JOURNAL OF THE SCIENTIFIC AGRICULTURAL SOCIETY OF FINLAND
Maataloustieteellinen Aikakauskirja
Vol. 54: 99–111, 1982

Fungus diseases of raspberry (*Rubus idaeus* L.) in Finland

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Abstract. During 1978–1981 a total of nearly 200 raspberry cane samples were investigated originating mainly from southern and eastern Finland. The samples consisted of young and already fruited canes injuried to different degrees.

Phoma sp., the conidial stage of *Didymella applanata* (Niessl) Sacc., causer of raspberry spur blight, was most common of the isolated fungi; the perfect stage did not develope until afer preservation in cold. The peak of pycnospore release on raspberry canes was in July 1981.

Other weak wound pathogens were isolated: *Fusarium avenaceum* (Cda. ex Fr.) Sacc., which occurred in 22 % of the transfers, *F. culmorum* (W. G. Sm.) Sacc., *Botrytis cinerea* Pers. ex Fr. and the secondly most common *Phoma* species, *P. exigua* Desm. v. *exigua* Maas. The fungi mentioned above were mainly obtained from different depths of the raspberry stem tissues, the least on an average from the pith. *Alternaria alternata* (Fr.) Keissl. was the most common 'surface fungus', *Phialophora* spp., wood rotting saprophytes, common also in the pith. *Leptosphaeria coniothyrium* (Fckl.) Sacc., the most strong of the pathogens, was rare in the samples. The occurrence of *Cylindrocarpon destructans* (Zinssm.) Scholten in root samples changed 8–70 %.

The cv. Muskoka is more susceptible to spur blight than cv. Ottawa. On the other hand, the larvae of raspberry cane midge (*Resseliella theobaldi* (Barnes)) produced plenty of injuries in Ottawa-samples originating from Mikkeli in 1980 and thus increased also the fungal damage.

Introduction

Raspberry (*Rubus idaeus* L.) is cultivated in Finland up to southern Lapland, but mainly cultivation is centralized in WSW Finland and Kymenlaakso. The area of raspberry cultivation for commercial purposes, is relatively small being 100 hectares (ANON. 1982). This is partly due to the fact that foreign raspberry cultivars are not sufficiently winterhardy in Finland (SÄKÖ et al. 1980). Also commonly occurring virus- and fungal diseases reduce the fruit crops. The most common fungal disease is raspberry spur blight caused by *Didymella applanata* (Niessl) Sacc. (KOCH 1931, LABRUYÈRE & ENGELS 1963, GJAERUM 1974, MIŠIĆ et al. 1975, WILLIAMSON & HARGREAVES 1981). On the other hand, the great damages considered to be caused by this fungus, may be partly produced by other agents (SEEMÜLLER 1974).

D. applanata, as well as an other fungus, *Leptosphaeria coniothyrium* (Fckl.) Sacc., which causes raspberry cane blight are both wound pathogens, although they can also penetrate uninjuried young canes (SEEMÜLLER 1974). In Scotland, raspberry damage caused by *L. coniothyrium* has noticeably increased due to mechanical harvesting (HARGREAVES & WILLIAMSON 1978). On the other hand, STALDER (1965) in Germany has established cane death caused by frost similar to that of fungal cane blight. Much attention has been paid to the feeding wounds of raspberry cane midge (*Resseliella theobaldi* (Barnes)) larvae as entrances to *L. coniothyrium* and other fungi into the vascular cane tissue (PITCHER 1952, NIJWELDT 1963, WILLIAMSON & HARGREAVES 1979). According to PITCHER & WEBB (1952) the damage is called midge blight.

In Finland, raspberry spur blight has been known for a long time (HÅRDH 1956). Fungiside trials have been carried out to try to find means to control the disease, but none of the fungisides have been sales licensed in Finland (BREMER 1981). During the past few years control tests on raspberry spur blight have been continued at the South Savo Experimental Station near Mikkeli (*Sa,* Fig. 1). Also in Mikkeli the control of insects have been added to the experiments. Whereas in the Institute of Horticulture at Piikkiö (*Ab*) cultivation experiments have been carried out.

The aim of this study was to discover and identify the most common fungal pathogens, which on their part have effect upon the cultivation security of raspberry.

Material and methods

The material for this study comprised of some 200 raspberry canes collected in 1978–1981 from the following localities: The South Savo Experimental Station and The Institute of Horticulture, both belonging to the Agricultural Research Centre, the Department of Plant Pathology at Viikki (*N*) and 10 private raspberry plantations in southern and eastern Finland (Fig 1).

The majority of the samples, 40–60 cm long pieces from the base of the canes were collected in August–October. Of these, about two thirds originated from first year canes and one third from fruited canes. Transfers to the nutrient media were made mainly as three partial transfers: a piece from the epidermis, the periderm and the pith, all being from the same part of the stem. The pieces from the epidermis and the periderm often included cells from the outer cortex. Cells from the vascular tissue were also possible in the pieces from the periderm. Transfers were made also from buds, leaves, petioles and roots.

The nutrient media and the cultivation methods were mainly similar to those reported earlier (RUOKOLA 1981). The majority of cultivations were made from samples of the cvs. Muskoka and Ottawa. The cultures were incubated at a temperature of 20–25°C for 3–4 weeks, the fungi were

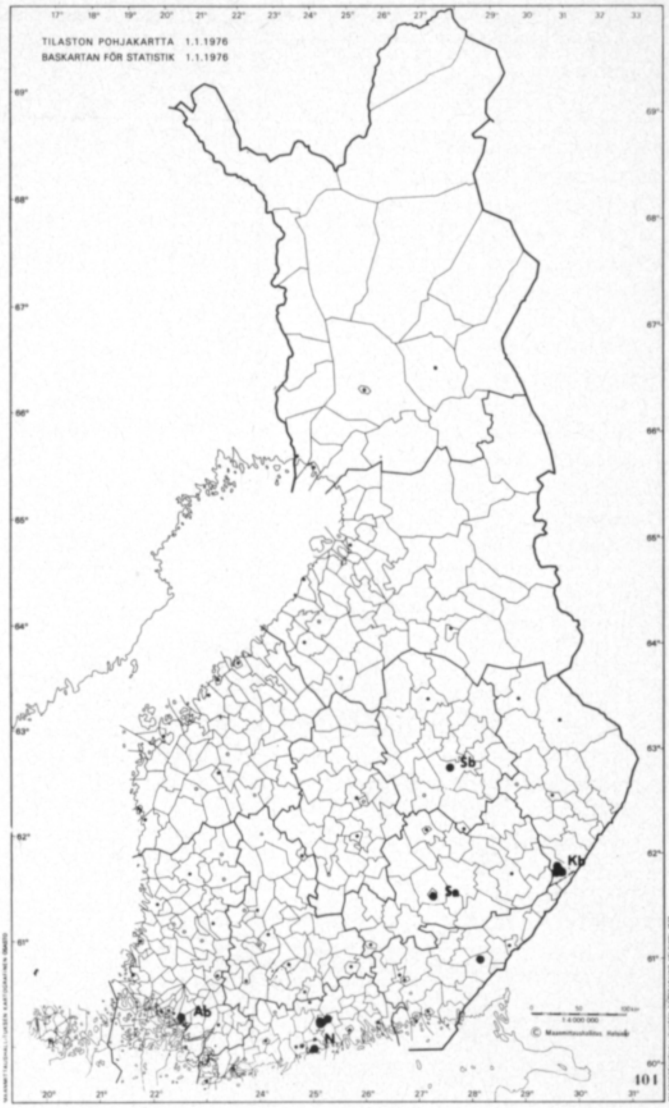

Fig. 1. The origin of raspberry samples by localities.

identified and before the final examination the cultures were kept at a temperature of 10°C for a month.

Results and discussion

A total of 290 transfers were made to the nutrient media, comprising of about 30 % of samples from Mikkeli. The partial transfers, 2–3 pieces, from different depths of the stem tissues (cf. p. 100) and the isolates of the same fungus obtained, respectively, have been mainly counted as one. Of the transfers the *Phoma* fungi grew clearly best (Table 1); their portion was more than twofold compared to the occurrence of the secondly most common, *Fusarium avenaceum* and *Phialophora* fungi. As regards *D. applanata*,

Table 1. The frequency of principal fungal species isolated from raspberry stands in 1978–1981.

Fungus	Isol. No.	%
Alternaria alternata (Fr.) Keissl.	56	19.3
Botrytis cinerea Pers. ex Fr.	14	4.8
Coniothyrium fuccelii Sacc.	6	2.1
Cylindrocarpon destructans (Zinssm.) Scholten	12	4.1
Didymella applanata (Niessl) Sacc. (perf. st.)	4	1.4
Fusarium avenaceum (Cda. ex Fr.) Sacc.	65	22.4
F. culmorum (W. G. Sm.) Sacc.	8	2.8
F. sambucinum Fuckel	1	0.3
F. sulphureum Schlecht.	1	0.3
Fusarium sp.	2	0.7
Phialophora spp.	65	22.4
Phoma spp.	146	50.3
Total	379	

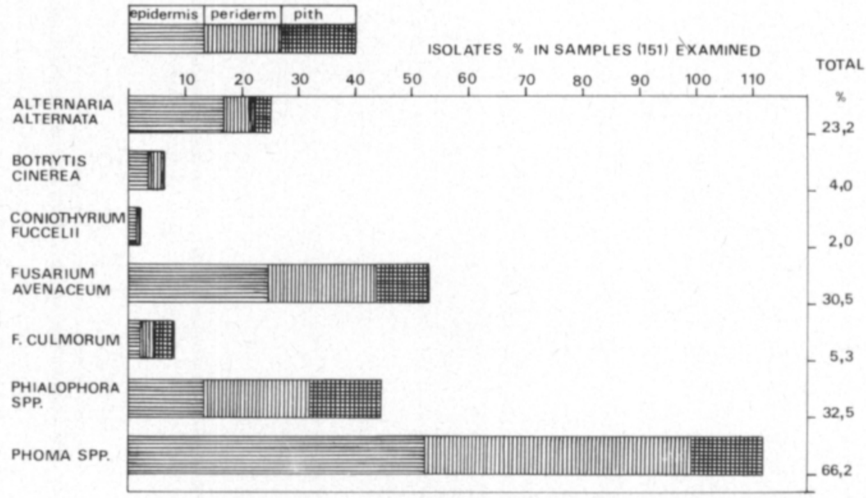

Fig. 2. The frequency of principal fungal species isolated from raspberry stems (epidermis, periderm, pith) in 1978–1980.

the low frequency is partly due to the fact that the perfect stage developed only in cultures which were kept in a refrigerator over the winter.

When comparing the number of isolates of the principal fungal species, found from the epidermis (%/151 samples) to the number isolated from the periderm, correspondingly, the ratio changed between different fungi (Fig. 2). Nearly the same amount of the most common fungi, *Phoma* spp. and *F. avenaceum* were found from both tissues, but from the pith noticeably less. Whereas, *Alternaria alternata* was 3–5 times as common in the outermost cortex as in the other stem tissues investigated. Wood rotting saprophytes, *Phialophora* spp. (cf. WILLIAMSON & HARGREAVES 1978), were as common in the epidermis as in the pith tissue.

Didymella applanata, raspberry spur blight

The causer of spur blight is an ascomycete, which SACCARDO (1882) placed in the genus *Didymella* Sacc. The fungus has also an imperfect stage which, according to literature (KOCH 1931, BLAKE 1980, CORLETT 1981) is assigned to the genus *Phoma* Sacc.

The fruit bodies (pseudothecia) of *D. applanata* mature in hibernated canes of raspberry. The ascospores discharged during the summer are carried by air currents and raindrops onto the young raspberry canes. Infection often takes place through the leaves and petioles (LABRUYÈRE & ENGELS 1963). Because of this the lower part of infected canes is covered with violet-brown discoloured lesions, chiefly at the nodes. Towards the autumn the lesions extend to cover practically the whole basal part of the young canes. Partially the diseased cane show a splitting of the bark, air pushes beneath the epidermis, and the cane turns silver. According to GJAERUM (1974) the fungus produces the perfect stage only in the main shoot, the conidial stage also in the laterals and leaves.

As regards the several observations, carried out at Viikki during the growing season of 1981, the pseudothecia of *D. applanata* matured from the beginning of June until early of July (Fig. 3 D). May, 1981 at Viikki was rather warm, but rainless and June quite cool and rainy. It also rained in abundance in July and August.

Violet-brown lesions around often already dead axillary buds were observed in the basal parts of young canes, particularly cv. Muskoka at the beginning of July. Light brown pycnidia quickly developed in the lesions (Fig. 3 A, B). From the pycnidia discharging pycnospores spread the disease. The lower leaves of infected canes turned partially yellowish and angular, brown spots were seen on the leaves. At the same time spur blight symptoms also occurred in wild raspberry in the neighbourhood. The pycnidia of the cvs. Muskoka and Ottawa continued to be exhausted until the end of September, and the dark fruit bodies were already developing.

D. applanata fungus penetrates into the plant through different injuries, which may be caused by pruning, wind rubbing, natural splitting of the epidermis, hoeing or night frost. The wounds caused by larvae of insects, particularly of cane midge, also promote the penetration of fungal pathogens into the plant (NIJVELDT 1963, SEEMÜLLER & GRÜNWALD 1980).

In Holland it has been established by LABRUYÈRE & ENGELS (1963) that out of the buds, occupied by both *D. applanata* as well as *B. cinerea*, only 50–60 % developed normally. Infected buds often freeze during the winter. Leaves wither and the fruit crop remains low even in light diseased canes. On the other hand, WILLIAMSON and LAWSON (1979) have experimentally established that the crop compensated for the laterals lost at the base of the canes by increases in the number of fertile laterals at the top and in mean berry

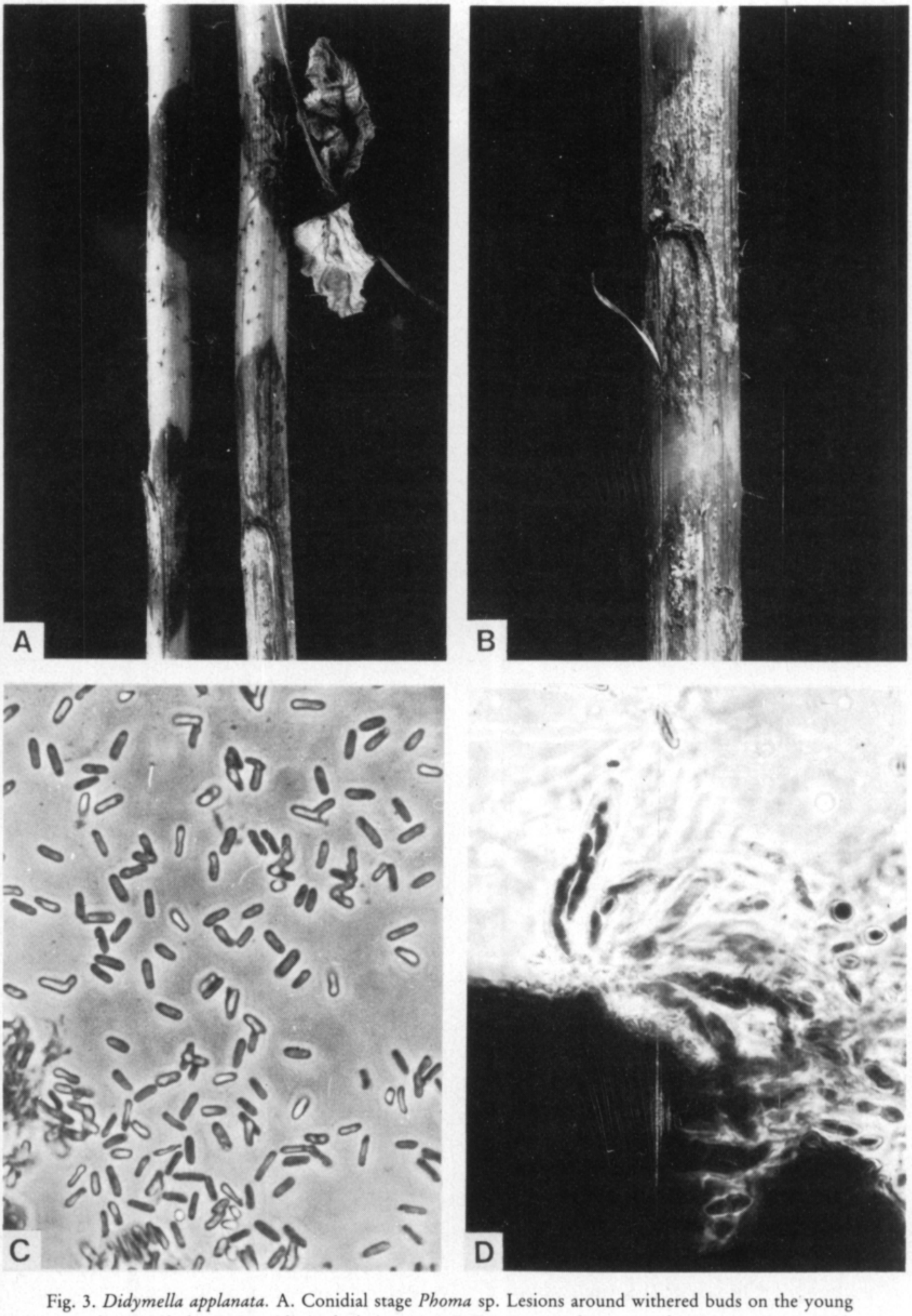

Fig. 3. *Didymella applanata*. A. Conidial stage *Phoma* sp. Lesions around withered buds on the young cane of cv. Muskoka. B. Pycnidia in the lesions, x 2. C. Pycnospores from cane after preservation in cold, x 870. D. Pseudothecia and asci with ascospores, x 430.

weight. However, in cool climates the damage may turn out to be even greater.

In raspberry cane samples kept moist and at a low temperature of about −10° – +10°C during the winter pseudothecia of *D. applanata,* developed slightly. Whereas, there were plenty of perithecia of another ascomycete, particularly in the samples from Piikkiö. A similar fungus, established in the old stems of arctic bramble, was indentified to *D. applanata* (RUOKOLA 1981). A later examination, however, showed that the fungus was similar to an ascomycete, which LARSEN (1952) supposed to be *Didymella mesnieriana* (Rehm & Thüm.) Sacc., but which MUNK (cf. LARSEN 1952) identified to belong to the genus *Sydowiella* Petrak. In Denmark this fungus was found from the dead canes of raspberry.

The most important dimensions (μm) of *D. applanata* and *Sydowiella* sp:

	Pseudothecia	Asci	Ascospores
D. applanata (growing canes)	140–230	50–74×10–13 (65×11,9)	14–18×, 5–7 (15,2×6,0)
	Perithecia		
Sydowiella sp.	250–900	65–124×10–17,5 (97,3×12,1)	17–30×6–10 (27,9×7,4)

Morphologically these fungi differ from each other mainly because of the structure of the asci.

The majority, about two thirds of *Phoma*-isolates (146) were by growth habit similar to the description of the conidial stage of *D. applanata* given by KOCH (1931). The dimensions of pycnidia and pycnospores (μm) presented here correspond to the information regarding this fungus in literature (cf. KOCH 1931, CORLETT 1981): From growing cane (Fig. 3C), pycnidia 140–250, pycnospores 5,5–11,0×2,0–3,5 (7,3×2,3).

Other fungi isolated from the raspberry

The following 4 species were indentified from among *Phoma*-isolates: *P. macrostomum* Mont. v. *macrostomum* (cf. BOEREMA & DORENBOSCH 1970), *P. glomerata* (Cda.) Wollenw. & Hochapf., *P. eupyrena* Sacc. and *P. exigua* Desm. v. *exigua* Maas. From these relatively scarce fungi *P. exigua* v. *exigua* was the most common, which is the weak pathogen of raspberry (SEEMÜLLER 1974). This fungus occurred particularly in the fruiting canes at Mikkeli in 1978.

4 isolates of *P.exigua* v. *exigua,* 3 of *Phoma* spp. and 3 of *F. avenaceum* were grown from transfers (21) employed from buds or near them.

Botrytis cinerea, gray mold, was only isolated noticeably from samples originating from Mikkeli during growing season 1978 (Fig. 2). According to LABRUYÈRE & ENGELS (1963) the fungus causes damage mainly by destroying buds (cf. p. 103). On the other hand, WILLIAMSON & HARGREAVES (1981) have established that buds of infected nodes are only weakly suppressed in spring by the metabolites of *B. cinerea* and *D. applanata.* In the present study

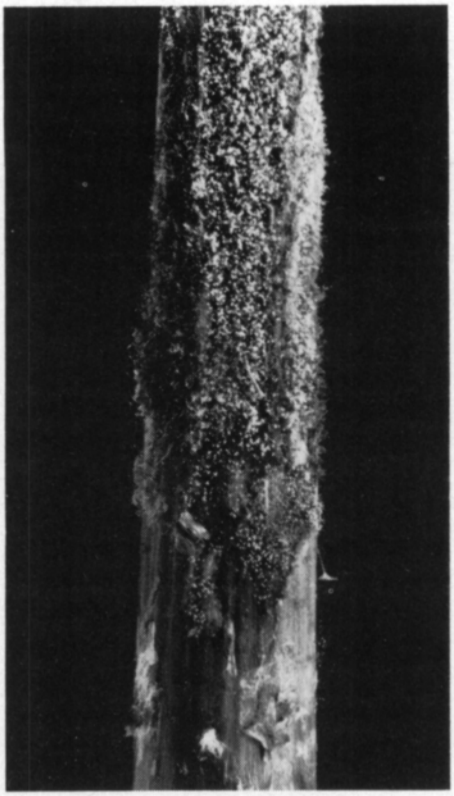

Fig. 4. Infection of cv. Muskoka young cane by *Botrytis cinerea.*

Fig. 5. Full-grown larvae of *Resseliella theobaldi* on first-year raspberry cane (NIJVELDT 1963).

B. cinerea caused a deep infection even in raspberry canes, cane botrytis (cf. HOCKEY 1952). The fungus produced brown lesions on the canes in which the conidiophores with conidia (Fig. 4) and later dark sclerotia were formed.

Fusarium avenaceum. The fungus often occurred as mixed colonies together with other fungi; sometimes its yellow sporodochia were to be seen on the epidermis of the cane. *F. avenaceum* was obtained in 63 % of some strongly diseased cane samples from Järvenpää (*N*).

JARVIS and HARGREAVES (1972) have established that *F. avenaceum* was probably responsible for damage in which many lateral buds of red raspberry failed to grow and some others which had grown out, later wilted. The fungus was also occasionally isolated from the roots of diseased plants and from their soil. Out of 34 root samples examined in the present study, *F. avenaceum* was only isolated from two and *F. sulphureum* from one.

F. culmorum was isolated from samples of Ottawa originating from Kesälahti (*Kb*) in 1979 and respectively, from samples originating from Mikkeli in 1980; it occurred in 17–20 % of the samples.

Cylindrocarpon destructans, which has been found to cause raspberry root rot (BERKELEY 1936) was rather common in the root samples of the present study. The frequency of the fungus was on an average 26,5 %, but it changed due to the origin of the samples. In the samples from Piikkiö which were only weakly diseased, *C. destructans* occurred in 8,3 %, and respectively, in samples rather strongly diseased originating from Sipoo (*N*) in 70 %.

Coniothyrium fuccelii, the conidial stage of *Leptosphaeria coniothyrium* was only in about 2 % of the transfers from samples. They commonly originated from strongly infected canes. The fungus was also isolated from the roots. *L. coniothyrium* causes dark brown lesions at the basis of the primocanes. In next spring whitened lesions begin to produce black pycnidia which, after rain exude mugilage containing black 1-celled pycnospores (WILLIAMSON & HARGREAVES 1978). This wound parasite which affects the vascular tissue of cane blocks the translocation in the sector supplying the failed or withering buds and laterals.

In the present study the symptoms caused by *D. applanata* and *L. coniothyrium* were mixed with each other. The size of the pycnospores of *L. coniothyrium* was (MA): 3,0–4,5×2,5–3,5 μm; pycnidia, 170–270 μm.

Elsinoë veneta (Burkh.) Jenk., the causer of cane spot in raspberry was not established in the samples. Earlier it occurred on the cv. Asker, which is quite susceptible to this fungus (E. TAPIO, pers. comm.).

Other fungi (cf. GROVE 1935, BARRON et al. 1961, ELLIS 1971, DOMSCH et al. 1980), mainly saprophytic ones or those occurring scarcely, were also isolated from the raspberry canes: *Absidia glauca* Hagem, *Acremonium* sp., *Acremoniella atra* (Cda.) Sacc., *Aspergillus* sp., *Aureobasidium pullulans* (de Bary) Arnaud, *Chaetomium globosum* Kunze ex Fr., *Cladosporium* spp., *Cytospora ambiens* Sacc., *Dendrophoma pleurospora* Sacc., *Doratomyces stemonitis* (Pers. ex Fr.) Morton & Smith, *Epicoccum nigrum* Link, *Fusidium* sp., *Gliocladium* spp., *Gliomastix murorum* (Cda.) Hughes, *Graphium penicilloides* Cda., *Monilia* sp., *Monodictys glauca* (Cooke & Harkn.) Hughes, *Mucor* sp., *Papulaspora* sp., *Penicillium* spp., *Petriella guttulata* Barron & Cain, *Pleospora herbarum* (Pers. ex Fr.) Rabenh., *Pythium* sp., *Rhinocladiella mansonii* (Castellani) Schol-Schwarz, *Rhizoctonia solani* Kühn, *Sordaria fimicola* (Roberge) Ces. & de Not., *Torula* sp., *Trichocladium canadense* Hughes, *Trichoderma viride* Pers. ex Fr., *Ulocladium consortiale* (Thüm.) Simm. and some ascomycete- and basidiomycete-isolates, which were not identified. *Oidiodendron cerealis* (Thüm.) Barron and *Truncatella truncata* (Lév.) Stey were identified from the raspberry cane samples kept at a low temperature during the winter. Powdery mildew (*Oidium* sp.) occurred in the leaves of Muskoka in Viikki 1981.

The comparison between the raspberry cultivars

According to SÄKÖ et al. (1980) the cv. Muskoka is more susceptible to spur blight than Ottawa. A reliable comparison between the cvs. was not possible in the present study, because samples chosen for examination were mainly diseased ones. Based on relatively concise material taken for comparison, it can only be established that pathogenic fungi were found on average the same amount from both cvs. Muskoka and Ottawa (Fig. 6). *Phoma* sp. was established in 80 % of Muskoka cane samples originating from Piikkiö in 1980 and in 40 % of samples of Ottawa, respectively. Whereas in the samples from Mikkeli Ottawa seemed to be more susceptible to *Phoma* sp. than Muskoka (Table 2). However, in 1980 plenty of injuries caused by cane

Table 2. The frequency of various fungal species isolated from raspberry canes originating from South Savo Experimental Station in 1980.
Samples: Muskoka 10, Ottawa 15.

Fungus	Isolates			
	Muskoka		Ottawa	
	No.	% of samples examined	No.	% of samples examined
Acremoniella atra	0		1	6.7
Alternaria alternata	7	70	12	80.0
Botrytis cinerea	1	10	0	
Chaetomium globosum	0		1	6.7
Cladosporium sp.	0		1	6.7
Coniothyrium fuccelii	0		1	6.7
Fusarium avenaceum	5	50	8	53.3
F. culmorum	0		3	20.0
F. sp.	0		1	6.7
Fusidium sp.	0		2	13.3
Phialophora spp.	1	10	6	40.0
Phoma exigua v. *exigua*	0		1	6.7
Phoma spp.	2	20	8	53.3
Ulocladium consortiale	0		3	20.0
Ascomycete	0		1	6.7
Unidentified	1	10	1	6.7
Total	17		50	

midge (*Resseliella theobaldi*) larvae were found which on their part increased the damage caused by fungi. Of other fungal species *F. avenaceum* was more common in Muskoka than in Ottawa in 1978; in 1980 respectively, there was no difference.

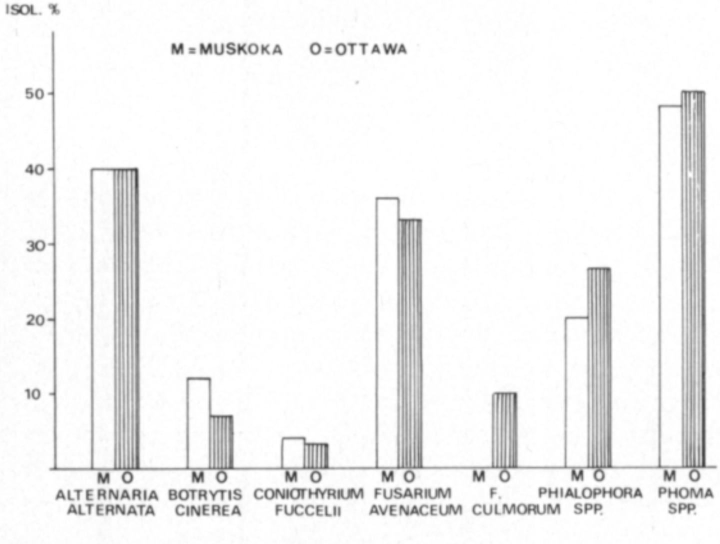

Fig. 6. The comparison between cvs. Muskoka and Ottawa. The principal fungal species and isolates % of samples examined (Muskoka 25, Ottawa 30). The samples were collected in 1978 and 1980 from Mikkeli and 1980 from Piikkiö.

Resseliella theobaldi, causer of midge blight

In the years 1980 and 1981 samples from Mikkeli were obtained, in which many injuries caused by cane midge larvae were established. The larvae, pink and 3 mm long, live in the outher cortical tissues (Fig. 5) causing brown patches or stripes which extend even into the vascular cane tissue (cf. WILLIAMSON & HARGREAVES 1979). The lesions are formed mainly on the young primocanes, whose outer periderm cell wall the larvae are able to penetrate (SEEMÜLLER & GRÜNWALD 1980). Obviously the larvae also have the capability with their entsymes to degrade the suberin of the periderm cell wall by which means they also open ways for several fungi. SEEMÜLLER & GRÜNWALD (1980) have even established that none of the fungi occurring in raspberry canes are able to grow into the vascular tissue via an intact periderm.

During the growing season 1981 in Mikkeli cane midge had two generations (P. DALMAN, pers.comm.). Larvae and their damage were observed mainly on the cv. Ottawa, because its outer cortex easily splits, thus opening entrances for insects. In 1980 there was also clearly more fungi isolated from this cv. than from Muskoka (Table 2). The principal fungal species found from cv. Ottawa were mainly the same as those isolated by PITCHER & WEBB (1952) and LABRUYÈRE & ENGELS (1963) from the larval feeding wounds. They also record *F. culmorum* as a frequent isolate while WILLIAMSON & HARGREAVES (1979) didn't found it at all. In the samples of Ottawa from Mikkeli in 1980 the fungus occurred in 20 % of samples.

In Finland stem gall midge (*Lasioptera rubi* Heeg.) and coganberry cane fly (*Pegomyia rubivora* Coquillet) also injure raspberry stands (BREMER 1981). Thus like cane midge they probably promote the entering of wound parasites to the canes. According to literature (NIJWELDT 1963, LAWSON 1981) the damages caused by cane midge and spur blight have been reduced by the removal of the first young shoots in spring and later by thinning the shoots grown too closely. In Finland, the commercial tissue culture propagation of crops in raspberry has proved to be profitable, although the originally healthy stands were already strongly infected by *D. applanata* two years after planting (BREMER 1980).

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Acknowledgements. I wish to express my sincere thanks to Mrs. Kaija Karhunen, M.Sc., from Ruukki, to Miss Lahja Pesonen and Mr. Pentti Heinänen, both from the Department of Plant Pathology, for their invaluable technical assistance during the course of this study.

Ms received April 24, 1982

SELOSTUS

Vadelman (*Rubus idaeus* L.) sienitaudit Suomessa

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Vadelmakasvustoissa esiintyvien haitallisten sienipatogeenien kartoittamiseksi tutkittiin vuosina 1978–1981 lähes 200 versonäytettä, pääasiallisesti Etelä- ja Itä-Suomesta. Näytteet koostuivat eriasteisesti vioittuneista nuorista ja jo marjoneista versoista.

Phoma sp., vadelman versotaudin aiheuttajan, *Didymella applanata*-sienen kuroma-aste, oli yleisin eristetyistä sienistä; koteloaste kehittyi vasta kylmäsäilytyksen jälkeen. Kuromaitiöiden muodostumisen huippu vadelman versoissa oli v. 1981 heinäkuussa.

Muita heikkoja haavapatogeeneja eristettiin: *Fusarium avenaceum*, joka löytyi 22 %:ssa siirrostuksia, *F. culmorum, Botrytis cinerea* ja toiseksi yleisin *Phoma*-lajeista, *Phoma exigua* v. *exigua.* Luetellut sienet eristettiin pääasiassa vadelman varren eri solukoista; ytimestä löytyi keskimäärin vähiten sieniä. *Alternaria alternata* oli yleisin 'pintasieni', saprofyyttiset puun lahottajat, *Phialophora* spp., yleisiä myös ytimessä. Patogeeneista voimakkain, *Leptosphaeria coniothyrium* oli näytteissä harvinainen. *Cylindrocarpon destructans*-sienen esiintyminen juurinäytteissä vaihteli 8–70 %.

Muskoka-lajike on Ottawaa alttiimpi ainakin versotaudille. Toisaalta vatun varsisääsken *(Resseliella theobaldi)* toukat aiheuttivat osassa Ottawa-näytteitä runsaasti vioituksia ja lisäsivät siten sienisaastuntaa.