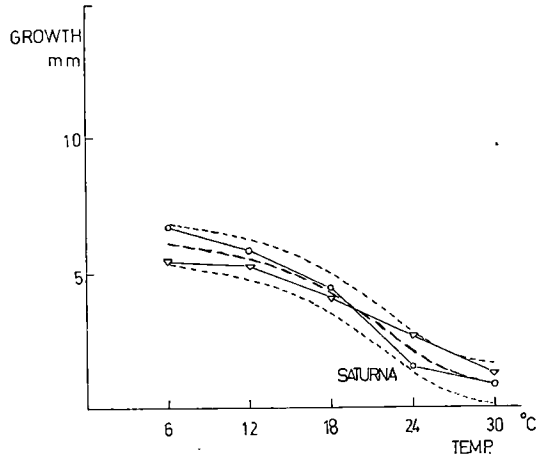
Table 1. The growth (mm) of *Phoma exigua* var. *foveata* in tubers of 5 cvs. incubated for 20 days at 5 different temperatures and uniform RH. See Fig. 1.

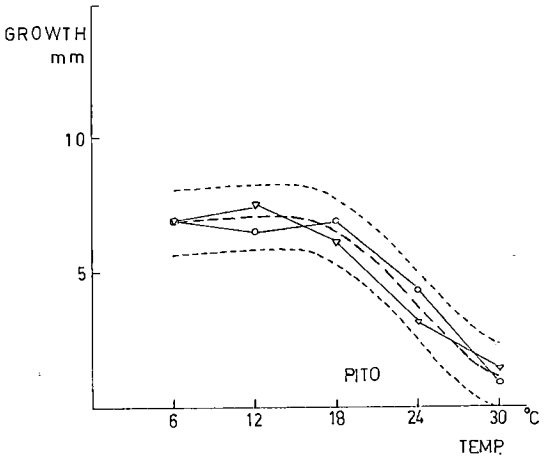
Temperature	Cultivar				
	Bintje	Pito	Record	Sabina	Saturna
6 °C	9,5[b]	6,9[a]	7,2[b]	7,6[c]	6,1[a]
12	13,7[a]	6,9[a]	8,8[a]	8,8[b]	5,5[a]
18	8,8[b]	6,5[a]	6,3[b]	10,1[a]	4,3[b]
24	4,4[c]	3,7[b]	2,4[c]	2,5[d]	2,1[c]
30	1,1[d]	1,1[c]	0,8[d]	1,2[e]	1,0[d]
F	56,16***	44,82***	96,06***	122,18***	89,41***
LSD_5%	1,9	1,2	1,0	1,1	0,7

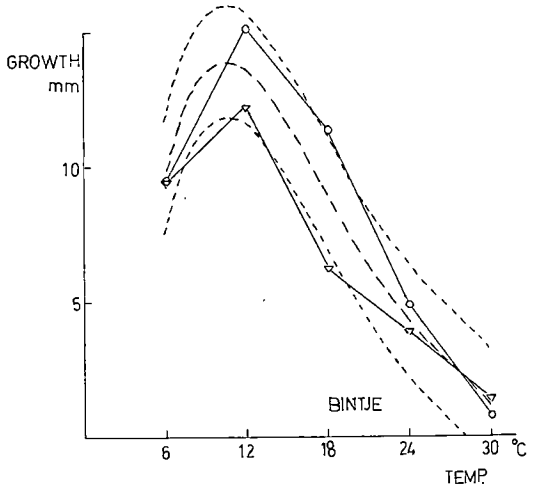
The curves calculated with a 4th potency model give a more exact value of the optimum but give no more essential information than the conventional method (Fig. 1).

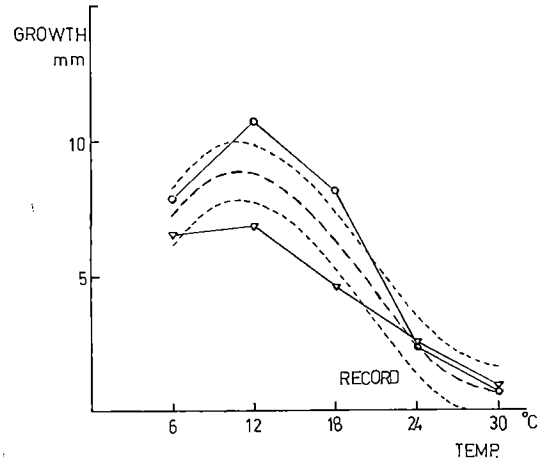
There were clear differences in radial and axial growth, too. In Pito and Saturna they were approximately equal, in Bintje and Record radial growth was stronger, and in Sabina axial growth was stronger. These differences are based at least partly on the different susceptibilities of the cortex and medulla, but hardly at all on their different temperature optima. The reactions of the other cvs. grown commonly in Finland must be tested.

Although the earliest determinations of the optimum growth temperature of the fungus in potato tubers (KRANTZ 1958, MALCOLMSON 1959) differed (10—12 and 5—6 °C, respectively)









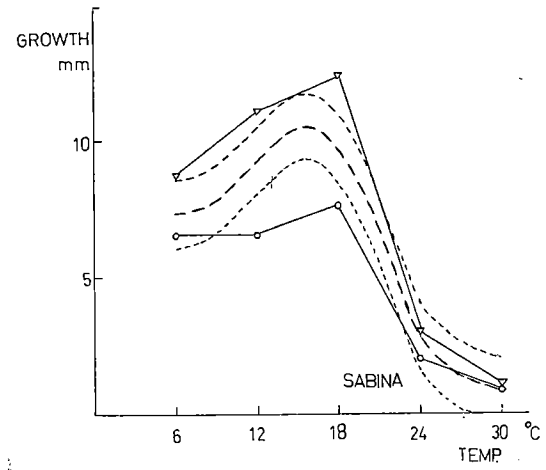


Fig. 1. Radial o———o and axial (▽———▽) growth of *Phoma exigua* var. *foveata* in tubers of 5 cvs. compared with mean growth curve (— — —) of 4th potency model and the corresponding curves of 5 % risk. See text.

and different results might be obtained from different cvs. and different isolates, the large differences found in this study are quite surprising, in particular the high optimum of Sabina. Another factor influencing this question is the timing of the test. LANGERFELD (1977) and later SCHEITZA (1981) have studied the different varietal development of resistance reactions during the storage season. The results presented here are thus not entirely valid for any time and any condition, but do give undisputed evidence of different varietal optimum temperatures. The variation may be affected by the fungus as well as by the cultivar, probably both of them. A corresponding variation in growth optima has been ascertained with some *Fusarium* species (SEPPÄNEN 1982 a).

Varietal resistance

In 1979—81, seven tests were carried out on var. *foveata* and three on var. *exigua*, (two with the brown and one with the grey isolate) (Tables 2 and 3). The test procedures varied within certain limits, causing some variation in the results: the inoculations were made at different times during the storage period and on harvests from different years; in the Feb. —80 test the isolate was inoculated into a 10 mm wound instead of the usual 2 mm wound; and the incubation conditions varied within narrow limits. In spite of these differences the results of separate tests were fairly similar. The Apr. —81 test was carried out with tubers not grown or treated uniformly before the test. The results were therefore excluded from the score calculation but were included in the common comparison for just that reason. They correlated fairly well with the other results (Table 4). There were either no or only weak correlations between the results from var. *foveata* and var. *exigua*.

Cultivars Hankkijan Tuomas and Eigenheimer proved to be the most resistant to var. *foveata*, followed by Jaakko, Posmo, Sieglinde and Hankkijan Tanu. The most susceptible was

Table 2. Varietal resistance to *Phoma exigua*. var. *foveata*. Growth of the fungus (mm) incubated for 20 days under different conditions (°C/RH%), and the scores of resistance derived from the growth figures into a scale of 1—9.

Cultivar	Tests performed in							Score of resistance
	Nov. —79 12±1/8±10	Febr. —80 7±1/80±10	April —80 6±1/75±10	Nov. —80 7±1/90±5	Dec. —80 7±2/90±5	April —81 6±2/90±5	Nov. —81 7±1/85±10	
1 Hankkijan Tuomas	3,4^{a}	8,9^{a}	4,2^{a}	4,7^{ab}	6,3^{a}	7,5^{bcd}	2,8^{a}	6
2 Eigenheimer	—	—	—	4,0^{a}	5,9^{a}	—	3,7^{ab}	6
3 Jaakko	3,3^{a}	9,4^{a}	5,0^{abc}	5,3^{bc}	7,1^{ab}	6,1^{a}	3,3^{a}	5
4 Posmo	—	—	—	6,9^{de}	7,6^{ab}	—	3,8^{ab}	5
5 Sieglinde	4,1^{b}	9,5^{a}	6,6^{e}	6,8^{de}	10,0^{defg}	—	3,2^{a}	5
6 Hankkijan Tanu	—	—	—	—	—	8,4^{de}	3,8^{ab}	5
7 Saturna	5,8^{c}	9,6^{ab}	4,8^{ab}	6,3^{cd}	7,8^{abc}	6,4^{ab}	5,8^{de}	4
8 Sabina	5,7^{c}	11,2^{bc}	5,7^{bcd}	6,0^{cd}	8,5^{bcd}	8,4^{de}	6,3^{e}	4
9 Maris Piper	—	—	—	6,5^{d}	9,6^{cdef}	—	5,6^{de}	4
10 Prevalent	—	—	—	7,3^{def}	9,6^{cdef}	—	4,9^{cd}	4
11 Sanna	4,7^{b}	11,8^{b}	5,4^{bcd}	7,9^{efg}	8,9^{bcde}	6,6^{ab}	5,5^{de}	4
12 Olympia	5,4^{c}	10,6^{bc}	6,0^{cde}	8,3^{fg}	11,6^{fgh}	—	4,5^{bc}	4
13 Pito	6,1^{c}	11,7^{c}	5,2^{bcd}	6,7^{de}	10,5^{defg}	7,9^{cde}	9,2^{hi}	4
14 Veto	4,7^{b}	11,0^{b}	5,6^{bcd}	8,3^{fg}	9,9^{defg}	—	7,6^{fg}	4
15 Provita	6,9^{d}	13,0^{d}	5,8^{bcde}	6,8^{de}	10,0^{defg}	8,8^{ef}	6,5^{e}	3
16 Stina	7,6^{d}	14,3^{d}	5,2^{bcd}	8,9^{gh}	11,5^{fgh}	8,5^{def}	6,2^{e}	3
17 Barima	—	—	—	8,8^{gh}	10,8^{efgh}	8,9^{ef}	7,9^{fg}	3
18 Record	7,1^{d}	13,5^{d}	5,0^{abc}	8,9^{gh}	11,8^{gh}	8,0^{cde}	9,2^{hi}	3
19 Hankkijan Timo	6,8^{d}	13,9^{d}	6,2^{de}	9,2^{gh}	12,0^{gh}	9,0^{ef}	8,4^{fgh}	2
20 Jo 0701	9,1^{f}	13,4^{d}	—	8,4^{fg}	12,6^{h}	—	—	2
21 Ostara	9,1^{f}	13,8^{d}	—	9,8^{h}	10,8^{defgh}	7,7^{cd}	7,6^{fg}	2
22 Sirtema	8,3^{e}	13,0^{d}	7,6^{f}	10,0^{h}	14,6^{i}	—	9,8^{i}	2
23 Bintje	9,3^{f}	11,8^{c}	8,0^{f}	11,0^{i}	17,5^{j}	10,5^{g}	8,6^{gh}	1
F	95,30***	22,51***	22,04***	487,46***	32,87***	17,38***	73,35***	
$LSD_{5\%}$	0,6	1,1	0,7	0,9	1,3	0,8	0,7	

Bintje, followed by Sirtema and Ostara. With regard to the scores of separate cultivars, we must always bear in mind that the test method used favours cultivars with high cortical resistance, so cvs. like Jaakko, Sabina and Sieglinde, which have quite a susceptible medulla might be ranked weaker on tests with a deep inoculation and a longer incubation time. On the other hand, as presented above; test temperature influences the results.

The scores of Hankkijan Tuomas and Eigenheimer are not higher than six. These mathematical estimates are much too low and the resistances of Hankkijan Tuomas and Eigenheimer would be worthy of a score of seven: many other cvs. also deserve relatively higher scores than they have received. It is evident that there is potential for developing a test method whose results could be directly read off the resistance scale 1—9 with an adequate degree of accurracy.

Table 3. Varietal tuber resistance to two isolates of *Phoma exigua* var. *exigua*. Growth of the isolates after incubation for 20 days and the scores of resistance derived from the growth figures onto a scale of 1—9.

Cultivar	Tests performed with			Score of resistance
	isolate 75184-3 (brown)		isolate 8075-2 (grey)	
	Apr. -80	Jan. -81	Jan. -81	
	10±1/ 75±10	12±1/ 95±5	12±1/ 95±5	
1 Eigenheimer	—	5,4^{a}	3,7^{a}	4
2 Saturna	6,4^{bc}	5,4^{a}	4,5^{bc}	3
3 Sieglinde	5,6^{ab}	6,2^{abc}	4,4^{bc}	3
4 Prevalent	—	6,1^{ab}	4,7^{bcd}	3
5 Ostara	—	6,3^{abc}	4,8^{cd}	3
6 Maris Piper	—	6,4^{abc}	4,9^{cd}	3
7 Bintje	5,4^{ab}	6,4^{abc}	5,2^{de}	3
8 Jaakko	6,3^{cd}	7,5^{cd}	4,2^{b}	3
9 Hankkijan Tuomas	7,3^{cd}	6,5^{abc}	4,6^{bc}	2
10 Provita	6,3^{bc}	6,0^{ab}	5,6^{ef}	2
11 Barima	—	7,4^{cd}	4,6^{bc}	2
12 Posmo	—	6,8^{bcd}	5,2^{de}	2
13 Record	4,9^{ab}	7,1^{bcd}	6,0^{f}	2
14 Sanna	7,7^{de}	6,1^{ab}	5,6^{ef}	2
15 Olympia	7,4^{cd}	6,7^{bc}	5,5^{ef}	2
16 Hankkijan Timo	7,1^{cd}	7,4^{cd}	5,0^{de}	2
17 Pito	7,0^{cd}	6,1^{ab}	6,0^{f}	2
18 Sabina	7,2^{cd}	7,8^{d}	5,1^{de}	2
19 Stina	7,6^{cd}	7,1^{bcd}	5,6^{ef}	2
20 Veto	7,8^{de}	8,0^{d}	5,6^{ef}	1
21 Sirtema	8,4^{e}	7,4^{cd}	5,7^{f}	1
22 Jo 0701	—	7,9^{d}	5,9^{f}	1
F	117,67***	8,66***	32,06***	
$LSD_{5\%}$	0,7	0,8	0,4	

Only some of the cvs. are the same as those used by other workers and so the chances of comparison are poor. In the tests by KRANZ (1959), only 3 cvs. (Olympia, Sieglinde and Sirtema) were the same as those used in our tests. He used a different method, with spore inoculation into 6 mm wounds, and the results were presented as percentages of infections. His results bear no comparison with the present ones. NIELSEN (1977) carried out fairly extensive tests over many years using a method fairly similar to ours. The cvs. Bintje, Sirtema, Record, Saturna and Sieglinde (ranked according to increasing resistance) were common to our tests, and his results were very similar to ours. The cvs. in common with BÅNG's (1972, 1976) tests were Bintje, Pito, Provita, Stina, Saturna, Sabina and Prevalent, and the results were somewhat alike. Only two of our cvs. (Record and Maris Piper) were also used by LANGTON (1971): Record proved to be medium resistant and Maris Piper more highly resistant. In our results, they were ranked in the same way, but Maris Piper was not classed better than medium resistant.

The varietal ranking order of resistance to var. *exigua* was not the same. Eigenheimer proved to be the most resistant, and Hankkijan Tuomas and Sabina were by far more susceptible to var. *exigua* than to var. *foveata*, Ostara and Bintje showed surprisingly much higher resistance than to var. *foveata*. Because the results of resistance to var. *exigua* are scanty and deviate strongly from each other, we must refrain from detailed comparisons. In any case there is hardly any clear correlation between the varietal resistance to var. *foveata* and to var. *exigua* (Table 4).

As we are speaking about resistance to gangrene, we must bear in mind that, besides the tuber resistance, varietal stem resistance to pycnospore production as well as resistance to wounding are of great importance, too.

Table 4. Correlations between varietal resistance tests to *Phoma exigua* var. *foveata* and *P. e.* v. *exigua*. The correlation coefficients obtained with 21 variables are underlined, those obtained with 11 are in parenthesis, and the others were obtained with 15 variables.

	Phoma e. v. *foveata*							*Phoma e.* v. *exigua*	
	Nov. -79	Feb. -80	Apr. -80	Nov. -80	Dec. -80	Apr. -81	Nov. -81	Apr. -80	Jan. -81
Phoma e. v. *foveata*									
Feb. —80	0,75**								
Apr. —80	0,62*	0,28							
Nov. —80	0,80***	0,68**	0,72**						
Dec. —80	0,86***	0,57*	0,84***	0,89***					
Apr. —81	(0,82**)	(0,57°)	(0,79**)	(0,69*)	(0,83**)				
Nov. —81	0,82***	0,75**	0,50°	0,79***	0,75***	(0,67*)			
Phoma e. v. *exigua*									
Apr. —80	—0,10	0,10	—0,04	0,01	—0,13	(—0,26)	0,02		
Jan. —81	0,01	0,26	0,10	0,33	0,24	(0,17)	0,38°	0,32	
Jan. —81	0,54*	0,70**	0,14	0,53*	0,52*	(0,38)	0,55**	0,23	0,31

P < 0,1 % is indicated with ***
0,1— 1,0 » » » **
1,0— 5,0 » » » *
5,0—10,0 » » °

Correlations between tests

The aim of these analyses was to ascertain the variation between separate tests within species, and to discover possible parallel resistance between the fungi.

The correlations within var. *foveata* were positive and close, most often highly significantly, even when the tests were done with somewhat different material and under different conditions. Thus the results obtained can be considered reliable, and indicate that the response of most cvs. to temperature variation was almost the same. There were only a few significant correlations between tests on var. *foveata* and var. *exigua*. No correlations were obtained between var. *foveata* and the brown isolate of var. *exigua*. Between var. *foveata* and the grey isolate var. *exigua* there was a closer positive correlation: five of the seven coefficients were significant. No correlations were found between the isolates of var. *exigua*. A weak correlation between the *Phoma* species is not surprising, the same can be ascertained between *Fusarium* species, too (Seppänen 1982 b).

A comparison of the results obtained with *Phoma* and *Fusarium* species showed some correlations. There were positive and very often significant correlations between the results of var. *foveata* and those of *F. avenaceum* and *F. solani* var. *coeruleum* obtained at low temperatures (6—9 °C). The correlation between var. *foveata* and *F. sulphureum* was weaker. With regard to var. *exigua*, the only correlation seemed to be between the grey isolate and *F. sulphureum*. A more detailed scrutiny of these relationships is presented in connection with Fusariums (Seppänen 1982 b).

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SELOSTUS

Jatkotutkimuksia lajikekestävyydestä *Phoma*-mätää vastaan

ESKO SEPPÄNEN

Maatalouden tutkimuskeskus

Tässä tutkimuksessa selvitettiin *Phoma exigua* var. *foveatan* kasvuoptimilämpötilaa eri lajikkeissa, sekä lajikkeittemme kestävyyttä sitä ja *P. e.* v. *exiguan* kahta isolaattia, ruskea ja harmaa, vastaan. Lisäksi tarkasteltiin korrelaatiolaskuin kestävyyden yhdenmukaisuutta. Tartutus- ja analysointimenetelmät olivat pääpiirteissään samat kuin aikaisemmassa tutkimuksessa. Tulosten laskentaa täydennettiin ATK:n avulla.

Sienen kasvun optimilämpötila vaihteli suuresti lajikkeen mukaan. Saturnassa se oli pienempi kuin kokeiden alhaisin lämpötila 6 °C, Bintjessä ja Rekordissa 10—11 °C, ja Sabinassa n. 16 °C. Pidossa ei todettu selvää optimia, vaan sieni kasvoi lähes yhtäläisesti 6, 12 ja 18 °C:ssa. Pidossa ja Saturnassa sieni eteni lähes yhtäläisesti leveys- ja pituussuuntaan, Bintjessä ja Rekordissa nopeammin leveyssuuntaan, kun taas Sabinassa syvyyssuuntaan.

Lajikkeistamme osoittautuivat Hankkijan Tuomas ja Eigenheimer kestävimmiksi var. *foveataa* vastaan, lähinnä Jaakko, Siikli, Posmo ja Hankkijan Tanu. Alttein oli Bintje, lähinnä Sirtema ja Ostara. Kestävyyttä arvioitaessa on otettava huomioon lämpötila ja tässä esitetyt tulokset perustuvat pääosaltaan alhaisessa, 6—7 °C:ssa tehtyihin testeihin.

Eigenheimer oli kestävin myös var. *exiguaa* vastaan, mutta Hankkijan Tuomas oli heikompi. Toisaalta mm. Bintje oli sitä vastaan suhteellisesti kestävämpi kuin var. *foveataa* vastaan.

Testitulokset var. *foveataa* vastaan korreloivat positiivisesti ja ovat muutamaa poikkeusta lukuun ottamatta merkitseviä. Sen sijaan var. *foveatan* ja var. *exiguan* isolaattien keskeinen korrelointi oli heikko, var. *exiguan* harmaa isolaatti korreloi jonkin verran var. *foveatan* kanssa, mutta ruskea isolaatti ei kummankaan e.m. kanssa.

Verrattaessa tuloksia *Fusarium*-lajeilla tehtyihin testeihin voitiin todeta, että var. *foveatan* tulokset korreloivat *F. avenaceumin* ja *F. solani* var. *coeruleumin* alhaisissa lämpötiloissa (6—12 °C) saatujen tulosten kanssa. *F. sulphureumiin* nähden korrelointi oli heikompi. Var. *exiguan* harmaa isolaatti korreloi vahvasti *F. sulphureumin* tulosten kanssa. Yksityiskohtaisemmin näitä tuloksia tarkastellaan *Fusarium*-lajeja käsittelevässä työssä.

ANNALES AGRICULTURAE FENNIAE, VOL. 21: 162—168 (1982)
Seria PHYTOPATHOLOGIA N. 91 — Sarja KASVITAUDIT n:o 91

FUSARIUMS OF THE POTATO IN FINLAND V. FURTHER INVESTIGATIONS INTO THE GROWTH OPTIMA OF FUSARIUM SPECIES IN POTATO TUBERS

ESKO SEPPÄNEN

SEPPÄNEN, E. 1982. **Fusariums of the potato in Finland V. Further investigations into the growth optima of *Fusarium* species in potato tubers.** Ann. Agric. Fenn. 21: 162—168. (Agric. Res. Centre, Inst. Pl. Path. SF-01300 Vantaa 30, Finland.)

Artificially infected tubers of 5 cvs. (Bintje, Pito, Record, Sabina and Saturna) were incubated at five different temperatures and uniform humidity. The responses of the cvs. differed, indicating that each cv. has a different optimum temperature for infection. *Fusarium avenaceum* grew best at temperatures of 24 and 30 °C. Record has a little lower and Pito and Saturna higher optima than Bintje and Sabina. The growth curves of *F. solani* v. *coeruleum* were fairly similar, the optimum in Sabina being higher (22—24 °C) than in the other (18—20 °C). Differences were greatest in the growth of *F. sulphureum;* in Sabina its optimum was about 30 °C, in Pito, Record and Saturna between 24 and 30 °C, and in Bintje two clear temperature optima, 12 and 24 °C, were demonstrated.

Index words: potato, dry rot, *Fusarium avenaceum*, *F. solani* v. *coeruleum*, *F. sulphureum*, varietal optimum temperature.

INTRODUCTION

In an earlier report the optimum growth conditions of 12 *Fusarium* species pathogenic to potatoes determined in tubers of Bintje (SEPPÄNEN 1981). They varied to a very large degree. TIVOLI and JOUAN (1981) presented fairly similar results concerning the growth of six *Fusarium* species in Bintje tubers.

The available literature contains no report on whether or not the fungi have the same growth optimum in all potato cvs. The aim of the present study was to find out whether any varietal differences exist.

MATERIAL AND METHODS

Earlier studies were carried out with one cultivar, Bintje, but the present study includes few more — Pito, Record, Sabina and Saturna. They were grown and stored using standard but uniform procedures. Three tests with each fungus and each cv. were carried out between December and April.

The tubers were infected, incubated and analyzed as described elsewhere (SEPPÄNEN 1981). The tests were carried out using only three fungi. *Fusarium avenaceum*, *F. solani* v. *coeruleum* and *F. sulphureum*, which are of great practical significance. Only one value of relative humidity (RH) was used at each temperature, because all the fungi grow well at high RH, even though *F. sulphureum* favours dry conditions.

RESULTS AND DISCUSSION

The aim was to demonstrate whether or not there are any differences in the response of different cvs. to a given fungus. The results of the first test were surprising, so we repeated each test twice. However, the results of tests with each fungus were similar. The number of tubers in each test (10 with three replicates) was large enough to give a reliable picture of the question under study.

Fusarium avenaceum. As a rule the results with different cvs. were fairly similar (Table 1 and Fig. 1). The axial and radial growths were almost the same, the former usually being more rapid. At 6 and 12 °C the growth of the fungus was slow, but increased with the rise in temperature, from 12 to 18 °C. The most significant difference was between 18 and 24 °C. The growth in Record was nearly at its optimum at 24 °C, the optima of the other cvs. seem to be a little higher but hardly higher than 30 °C (Cf. SEPPÄNEN 1981). The relatively better resistance of cv. Record than the other cvs. at low temperatures (6 and 12 °C) is worth nothing. This resistance, or the lower optimum temperature of Record, or a combination of the two caused the large difference between the growth rates at 12 and 18 °C.

Fusarium solani var. *coeruleum*. The growth curves of this fungus were also very similar in different cvs. (Fig. 2). The optimum temperature in Sabina however is, about 4 °C higher than that in Bintje, at approximately 23 and 19 °C, respectively, the others being intermediate. The axial growth was more rapid than the radial growth, as in *F. avenaceum*. As a rule the differences were biggest near the optimum.

Table 1. The growth (mm) of *Fusarium avenaceum*, *F. solani* var. *coeruleum* and *F. sulphureum* in five cultivars incubated for 20 days at five different temperatures and uniform relative humidity.

	Bintje	Pito	Record	Sabina	Saturna
F. avenaceum					
6 °C	4,3[a]	2,6[a]	1,9[a]	2,8[a]	2,4[a]
12	6,0[b]	3,4[a]	2,6[a]	4,4[a]	1,9[a]
18	7,4[c]	8,1[b]	7,2[b]	9,1[b]	4,5[b]
24	13,8[d]	11,7[c]	11,3[c]	13,2[c]	9,4[c]
30	14,2[d]	9,9[bc]	11,0[c]	10,9[b]	10,9[d]
F	243,42***	18,16***	59,86***	19,00***	118,97***
$LSD_{5\%}$	0,9	2,7	1,7	2,9	1,2
F. solani var. *coeruleum*					
6 °C	1,1[a]	1,3[a]	1,3[a]	1,5[a]	1,5[a]
12	4,4[b]	3,7[b]	4,1[b]	3,4[b]	3,1[b]
18	7,2[d]	5,6[c]	6,3[c]	5,6[c]	5,4[c]
24	5,5[c]	5,0[c]	5,9[c]	6,4[d]	4,6[c]
30	1,9[a]	1,6[a]	1,2[a]	1,0[a]	0,8[a]
F	50,34***	53,45***	79,96***	91,30***	45,93***
$LSD_{5\%}$	1,1	0,8	0,9	0,8	0,9
F. sulphureum					
6 °C	8,8[a]	8,2[a]	8,2[a]	5,9[a]	7,0[a]
12	12,7[b]	10,1[b]	9,5[b]	7,4[a]	6,6[a]
18	7,8[a]	10,6[b]	9,6[b]	9,6[b]	6,7[a]
24	12,3[b]	13,1[c]	13,3[c]	11,2[c]	11,4[b]
30	8,0[a]	12,6[c]	13,4[c]	13,8[d]	11,2[b]
F	20,93***	21,24***	35,01***	37,49***	39,90***
$LSD_{5\%}$	1,6	1,3	1,2	1,6	1,2

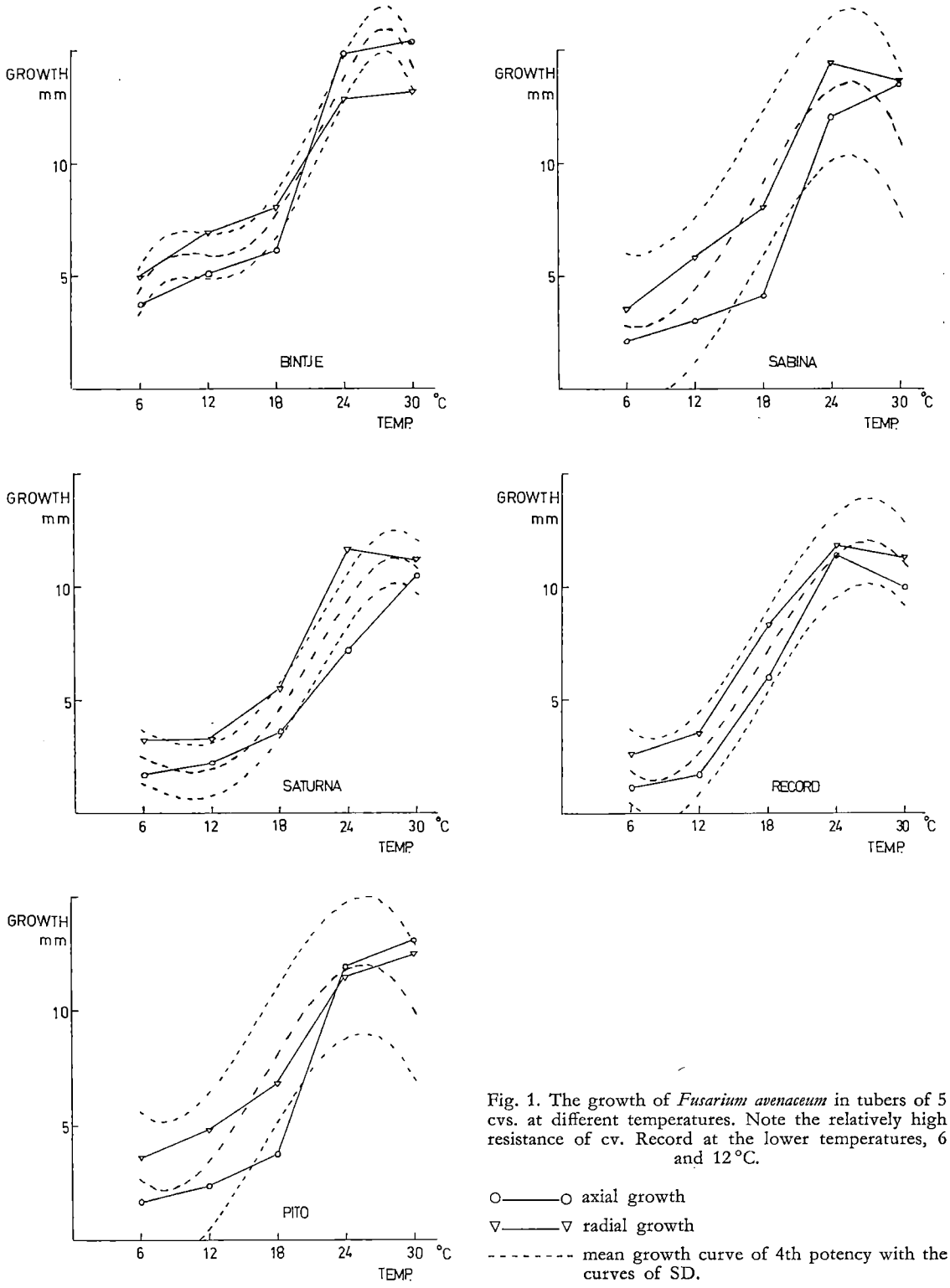

Fig. 1. The growth of *Fusarium avenaceum* in tubers of 5 cvs. at different temperatures. Note the relatively high resistance of cv. Record at the lower temperatures, 6 and 12 °C.

○———○ axial growth

▽———▽ radial growth

- - - - - - - - mean growth curve of 4th potency with the curves of SD.

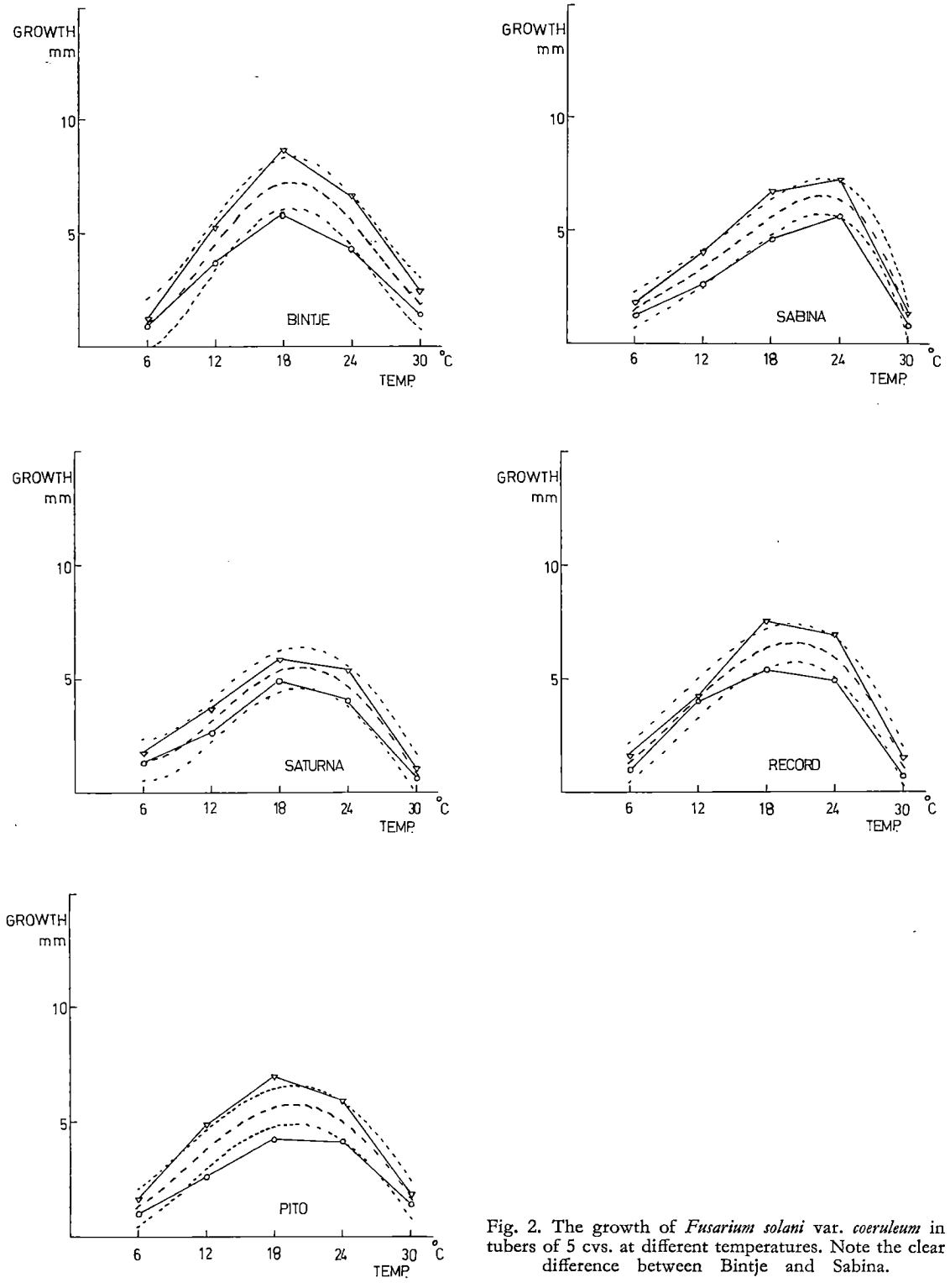

Fig. 2. The growth of *Fusarium solani* var. *coeruleum* in tubers of 5 cvs. at different temperatures. Note the clear difference between Bintje and Sabina.

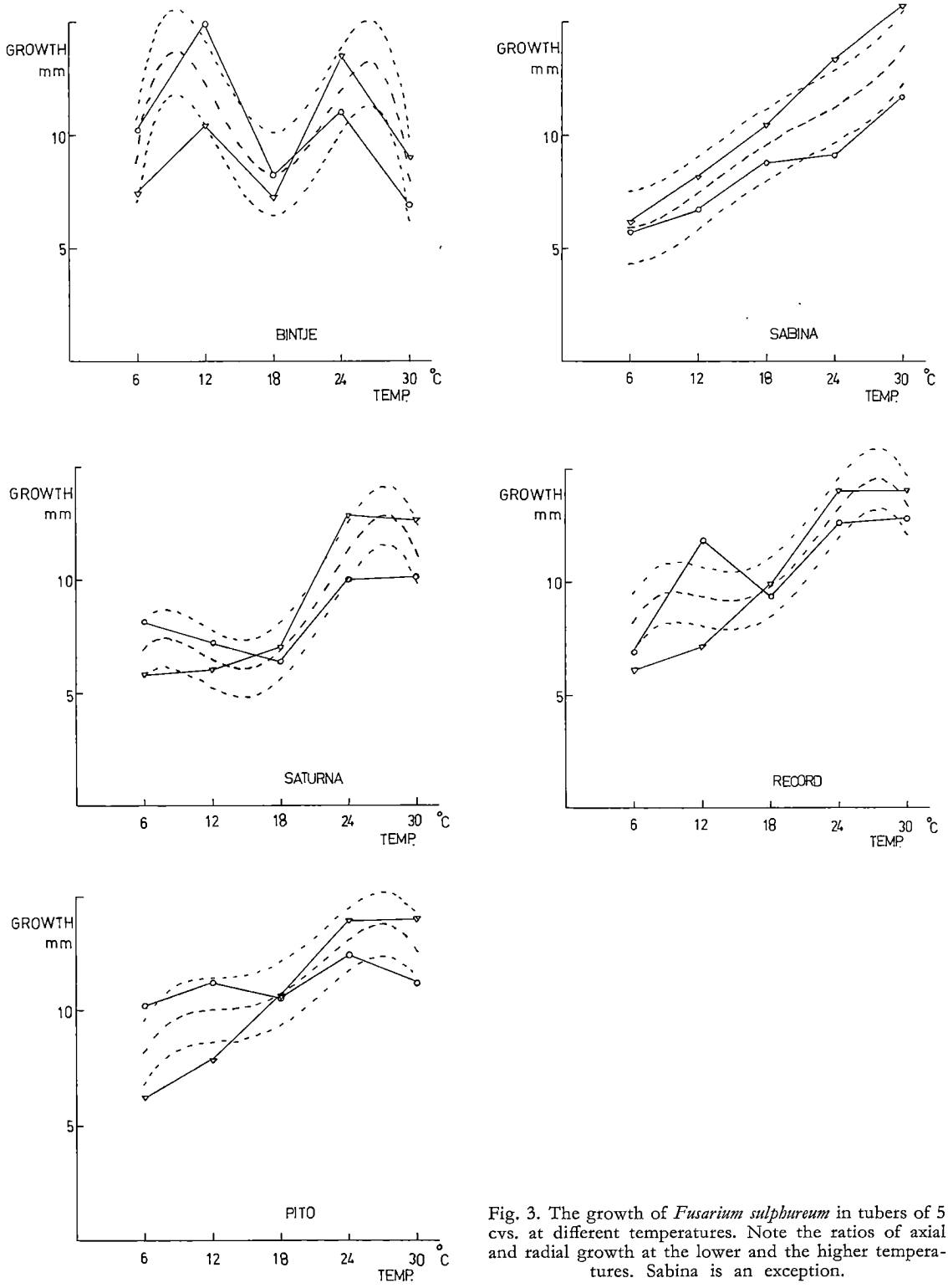

Fig. 3. The growth of *Fusarium sulphureum* in tubers of 5 cvs. at different temperatures. Note the ratios of axial and radial growth at the lower and the higher temperatures. Sabina is an exception.

Fusarium sulphureum. The differences between cvs. were most striking with this fungus (Table 1., Fig. 3). The results again proved that Bintje has two clear temperature optima, at about 12 and 24 °C, radial growth being predominant in the former and axial growth in the latter. This ratio of the directions of growth was also ascertained in the other cvs., excluding Sabina. Another feature common to all the cvs. except Sabina was the weaker growth of the fungus at 18 °C than at 12 and 24 °C. It caused two optima in Bintje and two optima in radial growth in Record. In Saturna the fungus grew nearly equally at 6, 12 and 18 °C, the optimum being between 24 and 30 °C. In principle, the responses of Pito and Record were almost the same, their optima being at the same level as in Saturna. In Sabina both the axial and radial growths were fairly similar and correlated almost linearly. The optimum in Sabina was at least 30 °C.

If we compare these results with those obtained with *Phoma exigua* var. *foveata* (SEPPÄNEN 1982) we can see that Bintje and Record were fairly similar in many respects, as were Pito and Saturna. Sabina, with its higher optimum temperatures, differed from the others. Varietal differences were smaller with the *Fusarium* species than with *P. e.* v. *foveata*.

With regard to the question of whether these results can be generalized, one can see that, in principle, the results of three separate tests gave, almost the same result, but more or less different results are possible with other material. This study was biased in the respect that we used only one, very virulent isolate of each fungus, the tests were carried out during the latter part of storage period, only one method of infection was used and only one incubating period was chosen. According to my experience these factors have some influence on the results, but they do not change the result of varietal differences.

In the light of these results we can conclude that test temperature is of great importance when ranking cultivars for their resistance to a given fungus, especially when testing the resistance to *F. sulphureum*. Tests required to give the best information for practical purposes must be done under as nearly identical conditions as possible.

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SELOSTUS

Fusarium-sienten kasvun optimit eri lajikkeissa

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Maatalouden tutkimuskeskus

Aikaisemmassa tutkimuksessa selvitettiin *Fusarium*-lajien kasvua Bintjen mukuloissa erilaisissa lämpö- ja kosteusoloissa. Tämän työn tavoitteena oli lajikkeiden keskeisten erojen tutkiminen. Kysymystä selvitettiin tartuttamalla 5 lajikkeen (Bintje, Pito, Rekord, Sabina ja Saturna) mukuloita 3:lla sienellä (*Fusarium avenaceum*, *F. solani* var. *coeruleum* ja *F. sulphureum*) ja säilyttämällä ne 20 pv. 5:ssä eri lämpötilassa (6, 12, 18, 24 ja 30 °C) ja yhdenmukaisissa kosteusoloissa (95 $\pm$ 5 % suhteellinen kosteus). Sienten kasvun optimit olivat eri lajikkeissa jonkin verran erilaiset.

*Fusarium avenaceum*in kasvun optimi oli Rekordissa hieman alempi (24 °C) ja Pidossa sekä Saturnassa hieman korkeampi (n. 30 °C) kuin Bintjessä ja Sabinassa.Lähes poikkeuksetta sieni eteni syvyyssuuntaan nopeammin kuin pinnanmyötäisesti. *F. solani* v. *coeruleum*in eteneminen oli kaikissa lajikkeissa hyvin yhdenmukainen, Sabinassa optimi oli kuitenkin korkeampi (22—24 °C) kuin muissa lajikkeissa (18—20 °C). *F. sulphureum*in suhteen lajikkeitten reagointi vaihteli eniten. Bintjessä oli jälleen todettavissa kaksi selvää optimia, alempi n. 12 ja ylempi n. 24 °C. Edellisen ensisijainen aiheuttaja on sienen nopea pinnanmyötäinen eteneminen kun taas jälkimmäisessä syvyyssuuntainen kasvu oli selvästi suurempi. Tämä syvyys- ja leveyskasvujen suhde on havaittavissa kaikissa lajikkeissa. Sabinassa kasvu oli aina sitä suurempi mitä korkeampi oli lämpötila, optimi tuskin kuitenkaan on mainittavasti 30 °C:n yläpuolella, sillä sienen kasvukyvyn raja on suunnilleen 35—36 °C. Pito ja Rekord reagoivat samaan tapaan kuin Sabina, mutta niissä optimit ovat alempana, 26—27 °C:ssa. Saturnassa optimi on suunnilleen samalla tasolla, mutta sille on ominaista sienen melko yhdenmukainen kasvu kaikissa kolmessa alimmassa lämpötilassa.

Sienten kasvulle optimilämpötila on eri lajikkeissa erilainen. Tämän ohella on kiinnitettävä huomiota niiden kasvunopeuteen niissä lämpötiloissa, joissa perunaa eri tuotantovaiheissa käsitellään ja varastoidaan. Tällöin kiinnittää erityistä huomiota se, että Rekord on ollut alhaisissa lämpötiloissa (6 ja 12 °C) suhteellisesti kestävämpi kuin korkeammissa.

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Seria ANIMALIA DOMESTICA N. 60 — Sarja KOTIELÄIMET n:o 60

THE INCIDENCE OF TIBIAL DYSCHONDROPLASIA IN TWO BROILER STRAINS AND THEIR PERFORMANCE ON DIFFERENT DIETS

TUOMO KIISKINEN and PER ANDERSSON

KIISKINEN, T. & ANDERSSON, P. 1982. **The incidence of tibial dyschondroplasia in two broiler strains and their performance on different diets.** Ann. Agric. Fenn. 21: 169—176. (Agric. Res. Centre, Inst. Anim. Husb. SF-31600 Jokioinen, Finland.)

Two cereal compositions (wheat/barley) and two levels of brewers dried yeast (0, 2,5 %) were used in diets for two broiler strains to study the incidence of tibial dyschondroplasia (TD) and the performance of birds. Broiler chicks were housed on litter for 6 weeks. Observations of unclassified leg weakness were made in the broilerhouse and carcases were examined for TD, perosis, bone fractures, breast blisters and bruises.

The growth rate differed significantly ($P < 0,01$) between the strains. The faster growing strain had a higher incidence of leg weakness (21,4/9,3 %; $P < 0,001$) and a higher mortality (7,0/4,0 %; $P < 0,01$). Investigation of broiler carcasses showed that the frequency of TD was clearly higher in the strain with heavier final body weight. The dietary treatment did not affect incidence of leg weakness significantly, but there was a clear tendency towards higher occurrence of TD on the wheat diets compared to the barley diets. The diet had no significant influence, on the final body weight of the broilers. Feed conversion of the barley diets was inferior ($P < 0,01$) to that of the wheat diets.

Index words: broilers, tibial dyschondroplasia, cereal composition, brewers dried yeast.

INTRODUCTION

Tibial dyschondroplasia (TD) is a fairly widespread condition in growing broiler chickens and turkeys. It is characterized by the presence of uncalcified plugs of opaque, white unvascularized cartilage mainly at the proximal end of the tibia. The first signs of the condition include unsteady gait, sitting down on the hocks and utilizing of wing tips for lateral support. In extreme cases fracture of the epiphysis of the tibia may take place leading to complete immobilization.

Although the causes of TD are not well understood, genetic, nutritional and environmental factors evidently have influence upon the susceptibility to the disease in chickens. By selection broiler strains with either a high or low incidence of TD has been developed (LEACH and NESHEIM 1965 and 1972, RIDDELL

1976). According to SHERIDAN et al. (1978) a sexlinked gene may affect the inheritance of TD. LEACH and NESHEIM (1965) found a high incidence of TD in chicks fed on a purified diets with adequate levels of all known nutrients compared to those fed diets with natural ingredients. LEACH and NESHEIM (1972) reported that metabolic acidosis produced by the incorporation of ammonium chloride into the diets, significantly increased the incidence of TD. SAUVEUR and MONGIN (1974) concluded that there is a question of dietary relationship between chloride, sodium and potassium, and increasing the chloride content enhanced the incidence of cartilage abnormalities when sodium and potassium were low. Recently, VELTMANN and JENSEN (1981) also found dietary ammonium chloride to increase the incidence of TD, but various fermentation products failed to reduce it. VELTMAN and JENSEN (1980) suggest that some toxins or pathological agents produced under certain environmental conditions may influence the development of the disease. WALSER et al. (1980) found that 2 % corn contaminated with *Fusarium roseum* in a diet for broiler chicks resulted in a 90 % incidence of TD.

Pilch strain has been for several years the only broilermark in Finland. The performance of birds has not always been satisfactory, thus interest in other strains has eventually arisen. It is probable that the high growth rate may increase the incidence and severity of leg weakness caused by TD. Also, the energy concentration of the diet may play an essential role in the matter.

This experiment was conducted principally to compare the incidence of TD and the performance of two broiler strains (Pilch, Lohmann) on two cereal diets (ME-levels) testing at the same time the effect of brewers yeast supplementation.

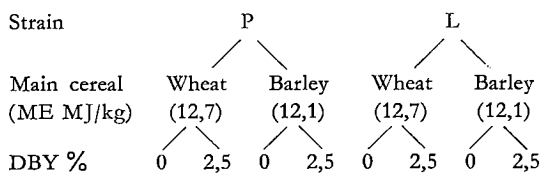
MATERIAL AND METHODS

Animals and housing

The eggs of the Lohmann strain were imported from Cuxhaven in FRG. The hatching of the eggs was performed in a private hatchery. The amount and average weight of the eggs was 2 147, 57,1 g (Pilch) and 2 126, 58,2 g (Lohmann). The day old, sex sorted chicks were devided into 32 litter floor pens, 86 birds (43 males, 43 females) per pen. The size of each pen was 6 m² and thus the rate of stocking approximately 14/m². The litter was sawdust. Conventional temperature and light programs were used. The chicks had access to automatic waterers and feed ad libitum.

Experimental design

The experiment was 2 × 2 × 2 factorial with 2 strains, 2 different cereal compositions (ME-levels) and 2 levels of brewers dried yeast (BDY). Four replicate pens were thus assigned to each of the eight groups.



Composition of diets

Table 1 shows the compositions of the starter and finisher rations of the experimental diets. The differences in energy concentrations were arranged by using wheat as a main cereal in diets 1 and 2 and barley in diets 3 and 4. Besides, the diets 1 and 2 contained dehulled and diets 3 and 4 whole oat. All diets contained Torula yeast 1—2 % and diets 2 and 4 in addition to that, 2,5 % brewers dried yeast.

Procedures

The total weight of birds in each pen was measured when the chicks were divided into them. Later at the age of 2,5 and 6 weeks the individual body weights were obtained. Feed consumption of chicks in each pen was controlled between the weighings. Dead birds and cases of leg weakness were registered. Dead chicks were sent to the State Veterinary Medical Institute for obductions. In the slaughterhouse the total slaughter weight of each pen was measured. Twisted legs (TD, perosis), bone fractures, breast blisters and bruises were observed.

Conventional feed analysis was made from each diet (Table 1). Also calcium and phosphorus were determined.

The data of body weights and feed consumption were analyzed by analysis of variance, while Tukey's test was used to separate treatment means (STEEL and TORRIE 1960). In the case of mortality and leg weakness, the differences between the strains and dietary treatments were tested by t-test.

Table 1. Composition, calculated and analyzed contents of the experimental diets.

Diet	1		2		3		4	
	S	F	S	F	S	F	S	F
Soybean meal	12,0	13,5	9,5	11,0	12,0	13,5	9,5	11,0
Fish meal	12,8	5,9	13,0	6,1	11,7	5,0	11,9	5,2
Brewers dried yeast	—	—	2,5	2,5	—	—	2,5	2,5
Torula yeast	1,0	2,0	1,0	2,0	1,0	2,0	1,0	2,0
Wheat	50,0	50,0	50,0	50,0	10,0	10,0	10,0	10,0
Barley	—	3,1	—	3,1	41,1	44,0	41,0	44,0
Oat (dehulled)	13,0	14,0	12,9	13,9	—	—	—	—
Oat (whole)	—	—	—	—	13,0	14,0	12,9	13,9
Fat	3,3	3,5	3,2	3,4	3,3	3,5	3,2	3,4
CaHPO4	1,7	1,8	1,7	1,8	1,7	1,8	1,7	1,8
Vitamin- and mineral premix (in wheat meal)	6,2	6,2	6,2	6,2	6,2	6,2	6,2	6,2
Moisture % anal.	12,3	12,7	12,2	12,6	12,2	12,6	12,4	12,7
Crude protein % calc.	23,0	20,0	23,1	20,1	22,1	19,1	22,2	19,2
» » % anal.	23,9	21,2	23,5	21,2	22,9	19,3	22,0	19,2
Ether extract % »	5,7	5,7	5,7	5,6	6,1	5,6	5,6	5,4
Crude fibre % »	2,5	2,7	2,4	2,5	3,9	3,8	3,4	4,0
Ash % »	5,8	5,1	5,7	4,2	5,9	5,2	5,6	5,2
Calcium % »	1,3	1,2	1,3	1,1	1,2	1,1	1,3	1,0
Phosphorus % »	0,9	0,8	0,9	0,8	0,9	0,8	0,9	0,8
ME MJ/kg calc.	12,70	12,53	12,78	12,61	12,15	11,94	12,23	12,03

S = Starter (0—2,5 weeks)
F = Finisher (2,5—6 weeks)

RESULTS

Mortality and leg weakness

Mortality was higher among the Lohmann than the Pilch strain in every dietary treatment (Table 2). On an average, the difference between the strains was significant from 0 to 2,5 weeks of age ($P < 0,05$) and during the whole growing period ($P < 0,01$). The only significant ($P < 0,05$) difference in mortality in the dietary treatments was between the BDY-groups from 0 to 2,5 weeks of age both strains together.

The incidence of leg weakness among Lohmann chicks (21,4 %) was surprisingly high compared to Pilch broilers (9,3 %, $P < 0,001$).

Table 2. Mortality and leg weakness observed in the broilerhouse.

Age weeks	Dietary treatment	Strain P	Strain L	Strain P+L
			Mortality %	
0—2,5	wheat	2,9	5,0 NS	3,9
»	barley	2,2	4,7 »	3,4
»	BDY 0	2,3	3,6 »	3,0
»	» 2,5	2,8	6,0 »	4,4
»	$\bar{x}$	2,6	4,8 *	3,7
2,5—6	wheat	1,5	2,6 NS	2,1
»	barley	1,5	2,0 »	1,7
»	BDY 0	1,9	2,9 »	2,4
»	» 2,5	1,1	1,7 »	1,4 *
»	$\bar{x}$	1,5	2,3 »	1,9
0—6	wheat	4,4	7,4 »	5,9
»	barley	3,7	6,6 »	5,1
»	BDY 0	4,2	6,4 »	5,3
»	» 2,5	3,8	7,6 »	5,7
»	$\bar{x}$	4,0	7,0 **	5,5
			Leg weakness %	
0—6	wheat	9,5	22,0 NS	15,7
»	barley	9,2	20,9 »	15,0
»	BDY 0	9,2	21,8 »	15,5
»	» 2,5	9,5	21,1 »	15,3
»	$\bar{x}$	9,3	21,4 ***	15,4

* $P < 0,05$
** $P < 0,01$
*** $P < 0,001$

Table 3. Observations in slaughterhouse % in carcasses.

Dietary treatment	Strain P	Strain L	Strain P+L
		T.D.	
Wheat	7,2	13,0	10,1
Barley	5,7	7,7	6,7
BDY 0	6,5	10,4	8,4
» 2,5	6,4	10,3	8,3
$\bar{x}$	6,4	10,3	8,3
		Perosis	
Wheat	0,8	2,7	1,8
Barley	1,4	2,6	2,0
BDY 0	1,1	1,9	1,5
» 2,5	1,1	3,4	2,2
$\bar{x}$	1,1	2,6	1,8
		Breast blisters	
Wheat	17,8	16,7	17,2
Barley	17,2	17,6	17,4
BDY 0	15,1	16,3	15,6
» 2,5	19,8	18,0	19,0
$\bar{x}$	17,5	17,2	17,3
		Bruises	
Wheat	1,3	1,8	1,5
Barley	1,8	3,0	3,2
BDY 0	2,0	2,7	2,3
» 2,5	1,1	2,1	2,3
$\bar{x}$	1,5	2,4	2,3
		Bone fractures	
Wheat	0,9	1,6	1,3
Barley	1,2	0,7	1,0
BDY 0	0,9	0,7	0,8
» 2,5	1,2	1,6	1,4
$\bar{x}$	1,1	1,1	1,1

The differences between the dietary treatments were insignificant (Table 2). In the investigation performed in the slaughter house TD frequencies among Lohmann and Pilch broilers were 10,3 and 6,4 % respectively (Table 3). If we take into account those cases of TD observed in the obductions the corresponding frequencies are 6,7 and 13,0 % (Table 4). The incidence of TD ceems to increase on the diet containing wheat, sompared to the barley diet (Table 5). This showed in both strains. Unfortunately the statistical analysis could not be made because both strains were handled as one group. The adding of brewers dried yeast had no effect on the frequency of TD. Perosis was also more general among Lohmann than Pilch broilers but the frequencies of breast blisters and bone fractures were the same in both strains. There was a tendency to a higher incidence of bruises among Lohmann carcasses.

Table 4. The results of the obductions and total frequency of TD.

	Number of observations Pilch	Number of observations Lohmann
TD	5 (2+3) [1]	39 (24+15) [1]
Perosis	—	4
Trauma	2	3
Acute cardiac failure	—	6
Others	22	16
	29	68
TD % (all observations) ..	6,7	13,0

[1]) in the parenthesis: wheat + barley

Body weight gain

The average weights of day old chickens were 35,7 (Pilch) and 36,8 g (Lohmann). Lohmann broilers gained more weight ($P < 0,01$) than Pilch broilers (Tables 5 and 6). The difference was significant in both sexes on each of the dietary treatments. The average weights of chicks at 2,5 and 6 weeks of age were 551 (P), 572 (L) and 1 744, 1 803 g. The slaughter weights were respectively 1 150 and 1 173 g ($P < 0,01$). The dietary treatment did not significantly affect the final body and slaughter weights of broilers (Table 7). On the barley ration the weight gain during the first 2,5 weeks was significantly ($P < 0,01$) less than on the wheat rations. This could be found in both sexes.

Table 5. Performance of the broiler strains on different diets [1]).

Dietary treatment strain	Wheat		Barley		Brewers dried yeast 0		Brewers dried yeast 2,5		All diets	
	P	L	P	L	P	L	P	L	P	L
Body weight g 2,5 weeks	556	577 **	546	567 **	551	572 **	552	571 **	551	572 **
Body weight g 6 weeks	1 759	1 805 **	1 735	1 802 **	1 749	1 805 **	1 740	1 801 **	1 744	1 803 **
Slaughter weight g .	1 164	1 182 NS	1 135	1 164 *	1 156	1 174 NS	1 144	1 172 *	1 150	1 173 **
Feed consumtion										
g/d 0—2,5 weeks ..	35,1	35,7 NS	36,0	36,6 NS	35,7	36,6 NS	35,4	35,7 NS	35,6	36,2 NS
2,5—6 » ..	113,3	117,9 »	119,5	124,6 »	117,1	121,3 »	115,7	121,2 »	116,4	121,2 **
Feed conversion										
kg/kg 0—2,5 weeks	1,39	1,37 NS	1,45	1,43 NS	1,43	1,41 NS	1,42	1,39 NS	1,42	1,40 NS
weight 2,5—6 »	2,07	2,14 *	2,20	2,23 »	2,14	2,20 »	2,13	2,18 »	2,14	2,19 **
gain 0—6 »	1,86	1,90 *	1,97	1,98 »	1,92	1,95 »	1,91	1,93 »	1,91	1,94 *
kg/kg slaught. w. ...	2,76	2,87 *	2,96	3,03 »	2,87	2,97 »	2,84	2,93 »	2,86	2,95 **

* $P < 0,05$
** $P < 0,01$

[1]) There were no significant strain × diet interactions.

Table 6. The body weight of sexes in the strains.

	Pilch	Lohmann	
♂ ♂	g±SD	g±SD	
2,5 weeks .	592±56	612±53 **	P<0,01
6 » ...	1 930±182	1 980±186**	»
♀ ♀			
2,5 weeks ...	512±49	534±55 **	»
6 » ...	1 567±154	1 644±197**	»

Feed consumption and conversion

Lohmann chicks consumed more feed than Pilch chicks (Table 5). The mean daily intakes from 2,5 to 6 weeks of age were 116,4 (P) and 121,2 g (L, $P < 0,01$). The consumption of the barley diets was higher than that of the wheat diets (Table 7). No significant differences in feed intake could be found between BDY-diets. Lohmann broilers consumed considerably ($P < 0,01$) more feed per kg weight gain than Pilch broilers from the age of 2,5 to 6 weeks (Table 5). Also, the difference from 0 to 6 weeks of age (1,94/1,91) was significant ($P < 0,05$). Feed efficiency on the barley rations was significantly ($P < 0,01$) inferior to that of the wheat rations (Table 7). The conversion of metabolizable energy (MJ/kg w.gain) was equal in both treatments. The brewers dried yeast had insignificant effect on feed efficiency.

Table 7. Performance of broilers on different diets.[1])

Dietary treatment	Wheat	Barley		Brewers dried yeast 0		Brewers dried yeast 2,5		$\bar{x}$
Body weight g 2,5 weeks								
Male	606	597	**	601		602	NS	602
Female	529	517	**	522		523	»	523
Comb. sexes	566	555	**	560		561	»	561
Body weighth g 6 weeks								
Male	1 962	1 946	NS	1 960		1 949	NS	1 954
Female	1 611	1 601	»	1 606		1 606	»	1 606
Comb. sexes	1 779	1 768	»	1 777		1 770	»	1 773
Slaughter weight (comb. sexes)	1 173	1 150	»	1 165		1 158	»	1 161
Feed cons. g/day 0—2,5 weeks	35,4	36,3	*	36,2		35,6	NS	35,9
» » » 2,5—6 »	115,6	122,0	**	119,2		118,5	»	118,8
Feed convers. 0—2,5 »	1,38	1,44	**	1,42		1,40	»	1,41
kg/kg w.gain 2,5—6 »	2,10	2,22	**	2,17		2,15	»	2,16
» » 0—6 »	1,88	1,98	**	1,94		1,92	»	1,93
kg/kg slaught.w.	2,81	2,99	**	2,92		2,88	»	2,90
ME-conversion 0—2,5 weeks	17,6	17,6	NS	17,6		17,5	»	17,6
MJ/kg w.gain 2,5—6 »	26,4	26,6	»	26,5		26,5	»	26,5
» » 0—6 »	23,7	23,8	»	23,8		23,7	»	23,7
MJ/kg slaught.w.	35,5	36,0	»	35,8		35,6	»	35,7

* $P < 0,05$ ** $P < 0,01$

[1]) Sex x diet and cereal x BDY interactions were not significant.

DISCUSSION

The incidence of leg weakness and especially TD among Lohmann broilers was surprisingly high. The frequency of TD (6,4 %) was unexpectedly high also among Pilch chicks, when compared with the average incidence (1 %) in nine strains in the study reported by VELTMAN and JENSEN (1981). The difference between these two strains may be partly connected to the heavier body weight of the Lohmann strain, which overloads the legs and promotes the appearance of leg abnormalities by twisting or bending the tibias, or by causing more frequent slipping of the tendon (perosis). However, according to a review by PIERSON and HESTER (1982) the hypothesis that heavier birds or strains are more susceptible to leg weakness, has not proved to be absolutely correct. It is obvious that there are genetic factors which are connected to the nutritional or environmental requirements of a strain. The producer of the Lohmann strain could not mention any exceptional incidende of leg problems in FRG. VASA (1980) found that the frequency of perosis and TD were clearly higher in Hybro than in Pilch chicks although no significant difference in the body weight gain could be ascertained. The higher mortality among Lohmann chicks in this experiment depended obviously on the inability of sick birds to move and feed. Almost 60 % of the dead and obducted Lohmann birds had tibial dyschondroplasia.

The higher incidence of TD and the higher mortality of Lohmann broilers was obviously the most important reason for the worse feed efficiency of that strains compared to Pilch. Also, the fattier carcasses of the Lohmann strain, which could be observed in the slaughter house, has added to the difference in the feed consumption per kg slaughter weight.

In general, the dietary treatments had no remarkable influence on mortality or leg weakness observed in the broilerhouse. However the

investigation in the slaughter house and obductions revealed that the incidence of TD was about twice as high on the wheat than on the barley diets. The difference between the cereal diets was more emphasized in Lohmann than in Pilch strain.

The negligible difference in weight gain of the cereal groups is surprising, because the feeding value of barley for chicks is not generally regarded as satisfactory. Naturally the barley diets were consumed more and their conversion (kg/kg) was inferior to the wheat diets because of the lower ME-concentration of the first. The supplementation of brewers dried yeast was effectless in all respects. It was obviously incorrect to supplement Torula yeast to the diets, however VELTMANN and JENSEN (1981) have recently found no evidence that fermentation products affect the incidence of TD.

Also the results of this study show, that there are differences between broiler strains in their susceptibility to TD, which is obviously connected to the high rate of growth. The cereal composition (ME-level) of the diet affects the incidence of abnormality. If new broiler strains are to be imported, their susceptibility to TD in our conditions ought to be clarified.

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SELOSTUS

Rehun koostumuksen vaikutus broilereiden jalkavikojen yleisyyteen, kasvuun ja rehun käyttöön

TUOMO KIISKINEN ja PER ANDERSSON

Maatalouden tutkimuskeskus ja Valtion Eläinlääketieteellinen laitos

Jalkavikojen yleistyminen on viime vuosina tullut ongelmaksi broilereiden kasvunopeuden lisääntyessä. Sen vuoksi tutkimuksessa käytettiin koe-eläiminä kahta kasvunopeudeltaan erilaista broilerjalostetta (Pilch/Lohmann). Tutkimuksessa selvitettiin lähinnä sääriluun epänormaalin rustonmuodostuksen (tibiaalinen dyskondroplasia) esiintymistä näillä kahdella jalosteella sekä rehun viljakoostumuksen (vehnä/ohra) ja panimohiivalisäyksen (2,5 %) vaikutusta jalkavikojen esiintymiseen, eläinten kasvuun ja rehun käyttöön.

Kussakin koeryhmässä oli 344 broileria (4 × 86) ja ne kasvatettiin 6 viikon ikäisiksi. Siirtyminen 1. rehusta (valkuaispitoisuus 22—23 %) 2. rehuun (19—20 %) tapahtui poikasten ollessa kahden ja puolen viikon ikäisiä.

Lohmann-broilerit kasvoivat nopeammin, mutta niillä oli selvästi yleisemmin jalkavikoja sekä kuolleisuus korkeampi kuin Pilch-broilereilla. Kuolleet ja teurastetut eläimet tutkittiin ja tutkimus osoitti kokeen aikana tehtyjen havaintojen kanssa yhtäpitävästi, että Lohmann-poikaset olivat alttiimpia sääriluun epänormaalille rustottumiselle kuin Pilch-poikaset. Rehun koostumus ei vaikuttanut merkitsevästi jalkavikojen yleisyyteen eikä broilereiden painoon. Rehun hyväksikäyttö oli Lohmann-poikasilla yleisemmän jalkavikojen esiintymisen ja suuremman kuolleisuuden vuoksi huonompi kuin Pilch-poikasilla. Ohrapitoisen rehun hyväksikäyttö oli huonompi kuin vehnäpitoisen.

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LABORATORY EVALUATION OF DUST, SPRAY AND AEROSOL PREPARATIONS FOR CONTROL OF STORED-PRODUCT BEETLES

TUOMO TUOVINEN and PEHR EKBOM

TUOVINEN, T. & EKBOM, P. 1982. **Laboratory evaluation of dust, spray and aerosol preparations for control of stored-product beetles.** Ann. Agric. Fenn. 21: 177—183. (Agric. Res. Centre, Inst. Pest Inv., SF-01300 Vantaa, Finland.)

A laboratory test method for dust, spray and aerosol preparations was used to evaluate the effect of insecticides on larvae of *Attagenus woodroffei* (Halstead & Green), *Tribolium confusum* Duv. and *T. destructor* Uytt. and adults of *Rhyzopertha dominica* (F.), *Oryzaephilus surinamensis* (L.) and *T. confusum*.

A good general effect on beetles was achieved by preparations containing DDT/lindane, lindane, bendiocarb, diazinon, fenitrothion, chlorpyriphos and phoxim. Bromophos, fenchlorphos and malathion were also effective on most species. The effect of pyrethrins varied much according to the preparations.

A good general view of the effect of various insecticides on beetles can be obtained by using three insect species (larvae of *A. woodroffei* and *T. confusum* and adults of *O. surinamensis*), because of their different susceptibilities. The method is considered suitable but can be improved by using a shorter exposure time. In addition, testing of the residual effect using various materials instead of only filter papers and also using lower temperatures would provide valuable information for practical control purposes.

Index words: testing of insecticides, stored-product beetles, dusts, sprays, aerosols, *Attagenus woodroffei*, *Rhyzopertha dominica*, *Oryzaephilus surinamensis*, *Tribolium confusum*, *T. destructor*, bendiocarb, bromophos, chlorpyriphos, DDT, diazinon, fenchlorphos, fenitrothion, lindane, malathion, phoxim, pyrethrins.

INTRODUCTION

Insecticides to be used in Finland for the control of stored-product and household pests must be tested in the Institute of Pest Investigation before they can be accepted for sale. The tests include a series of laboratory tests on beetles. This report summarizes the results of tests carried out on 64 preparations including 12 dusts, 22 sprays and 30 aerosols. Tests were carried out in 1966—81, and the preparations tested were intended for the market as such. The amounts of active ingredients in the preparations were analysed by the State Institute of Agricultural Chemistry. The aim of the study is to compare the effect of insecticide preparations for use in practical pest control and to indicate possible ways of improving the test method. Some of the results have been published earlier by TUOVINEN et al. (1981).

METHODS

The insects used were larvae of the wave-banded fur beetle *Attagenus woodroffei* (HALSTEAD and GREEN 1979), adults of the lesser grain borer *Rhyzopertha dominica* (F.), adults of the saw-toothed grain beetle *Oryzaephilus surinamensis* (L.), larvae and adults of the confused flour beetle *Tribolium confusum* Duv. and larvae of the flour beetle *Tribolium destructor* Uytt. They were reared at room temperature and humidity in glass jars. Food sources were dog food, saddle blanket and yeast for *A. woodroffei*, flaked oats and yeast for *O. surinamensis*, *T. confusum* and *T. destructor* and wheat or barley grains for *R. dominica*. Normally active adults and larvae of the last instar were chosen for the tests.

Tests were carried out at room temperature and humidity (about +22 °C, 30—50 % Rh). For each insecticide preparation and insect species, 4—8 replicates were used with 30 animals each. Filter papers (⌀ 7 cm) were treated with dusts, sprays or aerosols. Filter papers were dusted using a piece of equipment fitted into a Potter tower and the treatment resulted in an application of about 1,5 g/m². The filter papers were treated with sprays by dipping them into an aqueous solution of the preparation, a procedure which resulted in about 170 ml/m². The papers were treated with aerosols by spraying them in a vertical position from a distance of 0,5 m for one second.

After one night's airing, filter papers were placed into glass dishes (⌀ 8 cm, height 4 cm) and test insects were put in. The dishes were covered with gauze. A small quantity of untreated food was added into each dish to sustain surviving insects. Control dishes with clean filter papers were included in all tests.

To assess knock-down and mortality the dishes were examined at 2 hours and 1, 2, 3, 6, 8, 10 and 13 days. Insects were judged knocked down if, when stimulated with a bristle brush, movement of the appendages could be seen but the insects were unable to move away. If no movement was seen the insects were considered dead. The »knocked down» columns in the tables include dead insects. All checks were done by the same person.

RESULTS AND DISCUSSION

Fenitrothion, diazinon, DDT + lindane (all combined with pyrethrins and piperonyl butoxide) as well as phoxim were the most effective dust preparations (Table 1). Malathion and bromophos + carbaryl were also effective, except on larvae of *A. woodroffei*. Other preparations had no satisfactory effect on the test insects, with some exceptions on *O. surinamensis* and adults of *T. confusum*.

Of the spraying solutions, a high concentration (0,3 and 3,0 %) of pyrethrins with piperonyl butoxide had the best knock-down effect (Table 2). Another preparation, with half the concentration, had only a poor effect. Lindane, bendiocarb, chlorpyriphos, fenitrothion and phoxim had almost the same knock-down effect and an even better killing effect than that of pyrethrins. Fenitrothion + trichlorphon was a very effective combination considering the small concentration used. Bromophos and fenchlorphos also had a satisfactory general effect. Dioxycarb, malathion and propoxur had some effect, but not on the larvae of *A. woodroffei*. Propoxur was very effective on *R. dominica* and *O. surinamensis*. Pyrethrins in lower concentrations, metoxychlor and a mixture of mineral oils had practically no effect.

The effect of aerosols differed a lot even with the same insecticides. DDT + lindane and lindane with or without pyrethrins and piperonyl

Table 1. Dusts. 24 hour's knock-down percentage (left-hand column) and 6 day's mortality percentage (right-hand column). Index of efficacy is calculated according to 2 and 24 hour's knock-down and 6 day's mortality. Preparations marked with the same letter do not differ significantly according to the Mann-Whitney test. p = pyrethrins, pb = piperonyl butoxide.

Active ingredients of preparations and conc. (%)	Index of efficacy	*A. woodroffei* larvae		*R. dominica* adults		*O.surinamensis* adults		*T. confusum* larvae		*T. confusum* adults		*T. destructor* larvae	
Fenitrothion, p and pb 2,5 + 0,2 + 1,0	90,0[a]	100	16	100	100	100	100	100	80	100	100	100	84
Diazinon, p and bucarpolate 4,0 + 0,4 + 2,1	88,4[a]	86	20	100	100	100	100	100	89	100	100	100	65
Phoxim 3,0	82,7[ab]	100	8	100	100	100	100	100	90	100	100	100	53
DDT, lindane, p and pb 6 + 1,5 + 0,4 + 2,1	80,9[a]	98	4	100	100	100	100	95	81	100	95	75	52
Bromophos and carbaryl 1,9—1,0	76,8[ab]	0	28	100	100	100	100	97	91	91	100	100	84
Malathion 4,0	70,8[ac]	3	6	—	—	100	100	100	79	100	100	100	73
Jodfenphos 5,0	59,4[b-e]	47	19	—	—	100	100	55	72	100	100	61	53
Bromophos 2,0	50,4[c f]	4	28	23	96	95	100	0	83	24	100	2	66
Metoxychlor 5,0	31,4[c-g]	94	0	—	—	29	97	3	16	11	21	7	25
Propoxur 1,0	21,8[g h]	0	0	59	91	40	73	2	4	0	1	1	3
Aluminium ammoniumsulphate 87,9	16,0[h]	—	—	0	8	8	67	—	—	0	1	1	3
Boric acid 99,0	13,1[h]	0	0	—	—	17	64	1	4	1	6	0	2
Control		0	0	0	7	3	11	1	6	0	1	0	2

butoxide were the most effective preparations (Table 3). A preparation including 10 % dichlorvos was the only one to achieve the same general effect. Bromophos, phoxim, fenchlorphos + pyrethrins and piperonyl butoxide or bucarpolate and also jodfenphos and tetrachlorvinphos had a satisfactory effect, too. Other aerosol preparations had only a relatively poor effect.

Table 2. Sprays. 24 hour's knockdown percentage (left-hand column) and 6 day's mortality percentage (right-hand column). Index of efficacy is calculated according to 2 and 24 hour's knock-down and 6 day's mortality. Preparations marked with the same letter do not differ significantly according to the Mann-Whitney test. p = pyrethrins, pb = piperonyl butoxide.

Active ingredients of preparations and conc. (%)	Index of efficacy	*A. woodroffei* larvae		*R. dominica* adults		*O.surinamensis* adults		*T. confusum* larvae		*T. confusum* adults		*T. destructor* larvae	
p and pb 0,3 + 3,0	84,6[a]	100	4	—	—	100	100	100	58	100	83	100	31
Lindane 0,4	83,7[ab]	95	21	100	48	100	100	100	77	100	99	100	61
Bendiocarb 0,4	83,7[ab]	86	24	—	—	100	100	100	83	100	100	100	65
Chlorpyriphos 1,26	76,5[b c]	99	5	99	100	100	100	100	52	100	100	100	100
Chlorpyriphos 0,4	71,4[b c d]	100	6	—	—	100	100	100	43	100	96	100	40
Fenitrothion 0,8	71,2[b-e]	98	9	100	100	100	100	100	63	100	100	100	52
Fenitrothion 0,38	69,0[c d e]	100	8	100	100	100	100	100	64	100	100	100	56
Fenitrothion and trichlorphon 0,03 + 0,03	68,0[c-f]	95	17	—	—	100	100	98	83	100	99	100	55
Phoxim 0,125	67,4[c-f]	77	13	99	100	100	100	98	98	98	98	100	45
Fenitrothion 0,1	64,9[c d f]	—	—	23	100	—	—	83	67	100	100	100	68
Chlorpyriphos 0,2	63,7[c d f]	93	13	—	—	100	100	100	52	100	97	100	36
Bromophos 0,13	62,6[c d f]	64	13	—	—	100	100	94	49	96	91	97	97
Fenchlorphos 1,65	61,3[f g]	39	25	22	92	99	100	95	68	100	92	94	87
Bromophos 0,08	59,2[d f g]	54	10	—	—	100	100	90	53	94	89	100	49
Malathion 1,0	57,8[e-h]	2	8	52	100	100	100	81	52	100	98	90	33
Dioxycarb 1,0	53,0[g h i]	1	0	—	—	88	98	41	55	58	69	81	48
Propoxur 0,4	52,6[a-i]	3	5	100	100	100	100	22	45	12	21	60	64
p and pb 0,05 + 0,5	23,8[h i j]	24	1	—	—	49	70	19	16	28	23	25	8
p and pb 0,15 + 1,5	22,5[i j k]	12	0	—	—	88	81	3	4	28	1	6	4
Metoxychlor 0,4	16,9[j k l]	35	0	—	—	1	58	3	9	12	8	2	20
p and pb 0,006 + 0,025	7,4[k l]	22	0	—	—	2	10	5	8	0	5	3	13
Varsol and ovanol 90,0 + 10,0	3,6[l]	0	1	—	—	2	6	2	1	1	7	2	3
Control		0	0	0	9	3	11	1	5	0	2	0	4

Table 3. Aerosols. 24 hour's knock-down percentage (left-hand column) and 6 day's mortality percentage (right-hand column). Index of efficacy is calculated according to 2 and 24 hour's knock-down and 6 day's mortality. Preparations marked with the same letter do not differ significantly according to the Mann-Whitney test. p = pyrethrins, pb = piperonyl butoxide.

Active ingredients of preparations and conc. (%)	Index of efficacy	*A. woodroffei* larvae		*R. dominica* adults		*O. surinamensis* adults		*T. confusum* larvae		*T. confusum* adults		*T. destructor* larvae	
Lindane, p and pb 2,0 + 0,5 + 3,0	94,0^{a}	—	—	100	100	—	—	100	91	100	99	100	23
DDT and lindane 2,8 + 8,0	93,5^{a}	100	16	100	100	100	100	100	91	100	99	100	72
DDT, lindane, allethrin, p and pb 2,1 + 0,4 + 0,15 + 0,02 + 0,14	89,7^{ab}	—	—	—	—	—	—	100	87	100	98	100	67
Dichlorvos, p and pb 10,0 + 0,04 + 0,26	87,5^{ab}	100	47	—	—	100	100	100	63	100	96	100	26
Lindane, p and pb 0,3 + 0,2 + 1,2	85,6^{a-d}	—	—	100	100	100	100	100	92	100	100	100	52
DDT and lindane 3,0 + 1,0	78,7^{a-d}	—	—	100	100	92	100	100	100	88	94	54	76
Bromophos, p and bucarpolate 4,0 + 0,4 + 2,0	74,5^{a-d}	96	17	100	100	100	100	100	69	100	100	100	18
Phoxim, p and pb 1,0 + 0,2 + 1,0	73,0^{bcd}	100	12	—	—	100	100	100	50	100	99	100	43
Lindane, p and pb 0,8 + 0,2 + 1,2	71,7^{b-e}	—	—	100	100	47	77	100	100	72	78	56	66
Fenchlorphos and p 1,0 + 0,05	70,2^{de}	—	—	74	100	88	100	82	79	96	99	97	90
Bromophos, p and bucarpolate 1,0 + 0,1 + 2,0	63,2^{def}	—	—	43	100	100	100	100	43	100	100	38	58
Jodfenphos 2,0	60,2^{d-g}	67	22	—	—	100	100	59	54	98	97	65	51
Tetrachlorvinphos 3,0	58,9^{e-h}	2	18	—	—	95	100	98	53	100	100	98	47
p and pb 1,2 + 5,0	54,9^{egh}	49	3	81	88	76	80	59	39	74	33	63	33
Propoxur and dichlorvos 2,0 + 0,5	54,3^{bd-h}	14	6	100	100	96	98	27	44	28	39	64	68
Propoxur 2,0	54,1^{b-h}	7	8	100	100	100	100	31	59	21	39	53	50
Fenchlorphos, p and pb 2,6 + 0,4 + 1,2	52,7^{e-h}	—	—	42	75	86	96	53	65	75	82	0	29
Bromophos, p and pb 2,0 + 1,0 + 5,0	52,3^{d-h}	36	2	—	—	88	100	40	45	100	93	47	28
Pertane, p and pb 5,6 + 0,33 + 0,23	52,0^{bd-h}	100	0	88	100	85	100	25	54	34	20	23	60
p and pb 0,4 + 3,0	49,5^{egh}	98	0	—	—	94	96	53	28	75	25	54	18
Metoxychlor, p and sulphoxide 2,0 + 0,2 + 1,0	35,3^{abgh}	—	—	—	—	—	—	0	5	83	33	0	8
Metoxychlor, p and pb 2,0 + 0,2 + 1,0	33,4^{hi}	89	0	63	62	45	89	16	19	24	12	8	15
Propoxur and tiophosvin 2,0 + 0,5	27,6^{eg-j}	1	3	—	—	88	99	23	33	0	2	23	30
p and pb 0,25 + 1,2	27,3^{eg-j}	34	0	—	—	95	98	2	3	48	8	63	0
p and pb 0,4 + 1,7	26,8^{h-k}	—	—	49	78	30	60	18	43	17	7	0	2
Aluminium ammoniumsulphate 87,9	23,3^{bhjk}	—	—	4	46	4	59	3	13	0	4	—	—
Dichlorvos, p and pb 0,4 + 0,1 + 0,8	19,6^{f-k}	—	—	67	71	—	—	5	8	1	0	1	1
p and pb 0,2 + 1,0	16,2^{ijk}	55	0	—	—	28	43	12	9	15	13	0	2
Tetramethrin, p and pb 0,26 + 0,1 + 1,4	7,5^{jk}	2	0	—	—	28	38	0	3	7	2	0	2
p and pb 0,3 + 1,25	1,6^{k}	1	0	—	—	0	4	1	1	0	0	1	2
Control		0	0	4	16	2	12	1	8	0	2	1	6

The results show that the following insecticides (active ingredients) had a good general effect on the insects tested, independent of the preparations: DDT + lindane, lindane, bendiocarb, diazinon, fenitrothion, phoxim and chlorpyriphos, of which the latter four are generally used for beetle control in Finland. When the concentrations used are taken into account, phoxim and fenitrothion were very effective. The second group which had the desired effect on most of the test insects, includes bromophos, fenchlorphos, and malathion. Other preparations differed a lot in efficacy depending on the insect species, formulations and concentrations.

Tyler and Binns (1977) tested the effect of lindane and some organophosphorous insecticides on 18 species of stored-product beetles and found following overall order of effectiveness: chlorphyriphos methyl > fenitrothion > pirimiphos methyl > phoxim > jodfenphos > bromo-

phos > lindane > malathion/lindane > malathion, when the same concentration of active ingredients was used. The effect of lindane was very poor on *O. surinamensis* but was quite good on *T. confusum* and *R. dominica* — this result differs from ours, in which *O. surinamensis* was the most susceptible species. This may be due to lindane resistence in *O. surinamensis* (TYLER 1982, unpubl.).

Larvae of *A. woodroffei* were the most tolerant in tests. For example, malathion had no effect on *A. woodroffei* although it had a satisfactory effect on other insects. The poor effect of malathion on fur beetles has been noted earlier (e.g. MATHLEIN and TUNBLAD 1971). Some larvae of *A. woodroffei* recovered from knock-down caused by pyrethrins, metoxychlor, pertane and also DDT and lindane dusts although the insects were in continuous contact with the insecticides. No preparation killed all larvae during the experimental period of 13 days.

Adults of *R. dominica* and *O. surinamensis* were susceptible to most of the preparations, and were usually killed. As opposed to the other species, both of these were also susceptible to propoxur.

The effect of the preparations on the larvae of *T. confusum* and *T. destructor* did not differ much. Adults of *T. confusum* were generally more susceptible than larvae. Some recovery was found in *T. confusum* and *T. tribolium* on pyrethrins.

The method used did not permit a direct comparison of the effect of active ingredients, because preparations were tested as such, using different concentrations. Amounts of active ingredients per filter paper differed greatly according to the preparations. The method is suitable for its purpose, but for an even better view of the effect of preparations in practice some improvements and additional tests are needed.

During the tests, the insects were constantly in contact with the insecticide-treated filter papers; in practice this does not happen — many of the insects' hiding places are not easily treated, and the insects may spend most of their time there. A shorter exposure time would provide essential knowledge about the effect of insecticides in practice.

To improve the testing procedure, a series of tests should be done using exactly the same amounts of active ingredient per filter paper. These should be done in addition to the normal tests using the amounts desired by the importers of the preparations. This would allow for better comparison of the results.

Tests on the residual effect of the preparations have been included in the test series, but are not presented here. Taking the residual effect into account is important in evaluating the preparations from the practical point of view. Furthermore, it would be desirable to use different materials instead of only filter papers to assess the effect of preparations on normal surface materials in buildings.

Sprays resulted in almost equal knock-down and kill in separate replicates. For dusts and aerosols the treatment method is not very satisfactory when an even distribution of insecticide on the filter papers is desired and this resulted in high standard errors with some preparations. If the standard error was high, tests were repeated in order to find out why. For instance, some failure in the nozzles or spraying pressures in aerosols may affect the results. However, one purpose of the tests was in fact to assess possible technical failings in aerosols.

Temperature is an important factor when evaluating the effect of insecticides. For example, TYLER and BINNS (1982) found big differences in the effect of organophosphorous insecticides on stored-product beetles at various temperatures. In Finland the temperature in stores changes very much, often being very low. Preparations should therefore have a good effect at low temperatures, too, if stored-product beetles are to be controlled. For practical control purposes it would also be useful to test prepara-

tions in temperatures lower than normal room temperature.

To reduce the work involved in the testing without substantially reducing the reliability of the tests the number of beetle species may be limited to three, viz. larvae of *A. woodroffei* and *T. confusum* or *T. destructor* and adults of *O. surinamensis*. These insects differ so much in susceptibility that it seems to be possible to evaluate the general effect of preparations on beetles according to tests carried out only on them.

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SELOSTUS

Pölytteiden, ruiskutteiden ja aerosolien tehokkuuden arviointi laboratoriotestein varastotuholaisina esiintyvien kovakuoriaisten torjuntaa varten.

TUOMO TUOVINEN ja PEHR EKBOM

Maatalouden tutkimuskeskus ja maatilahallitus

Asunto- ja varastotuholaisten torjunta-aineiden tehokkuuden tarkastukseen kuuluu koesarja, jonka avulla tutkitaan valmisteiden teho keltavöisen turkiskuoriaisen, hinkalokuoriaisen ja rohmukuoriaisen toukkiin sekä kapusiinikuoriaisen, riisihärön ja hinkalokuoriaisen aikuisasteisiin. Vuosina 1966—81 testattujen valmisteiden teho koehyönteisiin esitetään vertailukelpoisessa muodossa tässä yhteenvedossa.

Bendiokarbia, diatsinonia, fenitrotionia, klooripyrifossia ja foksiimia sisältävät valmisteet vastaavat tehokkuudeltaan käytöstä poistettuja DDT- ja lindaanipitoisia torjunta-aineita. Myös bromofossia, fenklorfossia ja malationia sisältävät valmisteet olivat yleensä tehokkaita. Pyretriinivalmisteiden teho oli vaihteleva.

Koemenetelmässä hyönteiset olivat jatkuvassa koskетuksessa torjunta-aineella käsiteltyihin suodatinpapereihin. Lyhentämällä vaikutusaikaa esim. yhteen vuorokauteen voidaan saada parempi kuva valmisteiden välisistä tehokkuuseroista. Kokeiden luotettavuuden heikkenemättä voidaan testien vaatimaa työmäärää vähentää käyttämällä ainoastaan kolmea kovakuoriaislajia, nimittäin keltavöistä turkiskuoriaista (toukka-aste), riisihäröä (aikuisaste) ja hinkalo- tai rohmukuoriaista (toukka-aste), joiden kestävyys torjunta-aineita vastaan on erilainen.

Koesarjaan kuuluu myös valmisteiden pitkäaikaistehon selvittäminen, mutta niiden tuloksia ei tässä käsitellä. Lisäksi tulisi harkita myös erilaisten pintamateriaalien käyttöä testeissä imupaperin sijasta tai ohella sekä valmisteiden tehokkuuden selvittämistä myös alemmissa lämpötiloissa, jolloin voitaisiin saada enemmän käytäntöä palvelevaa tietoa.

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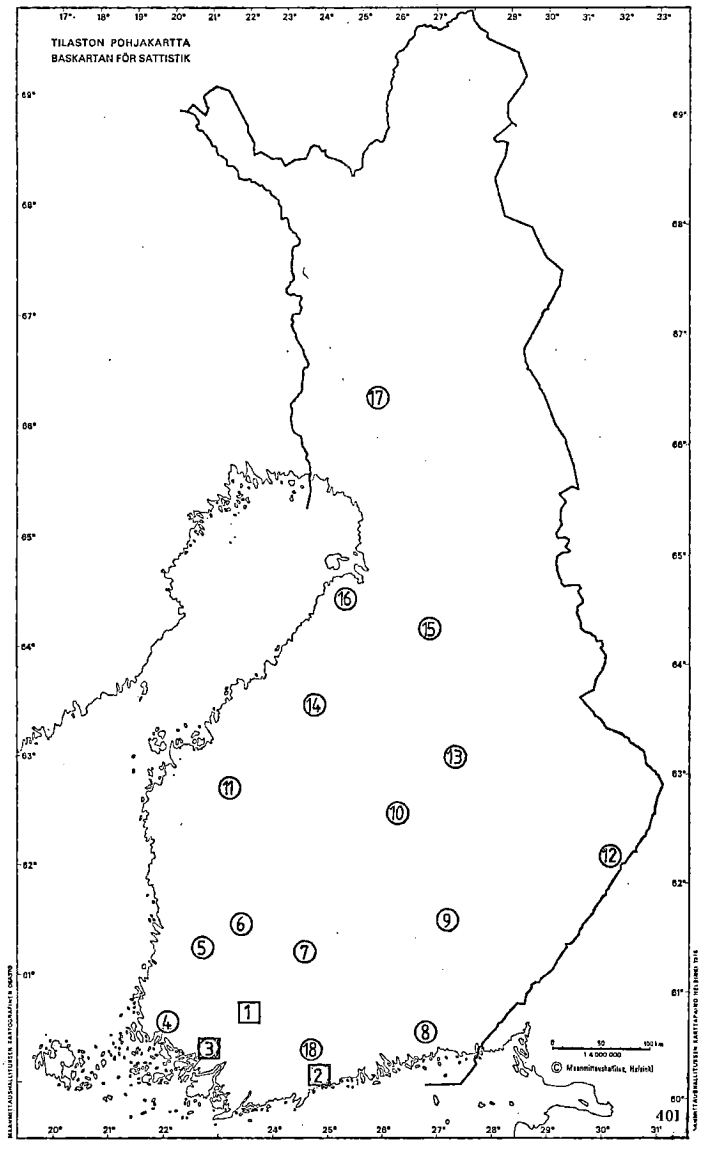

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