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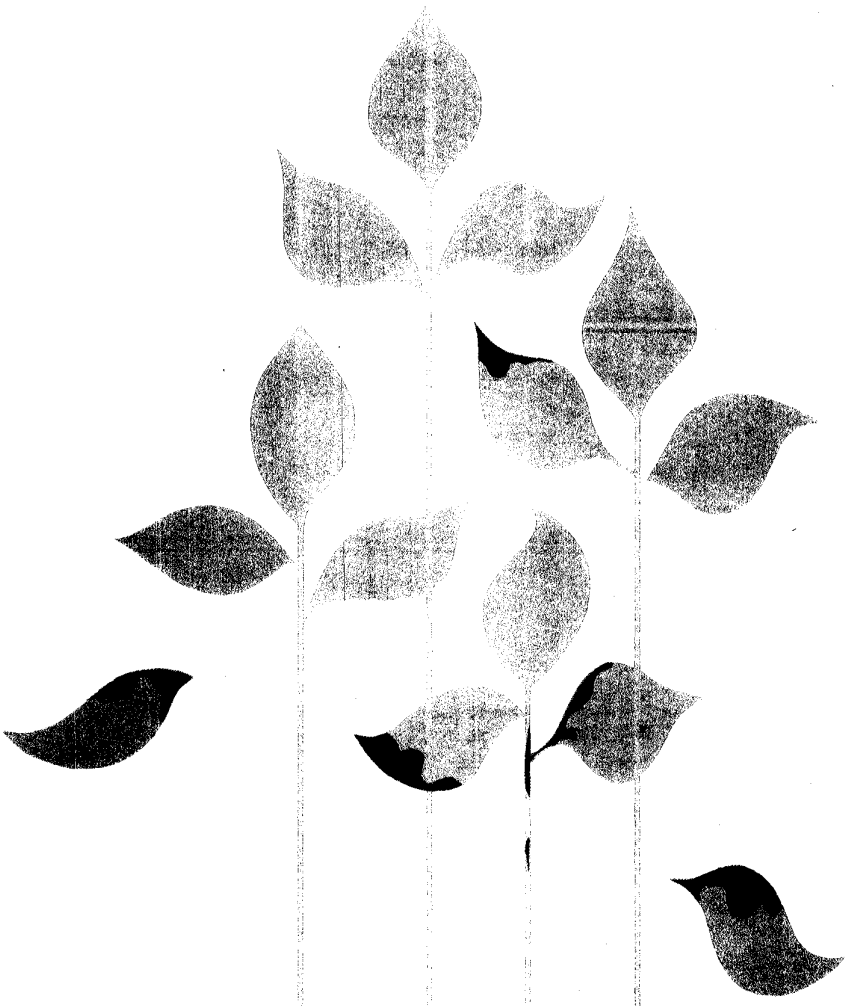

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The *Canadian Plant Disease Survey* is a periodical of information and record on the occurrence and severity of plant diseases in Canada and on the assessment of losses from disease. Other original information such as the development of methods of investigation and control, including the evaluation of new materials, will also be accepted. Review papers and compilations of practical value to plant pathologists will be included from time to time.

L'Inventaire des maladies des plantes au Canada est un périodique d'information sur la fréquence des maladies des plantes au Canada, leur gravité, et les pertes qu'elles occasionnent. La rédaction accepte d'autres communications originales notamment sur la mise au point de nouvelles méthodes d'enquête et de lutte ainsi que sur l'évaluation des nouveaux produits. De temps à autre, il inclut des revues et des synthèses de rapports d'intérêt immediat pour les phytopathologistes.

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Pseudocercosporella capsellae, the cause of white leaf spot and grey stem of Cruciferae in Western Canada[1]

G.A. Petrie[2] and T.C. Vanterpool[3]

White leaf spot and grey stem, a common disease of turnip rape (*Brassica campestris*) and rape (*B. napus*) and several cruciferous weeds in Western Canada is described. The causal fungus is *Pseudocercosporella capsellae*. Formerly the stem symptoms on *Brassica* spp. were attributed to *Mycosphaerella brassicicola*, the cause of ring spot of *B. oleracea*, but a connection of this fungus with white leaf spot remains in doubt. Production of the phytotoxic red pigment "cercosporin" by *P. capsellae* is reported for the first time. Formation of thick-walled hyphae in stem tissue, often in the form of mycelial mats, is thought to represent an important adaptation permitting survival of the pathogen under adverse conditions.

Can. Plant Dis. Surv. 58: 69-72. 1978

On décrit la tache blanche, maladie courante de la navette (*Brassica campestris*) et du colza (*B. napus*) et de plusieurs crucifères adventices de l'ouest du Canada. L'agent de cette maladie est le champignon *Pseudocercosporella capsellae*. Auparavant, on attribuait les symptômes sur la tige des *Brassica* spp. à *Mycosphaerella brassicicola*, l'auteur de la tache annulaire de *B. oleracea*, mais un doute subsiste sur le rapport entre ce champignon et la tache blanche. On a d'autre part, signalé pour la première fois la production d'un pigment rouge phytotoxique "cercosporine" par *P. capsellae*. La formation d'hyphes à parois épaisses dans le tissu de la tige, souvent sous la forme de feutres mycéliens, constituerait une importante adaptation permettant au pathogène de survivre en mauvaises conditions.

Introduction

In 1958, Vanterpool collected what appeared to be the disease ring spot [*Mycosphaerella brassicicola* (Fr. ex Duby) Lind.] on turnip rape (*Brassica campestris* L.) in east-central Saskatchewan (Vanterpool, 1960). However, ascocarps of *M. brassicicola* were never found on Cruciferae from the three Prairie Provinces at any time of the year and for many years spermogonia represented the only fruiting state observed. Within a few years of its discovery "ring spot" could be found late in the growing season throughout the park-belt of the prairies. Its appearance was often striking, particularly in northern park-belt areas where entire fields were discolored and no field free from it. Because of its late development, however, losses in yield appeared to be minimal.

Vanterpool subsequently observed a white leaf spot in fields of turnip rape and rape (*B. napus* L.). Elsewhere in North America and abroad, white leaf spot has caused major crop losses, principally in white turnip (*B. rapa* L.) (McKay, 1956; Miller and McWhorter, 1948). The pathogen involved was *Pseudocercosporella capsellae* (Ell. & Ev.) Deighton (Deighton, 1973). It will be shown in this paper that white leaf spot and grey stem ("ring spot") are different manifestations of a single disease. The earlier contention (Vanterpool, 1960) that the disease was ring spot now appears to be incorrect. It is our intention also, therefore, to examine points of similarity and difference between these two diseases.

Observations

Host ranges and symptoms of the white leaf spot and ring spot pathogens

We have found white leaf spot and grey stem in Saskatchewan on *Brassica campestris, B. hirta* Moench, *B. napus, B. oleracea* L. var. *capitata* L., *B. oleracea* L. var. *botrytis* L., *B. napobrassica* (L.) Mill., *B. rapa, Capsella bursa-pastoria* (L.) Medic., *Conringia orientalis* (L.) Dumort., and *Neslia paniculata* (L.) Desv. It has been reported on several other hosts (Deighton, 1973). *B. oleracea* is less severely affected than *B. rapa* or *B. campestris* and leaf symptoms on *B. oleracea* differ from those on the other two species (Miller and McWhorter, 1948). In contrast, *M. brassicicola* is largely restricted to oleraceous *Brassica* species (Dring, 1961; Weimer, 1926). Isolations made by the authors from the seed of turnip rape and from white leaf spots and grey stem lesions from cultivated and wild hosts from as far distant as Fort St. John, British Columbia, gave identical black, slow-growing colonies (Fig. 1F). White or buff-colored sectors were frequently observed in cultures of the wild-type from various sources. Conidia and spermogonia typical of *P. capsellae* were produced in culture, although in relatively small numbers.

Leaf spots produced by *P. capsellae* in nature are greyish white to brownish, often with a brown margin and occasionally with narrow line zonation (Fig. 1A, B).

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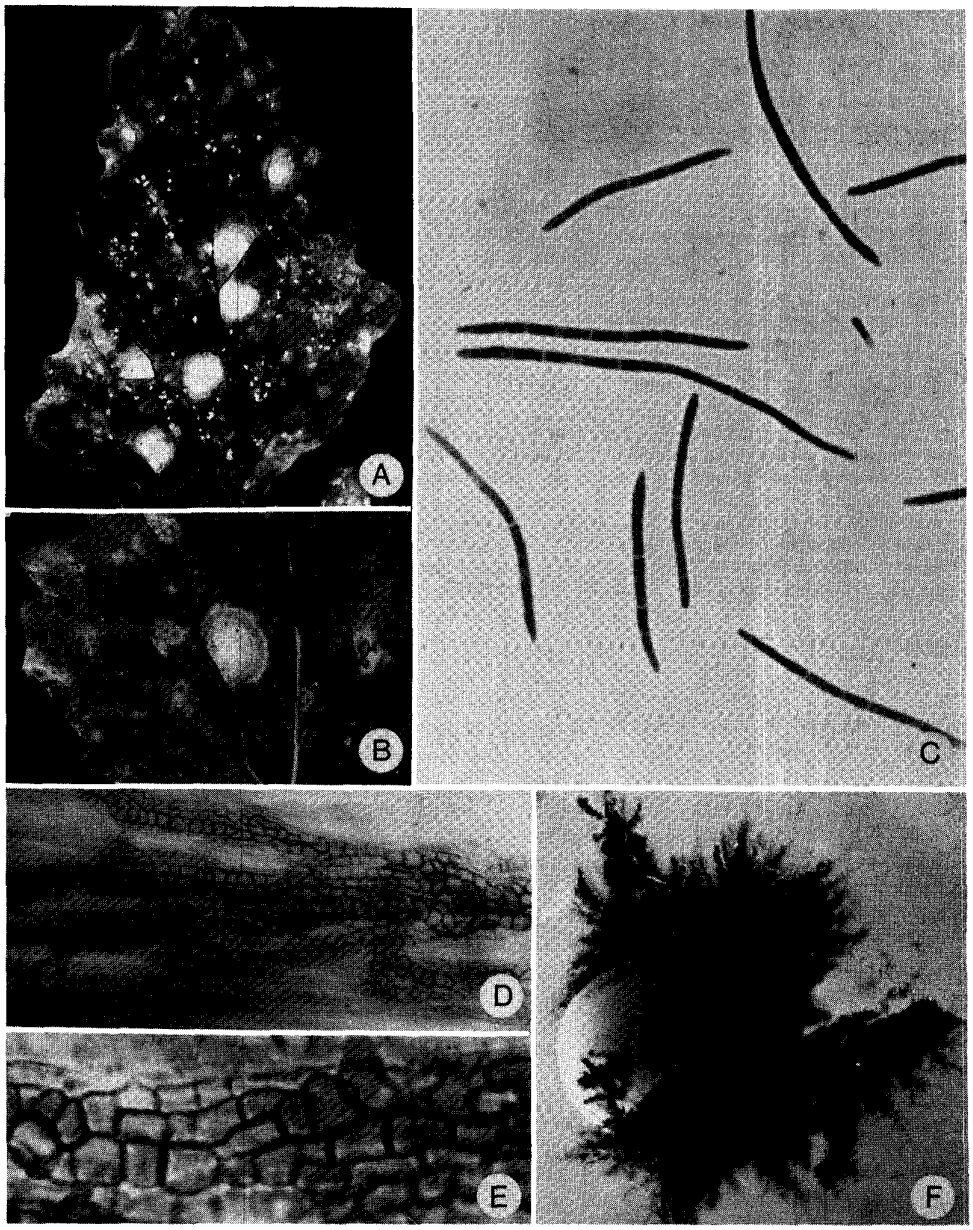

Figure 1. (A to F) *Pseudocercosporella capsellae*, the cause of white leaf spot and grey stem of rape. (A, B) Leaf symptoms from field collections of turnip rape and rape. Note narrow line zonation within spots. (C) Conidia of *P. capsellae* from leaf spots (natural infection). X 320. Spores stained with lactophenol-aniline blue. (D) Thick-walled overwintering mycelium of *P. capsellae* from a stem of turnip rape. Approx. X 100. (E) Enlargement of D. (F) Colony of *P. capsellae* growing from a naturally-infected seed of turnip rape.

McKay (1956) reported the presence of numerous "pseudo-sclerotia" embedded in infected leaf tissues. These were probably stromata, which vary considerably in size (Deighton, 1973). In comparison, spots caused by *M. brassicicola* on leaves have a brown background and contain black spermogonia, and frequently also perithecia, in a typical zonate arrangement. Each spot is surrounded by a narrow water-soaked area, with beyond this, a zone of chlorotic tissue. No fruiting bodies are formed when ringspot lesions are not exposed to moisture conditions near saturation (Nelson and Pound, 1959).

Mature stem and pod lesions caused by the two pathogens are similar in appearance. Transmission of *P. capsellae* in or on the seed itself seems to be of little consequence. Seed of *Conringia orientalis* from heavily infected pods failed to yield the fungus when plated on agar and seed of turnip rape and rape did so rarely (Fig. 1F). Infected bits of crop residue in seed samples may provide a ready means of transmission of the disease over wide distances. Such material is commonly found in samples of seed.

Morphology of P. capsellae and M. brassicicola

Those who have studied *M. brassicicola* are emphatic that only two spore stages occur, spermatial and ascosporic (McKay, 1956; Nelson and Pound, 1959; Snyder, 1946; Weimer, 1926). In *P. capsellae* a conidial and a spermatial state are found. This report would appear to be the first record of the latter for the white leaf spot pathogen. White leaf spots collected on *Brassica* spp. at Saskatoon in July during the past few years frequently gave no evidence of sporulation. Scores of conidia were obtained by incubating infected leaf pieces on wet filter paper for 24 h at 18-20°C under intermittent light.

Extensive immature brown lesions, along with mature greyish ones bearing numerous spermogonia, were collected on *Capsella* stems in late August, 1975. Stem segments bearing young lesions were incubated at 12 and 21°C under intermittent light in test tubes to which a small amount of water had been added. Within four days abundant *Pseudocercosporella* conidia formed at 12°C with only a few being obtained at the higher temperature. More mature stem lesions including some on *B. campestris* yielded few conidia under similar conditions.

Conidia from natural field infections ranged in length from 32 to 120 microns (mean 66) and were 2 to 3 microns wide. This agrees well with measurement recorded by others. Conidia from culture usually averaged about 5 microns longer than those from field material. Conidial morphology was as described by Deighton (1973). The presence of a truncate unthickened hilum on the conidium was an important characteristic serving to place the fungus under study in the genus *Pseudocercosporella*. The spores were usually 0- to 3-septate (Fig. 1C). Each cell was uninucleate and capable of germinating by a germ tube. Anastomoses of conidia via short germ tubes were observed. Infrequently segments of conidia from culture were seen to have developed into thick-walled cells. These might function as chlamydospores reminiscent of those formed in segments of spores in species of *Fusarium*.

In Western Canada, *P. capsellae* overwinters on residues of crucifers in the form of dark, thick-walled, closely septate, matted hyphae (Fig. 1D, E) on which conidia are produced in the spring. These serve for primary dissemination of the disease. Subsequent spread is via secondary conidia formed on the primary lesions. Observations indicated that conidia may be carried down stems by coalescing dew drops or by rain drops, resulting in the elongate lesions so conspicuous in the autumn. These lesions often occur in series along the entire stem.

No ascosporic state of *P. capsellae* is known. In addition, despite an often concentrated search over many years, no authentic ascocarps of *M. brassicicola* have been found on Cruciferae in the Prairie Provinces since "ring spot" was first collected in this area in 1958 (Vanterpool, 1960). On several occasions a species of *Mycosphaerella* has been collected on crucifers and members of other families of dicotyledons in Saskatchewan and Alberta. This species has been identified as *M. tassiana* (de Not.) Johans. var. *tassiana* (Petrie and Vanterpool, 1978).

In the apparent absence of a perfect state the resistant thick-walled hyphae referred to earlier assume considerable importance in the survival of the pathogen during the extreme cold of the prairie winters and also, perhaps, during hot, dry periods in midsummer. The widespread occurrence of this stage of the life cycle on overwintering crop residue and to a lesser extent on weeds is an adaptation which permits primary infection to occur readily. Solel (1970) reported that mycelium of *Cercospora beticola* Sacc. survived for 3 years in beet leaf debris left on the soil surface under dry conditions. It is not known how long *P. capsellae* can survive in dead leaf or stem tissue.

Production of the pigment "cercosporin"

Several species of *Cercospora* and closely allied fungi produce the pigment "Cercosporin" (Lynch and Geoghegan, 1977). A red pigment was extracted from mycelial mats from *P. capsellae* cultures representing all of the collections of the fungus made to date by the authors. The material was soluble in ethanol, chloroform, ether and acetone but was insoluble in petroleum ether and in water. In concentrated sulfuric acid it was purple and in alkali, a distinctive green color. In 1N-NaOH the visible spectrum showed major absorption peaks at 480 and 645 mu and other minor peaks. It was toxic to rape, inhibiting seed germination and subsequent root growth. In all these respects it resembles cercosporin. An authentic culture of *M. brassicicola* obtained from Dr. P.H. Williams, University of Wisconsin, Madison, did

not produce detectible red pigment nor did it produce conidia of any type in culture. Dring (1961) reported the production of a toxin by *M. brassicicola* which acted in advance of the invading hyphae. This would appear not to be cercosporin, however. Cercosporin production by the white leaf spot pathogen has not been previously reported.

Discussion

Several pieces of evidence, many of which on their own are inconclusive, suggest that white leaf spot and grey stem has no connection with ring spot as found on the west coast of the United States and in Europe. It has been stated (Nelson and Pound, 1959) that *M. brassicicola* is strictly limited to cool, very moist regions but this is not totally convincing (McKay, 1956). Leaf symptoms would appear to be an obvious point of dissimilarity but this difference becomes much less marked when *M. brassicicola* develops under dry conditions. Other apparent differences include host range, nature of spores produced, apart from spermatia, and presence or absence of the pigment cercosporin. A more detailed comparative study of the two species under a range of environmental conditions is required.

In our work, inoculations of plants under controlled conditions gave inconsistent results. It is our view that development of a cultural technique enabling consistent production of large numbers of conidia should be accorded high priority at the beginning of such a study.

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Control of root and crown rot of African Violet and of Gloxinia caused by Phytophthora nicotianae var. nicotianae

L.V. Busch and Elizabeth A. Smith[1]

A crown and root rot of African violet (*Saintpaulia ionantha* Wendl.) and of Gloxinia (*Sinningia speciosa* Benth. & Hook.) caused by *Phytophthora nicotianae* var. *nicotianae* is reported from Canada for the first time. Control of both diseases by the systemic fungicides, Aliette (May & Baker) and Ridomil (Ciba-Geigy) is reported.

Can. Plant Dis. Surv. 58: 73-74. 1978

La pourriture des racines et du collet provoquée par *Phytophthora nicotianae* var. *nicotianae* chez la violette africaine (*Saintpaulia ionantha* Benth. & Hook) et la gloxinie (*Sinningia speciosa* Wendl.) a été observée pour la première fois au Canada. On décrit ici une méthode de lutte contre ces deux maladies au moyen de deux fongicides endothérapiques, Aliette (May & Baker) et Ridomil (Ciba-Geigy).

Phytophthora nicotianae var. *nicotianae* is reported for the first time in Canada as a cause of crown rot and root rot of African violet (*Saintpaulia ionantha* Wendl.) and of Gloxinia (*Sinningia speciosa* Benth. & Hook). The leaves and petioles turned brown very rapidly, appeared water-soaked and rapidly degenerated. The plant died shortly after the first symptoms appeared.

The disease of African violet, which usually appeared when the plants were starting to flower, caused losses of 10 to 50% of the plants. Losses were lower during the summer and fall than during the winter months when humidity was high. Isolations from diseased petioles or leaves yielded a *Phytophthora* which was identified through the courtesy of Commonwealth Mycological Institute (C.M.I.) as *Phytophthora nicotianae* B. de Haan var. *nicotianae* mating type A2.

This was the first record of *Phytophthora* isolated from *Saintpaulia* or *Sinningia* in Canada although a similar disease from the former was reported from the United Kingdom (private communication, C.M.I.) caused by *P. nicotianae* var. *parasitica*, by Krober and Plate from Germany and more recently by Strider from the United States caused by the same organism.

A foliage and crown rot of Gloxinia (*Sinningia speciosa*) brought to our attention was also caused by *P. nicotianae* var. *nicotianae*, a culture of which mated with our original culture obtained from African violet (courtesy of Biosystematics Research Institute, National Identification Service, Ottawa). One thousand of these plants had been obtained from Florida by the grower as small transplants. When observed in December 1977 they were in 20 cm pots and just coming into flower. The grower had already lost over 400 plants and about half of the remainder were starting to show symptoms. This paper reports studies on the temperature and humidity requirements for infection and on control of the disease.

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Materials and methods

The pathogen was isolated from infected African violets and maintained on corn meal agar (CMA). Inoculum was grown for 7 days at 25°C on CMA.

To determine the optimum temperature for growth, 11 mm discs containing mycelium were placed in the middle of CMA plates and the plates were placed in incubators at 10, 15, 20 and 25°C. Growth was recorded 7 and 10 days after inoculation.

African violet plants, cultivar Marta 'Ballet series', in bud were inoculated by placing 2 to 3 11-mm CMA discs containing fungal mycelium and sporangia into the crown of the plant and enclosing the plants in plastic bags tied at the top. Dipping the plants in an aqueous spore-mycelial mixture or pouring a spore-mycelial mixture over the plant and soil proved less satisfactory. Adequate controls were used in all tests.

The plants were placed in Conviron controlled environmental chambers at 16, 18, 22, 25, 27 and 30°C programmed for 14 hours daylength, and examined periodically for symptom development.

Control was attempted using 'Aliette' [(LS 74-783) May & Baker, aluminium tris (ethyl phosphonate)] at 1600 ppm a.i. and 'Ridomil' [(Ciba-Geigy CGA 48988 DL-methyl N-(2,6-dimethyl phenyl)-N-(2-methoxyacetyl) alaninate] at 125 ppm a.i. applied to the soil at a rate of 50 ml per 10 cm pot one week prior to inoculation and at the time of inoculation.

Both materials were tested *'in vitro'* at the same concentration prior to the *'in vivo'* tests by incorporating 1 ml of the chemicals in the agar per 90 mm petri dish and inoculating the plate with an 11 mm agar disc containing fungal mycelium. Later, trials were conducted in the growers' greenhouses with naturally infected plants.

Results

The fungus grew most rapidly at 25°C and had completely covered the plates after 10 days growth. Infection took place at all temperatures tested but was more rapid and consistent at 25°C or above. At the higher temperatures symptoms appeared within 4 days of inoculation and the plants were dead three days later.

Aliette exhibited no activity *'in vitro'* while Ridomil completely inhibited growth on the plates. Both Aliette and Ridomil applied one week prior to inoculation gave 100% control of the disease in all tests at all temperatures. When applied at the time of inoculation the results were more erratic with some of the inoculated treated plants becoming diseased. Both fungicides applied to young plants in the growers' greenhouses proved to be very effective in preventing disease development. The amount of disease present was reduced from that usually found in the greenhouse to less than 1% in both cases.

A soil application of 100 ml per pot of Ridomil, 125 ppm a.i. applied to the Gloxinia plants which were starting to show symptoms, completely checked the disease and the majority of them were saleable.

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The effect of chlorothalonil on alternaria leaf spot of crucifers under laboratory conditions

Andres A. Reyes[1] *and Austin E. Maitland*[2]

Chlorothalonil was as effective as maneb and zineb in controlling alternaria leaf spot on cauliflower when plants were sprayed at least 3 h before inoculation. However, it did not prevent development of the disease when applied 2 or 3 days after inoculation. Control of leaf spot was not affected by mixing chlorothalonil with an insecticide. Chlorothalonil was not phytotoxic to crucifers.

Can. Plant Dis. Surv. 58: 75-76. 1978

Le chlorothalonil (tétrachloroisophthalonitrile) agit avec autant d'efficacité que le manèbe (éthylène bis- (dithiocarbamate) de manganèse) et le zinèbe (éthylène bis- (di-thiocarbamate) de zinc) dans la lutte contre la tache noire (*Alternaria brassicae*) du chou-fleur lorsqu'il est pulvérisé sur la plante au moins trois heures avant l'inoculation. Toutefois, il n'empêche pas l'évolution de la maladie lorsqu'il est appliqué deux ou trois jours après l'inoculation. Le mélange du chlorothalonil avec un insecticide n'a pas diminué son efficacité contre la tache noire et le chlorothalonil n'a pas manifesté de toxicité envers les crucifères.

The fungicides recommended in Ontario, Canada, in 1977 for the control of alternaria leaf spot of crucifers, caused by the fungus *Alternaria brassicae* (Berk.) Sacc., were maneb, zineb and fixed copper (2). However, notice of rebuttable presumption against registration involved maneb and zineb (3). Fixed copper was reported to produce poor control of alternaria leaf spot (1).

Chlorothalonil, registered in the U.S.A. for control of this disease, was given a temporary registration for crucifers in Canada in 1977 on condition that Canadian efficacy data are obtained. This study was initiated for this purpose.

Materials and methods

The fungicides used were chlorothalonil (tetrachloroisophthalonitrile, Bravo), maneb (manganese ethylene bisdithiocarbamate), zineb (zinc ethylene bisdithiocarbamate) and tricop (tribasic copper sulphate). The insecticides used were endosulfan (Thiodan 4 EC), azinphos-methyl (o,o-dimethyl S-(4-oxo-1,2,3-benzotriazin-3(4H)-ylmethyl) phosphorodithioate, Guthion), Dipel (*Bacillus thuringiensis* Berliner), methamidophos (o-S-dimethylphosphoramidothioate, Minotor), dimethoate (Cygon), mevinphos (Phosdrin Liq. Insect.), and carbaryl (Sevin). These chemicals were sprayed onto each of four plants at 140 kPa (20 psi) until runoff occurred. Maneb, zineb and tricop were used as standards because of their general use (2). Check plants were sprayed with water only.

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Seven-wk old seedlings of broccoli (*Brassica oleracea* L. var. *italica* Plenck) cv. Cleopatra, cabbage (*B. oleracea* L. var. *capitata* L.) cv. Early Marvel, and cauliflower (*B. oleracea* L. var. *botrytis* L.) cv. Idol Original each grown in 10-cm pot of soil were used. Unless otherwise indicated, treated plants were maintained in a growth-room. After each treatment the plants received 3 days of continuous dark (22 C, 98% relative humidity, RH) followed by 4 days of alternating periods of light (14 h, 32,000 lux, 75% RH) and dark (10 h). The plants were watered as required.

The inoculum was prepared as follows: Spores of *A. brassicae* were collected by vigorously shaking 50 g of severely infected leaves of greenhouse grown cauliflower plants for 5 min in 500 ml tap water in 2,800-ml flask. The number of spores in the suspension was adjusted to 15×10^4 spores/ml of water by dilution. Test plants were inoculated with this suspension using a vaporizer (Mastercraft, Toronto). Usually, inoculation followed chemical spraying by 3 h.

Disease severity was rated 0 when there was no leaf spot on the leaves, and 1, 2, 3 and 4 when there were 0.5, 1-2, 3-10 and more than 10 spots/4 cm^2 of the leaf, respectively. The number of fungal spores/4 cm^2 of leaf was determined by vigorously shaking 45 leaf squares (2 X 2 cm) from each plant for 5 min in 100 ml water in a 250-ml flask and counting the spores in the suspension with a haemacytometer.

Four tests were made. In Test 1, cauliflower plants were sprayed weekly with the fungicides and inoculated weekly with *A. brassicae*. Disease severity and fungal spores/4 cm^2 of leaf were recorded 28 days after the initial spraying and inoculation. In Test 2, broccoli plants were sprayed with chlorothalonil flowable at different times before or after inoculation. The results were recorded 7 days after spraying. In Test 3, cauliflower plants were sprayed with chlorothalonil flowable and

Table 1. Effect of chlorothalonil, maneb, zineb and tricop on the development of alternaria leaf spot on cauliflower

Active ingredient fungicide/liter		Leaf spot*	Spores/4 cm^2 leaf (x 10^4)
Chlorothalonil			
Wettable powder	1.8 g	0.1 c**	0 c
	3.7 g	0 c	0 c
Flowable	1.4 ml	0.1 c	0 c
	2.7 ml	0 c	0 c
Maneb	2.6 g	0.5 c	0 c
Zineb	2.5 g	0.3 c	0.2 c
Tricop	1.8 g	3.1 b	1.8 b
Water check	—	3.5 a	7.6 a

*0 = no leaf spot on the leaves; 1, 2, 3 and 4 = respectively, 0.5, 1-2, 3-10 and more than 10 spots /4 cm^2 leaf.

**Figures followed by the same letter are not significantly different ($P = 0.05$).

each of seven chlorothalonil–insecticide combinations. Disease severity was recorded 7 days after inoculation. In Test 4, broccoli, cabbage and cauliflower plants were sprayed twice at 7 days interval with 0.6, 1.2, 3.7 or 7.4 g active chlorothalonil wettable powder per liter water. The plants were not inoculated with *A. brassicae* but maintained for 14 days in the greenhouse (14 h. light, 10 h dark, 25± 2 C). Data were analyzed statistically (Duncan's multiple range test).

Results and discussion

Leaf spot and fungal spores/4 cm^2 leaf area of cauliflower plants that received weekly sprays of the fungicides and inoculations with *A. brassicae* were less on chlorothalonil, maneb and zineb treated plants than on those treated with tricop (Table 1). There was significantly more leaf spot on the check plants than on any of the fungicide treated ones. The results of the second test indicated that chlorothalonil was a protectant (Table 2). There was significantly less leaf spotting on plants sprayed 1 day after inoculation with *A. brassicae* than on those sprayed 2 or 3 days after inoculation. The disease was absent on those treated 3 h, 1 and 3 days before inoculation. Water treated check plants were heavily defoliated.

Table 3 data indicated that chlorothalonil was compatible with the insecticides used. Leaf spot was controlled equally by treatments of plants with chlorothalonil alone and any of the chlorothalonil-insecticide combinations. Significantly more leaf spot occurred on the checks than on any of the other treated plants.

Chlorothalonil proved not to be phytotoxic to the crucifers used in Test 4 in the greenhouse (data not presented). No abnormal symptoms on the foliage nor significant weight differences of chlorothalonil treated and nontreated check plants were observed.

Our work demonstrated that under laboratory conditions chlorothalonil effectively controlled leaf spot of crucifers.

Table 2. Effect of time of application of chlorothalonil (2.7 ml/liter water) on the development of alternaria leaf spot on broccoli

Time of spraying (days)	Leaf spot* Chemically treated	Water check
Before inoculation		
3	0 c**	4.4 a
1	0 c	3.5 a
0 (3 h)	0 c	3.6 a
After inoculation		
1	1.8 b	3.6 a
2	4.1 a	4.4 a
3	4.0 a	4.2 a
Noninoculated check	0 c	0 b

*0 = no leaf spot on the leaves; 1, 2, 3 and 4 = respectively, 0.5, 1-2, 3-10 and more than 10 spots/4 cm^2 leaf.

**Figures followed by the same letter are not significantly different ($P = 0.05$).

Table 3. Effect of chlorothalonil alone and chlorothalonil-insecticide combinations on the development of alternaria leaf spot on cauliflower

Active ingredient fungicide or insecticide/liter	Leaf spot*
Chlorothalonil flowable only (1.4 ml)	0.3 b**
Chlorothalonil flowable (1.4 ml) + insecticide	
Endosulfan (1.3 ml)	0 b
Azinphos-methyl (0.9 g)	0.5 b
Dipel (1.7 g)	0.5 b
Methamidophos (1.3 ml)	0.5 b
Dimethoate (0.6 ml)	0.3 b
Mevinphos (0.2 ml)	0.3 b
Carbaryl (1.7 g)	0 b
Water only (check)	3.5 a

*0 = no leaf spot on the leaves; 1, 2, 3 and 4 = respectively, 0.5, 1-2, 3-10 and more than 10 spots /4 cm^2 leaf.

**Figures followed by the same letter are not significantly different ($P = 0.05$).

However, it was not determined whether this fungicide can be used as an effective substitute for maneb, zineb and tricop for leaf spot control in the field.

Acknowledgment

We thank W. P. Skoropad, University of Alberta, Edmonton T6G 2E3, for supplying cultures of *A. brassicae* and Judy Shaw for technical help.

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Mycosphaerella tassiana on Cruciferae in Western Canada[1]

G.A. Petrie[2] *and T.C. Vanterpool*[3]

A species of *Mycosphaerella* commonly found in Western Canada on overwintered stubble of rape (*Brassica napus*) and turnip rape (*B. campestris*) and stems of weed species of the Cruciferae, Compositae and Chenopodiaceae has been identified as *M. tassiana* var. *tassiana*. The fungus in question is distinct from that causing ring spot of *B. oleracea*, *M. brassicicola*, authentic collections of which have apparently not been found to date on rape in Western Canada. Ascospore discharge in *M. tassiana* usually began during the first week of June, reached a peak by the third week of June, and then rapidly declined.

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Une espèce de *Mycosphaerella* généralement trouvée au printemps dans l'ouest du Canada sur les chaumes de colza (*Brassica napus*) et de navette (*B. campestris*) et sur des tiges d'espèces adventices de *Crucifères, Composées* et *Chénopodiacées* a été identifiée comme étant *M. tassiana* var. *tassiana*. Ce champignon est différent de *M. brassicicola*, agent de la tache annulaire chez *B. oleracea* dont on n'a vraisemblablement pas encore trouvé de véritable spécimen sur colza dans l'ouest du Canada. La décharge des ascospores de *M. tassiana* commence généralement la première semaine de juin, atteint son sommet au cours de la troisième semaine pour diminuer ensuite rapidement.

In 1958, Vanterpool collected in east-central Saskatchewan a disease of turnip rape (*Brassica campestris* L.) which was characterized by rather striking ashen grey stem lesions (Vanterpool, 1960). The disease appeared to be ring spot, which on this continent was reportedly confined exclusively to moist coastal regions of Washington, Oregon and California (Nelson and Pound, 1959). Although spermogonia were found in abundance in lesioned parts of the stems of the Saskatchewan material, the ascosporic state, *Mycosphaerella brassicicola* (Fr. ex Duby) Lind. was the object of an extensive but fruitless search over many years in Western Canada. However, since 1970, a species of *Mycosphaerella* has been collected on a number of occasions on overwintered rape stems both in Saskatchewan and Alberta. A study of this species was undertaken to determine whether it was in fact *M. brassicicola*. The widespread occurrence of ascocarps of the ring spot pathogen in the rape-growing area of Western Canada could be of considerable epidemiological significance. The results of these investigations are described in this paper.

Methods

Single ascospores cultures were secured in the following manner. Short pieces of infected rape stems were taped to the undersides of petri dish lids which were then placed over petri dish bottoms containing 15-20 ml of 2% water agar. Following ascospore discharge, isolated single spores of *Mycosphaerella* were aseptically removed to plates of V8 juice agar (V8A) containing, per liter, 200 ml V8 juice, 0.75 g calcium carbonate and 20 g agar. They were then compared with V8A cultures of various fungi, including *Cladosporium herbarum* Lk., *Pseudocercosporella capsellae* (Ell. & Ev.) Deighton, and *Mycosphaerella brassicicola*. A culture of the last-named species was obtained from Dr. P. H. Williams, University of Wisconsin, Madison. Ascocarps from field material were also crushed on microscope slides in drops of lactophenol-aniline blue and ascospores of *Mycosphaerella* measured at a magnification of 800X.

The ascospore discharge pattern of the species of *Mycosphaerella* was studied in ascospore liberation tunnels over a three-year period (1975-77) using a method similar to that of McGee (1977). Samples consisting of short segments of stems were stored out-of-doors. Each sample following thorough wetting with tap water was kept in a discharge tunnel for 1.5 h and spores collected on vaselined slides. Spore trapping was carried out at 4-week intervals.

Conidial suspensions from pure single ascospore cultures of the *Mycosphaerella* were atomized onto the leaves, flowers and young pods of plants of *B. napus* cv. Midas growing in the greenhouse, and the plants covered with plastic bags for periods of up to several days. Following uncovering, inoculated plants were examined periodically for several weeks for signs of infection.

Results

Between 1970 and 1977, many single ascospore cultures of the *Mycosphaerella* sp. were obtained from overwintered stems of turnip rape (*Brassica campestris* L.) and rape (*B. napus* L.) from the Peace River and

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Table 1. A comparison of reported dimensions of ascospores of two *Mycosphaerella* species with those of Saskatchewan collections of *Mycosphaerella* from Cruciferae and Compositae

Species	Source	Ascospore measurements (μ)	
		Average (L x W)	Range (L x W)
M. tassiana	Saskatchewan collections*		
var. *tassiana*	No. 16, *Brassica* sp.	22.6 x 7.4	18.2 – 32.5 x 6.6 – 8.8
	No. 78, *Brassica* sp.	24.1 x 7.2	20.4 – 28.6 x 6.1 – 8.3
	No. 109, *Brassica* sp.	23.2 x 7.8	20.9 – 30.8 x 6.6 – 9.4
	No. 5, *Sisymbrium loeselii*	22.0 x 6.9	17.6 – 27.0 x 5.5 – 7.7
	No. 12, *Sonchus* sp.	20.0 x 6.7	13.2 – 24.4 x 4.4 – 7.7
	No. 13, *Tragopogon pratensis*	21.1 x 7.0	18.7 – 26.4 x 5.5 – 7.7
M. tassiana			
var. *tassiana*	Wehmeyer (1963)		16 – 29 x 4.5 – 8.0
M. brassicicola	Dring (1961)		18–20–23 x 3.5 – 4.0
	Osmun and Anderson (1915)	24.5 x 4.3	
	Weimer (1926)		15 – 25 x 3.5 – 5.5

* Approximately 50 spores mounted in lactophenol-cotton blue were measured for each collection.

Lacombe areas of Alberta and, on several occasions, from the vicinity of Saskatoon, Saskatchewan. The ascospores were typically bicellular, but a second septum was frequently observed in germinating spores. All the isolations yielded only cultures identical with *Cladosporium herbarum*, the imperfect state of *Mycosphaerella tassiana* (de Not.) Johans. (Barr, 1958). They did not resemble the isolates of *Pseudocercosporella capsellae* or *Mycosphaerella brassicicola*. Unlike the typical greenish *Cladosporium* cultures, those of these two species were black to grey in color, considerably raised in the center, extremely restricted in their linear growth, and contained, in the case of *P. capsellae*, both spermogonia and cylindric to obclavate-cylindric conidia.

The species of *Mycosphaerella* was subsequently collected on overwintered stems of the following: *Arabis holboellii* Hornem., *Brassica campestris*, *B. napus* L., *Axyris amaranthoides* L., *Cirsium* sp., *Descurainia sophia* (L.) Webb, *Erysimum asperum* DC., *E. parviflorum* Nutt., *Sisymbrium loeselii* L., *Sonchus* sp., *Thlaspi arvense* L., and *Tragopogon pratensis* L.. Ascospore dimensions are compared in Table 1 with those reported in the literature for *M. brassicicola* (Dring, 1961; Osmun and Anderson, 1915; Weimer, 1926) and *M. tassiana* var. *tassiana* (Wehmeyer, 1963). Although spore lengths from the Saskatchewan collections did not differ greatly from those reported for *M. brassicicola*, spore widths were consistently greater than those of that species and approximated those of *M. tassiana* var. *tassiana*. In fact, the morphology of the unknown species resembled that of the latter very closely.

In spring, *Cladosporium herbarum* often appears on rape stubble as a black sooty mould on shiny black, often lens-shaped lesions extending from the stem base to a few cm above it or higher. This is the portion of the stem which often remains wet for a prolonged period during and after snow melt. It is from such material that ascospores of *M. tassiana* have been subsequently obtained. Striking symptoms of this type were observed in rape fields near Irma and Edgerton, Alberta, in May, 1973, and near Waldheim, Saskatchewan, in the early spring of 1975.

Ascospore discharge in *M. tassiana* generally increased rapidly from virtually nil in early June to a maximum during the third week of that month, and quickly declined thereafter (Fig. 1). In a few instances the high level of discharge was maintained until late July or early August.

The inoculated Midas plants remained free of symptoms for the duration of the greenhouse experiments. *C. herbarum* has been implicated as a cause of "pod drop" of rape (Petrie, 1973). However, blackening of the peduncles at the base of the pods, the symptom characteristic of pod drop, was not observed.

Discussion

It would appear that no authentic ascocarps of *M. brassicicola* have been found in the rape-growing area of Western Canada since "ring spot" was first described here (Vanterpool, 1960), nor has any other perfect state been linked to the disease as it occurs in this area. In 1968, the discovery of a "*Cercospora*" conidial state of "ring spot" was found in Saskatchewan. These and other pieces of evidence cast doubt on there being any connection of the disease, renamed "white leaf spot and grey stem", with *M. brassicicola* (Petrie and Vanterpool, 1975). The correct name of the conidial state of white

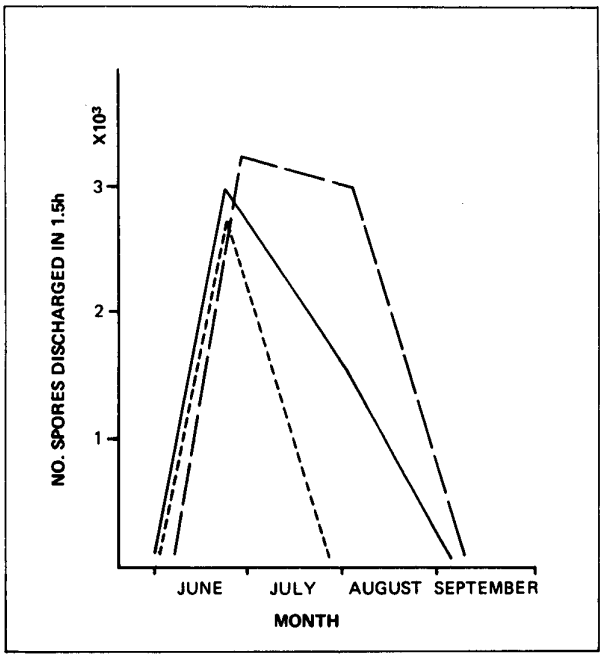

Figure 1. Ascospore discharge patterns for three representative collections of *Mycosphaerella tassiana* var. *tassiana* on rape stubble from Saskatchewan.

leaf spot and grey stem is *Pseudocercosporella capsellae* (Ell. & Ev.) Deighton (Deighton, 1973). This subject will be examined in more detail in a later publication.

The species of *Mycosphaerella* commonly found on rape and various weed species in Western Canada would seem to be the ubiquitous *M. tassiana* var. *tassiana*. Evidence for this is the morphology of the perfect and imperfect states and the unequivocal demonstration of a connection between the two. The fungus in culture is totally unlike *P. capsellae* or *M. brassicicola*. The host range of the *Mycosphaerella* from rape also is much broader than that of *M. brassicicola* which is reportedly confined to varieties of *Brassica oleracea* L. (Dring, 1961; Weimer, 1926). *M. tassiana* var. *tassiana* was found on a number of dicotyledons in the present study; it also has recently been reported as part of the air spora over brome grass crops in the Saskatoon area (Shoemaker et al., 1974). Conners (1967) lists numerous hosts of this species.

The significance of *M. tassiana* on rape is open to speculation. Its imperfect state, *C. herbarum,* is common in seed samples of turnip rape and rape. It has been associated with cotyledon yellowing of rape seedlings (unpublished data). In conjunction with *Alternaria alternata* (Fr.) Keissler it develops profusely on swathed rape under moist conditions and has been isolated from hypertrophies of the stem and inflorescence of turnip rape caused by *Albugo candida* (Pers. ex Lév.) Ktze. (*A. cruciferarum* S. F. Gray) (Petrie and Vanterpool, 1974). There is no evidence that *M. tassiana* is a pathogen of Cruciferae despite its association with pod drop of rape. Whether or not it in fact contributes in any way to the latter condition has not been satisfactorily demonstrated.

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Ranges of distribution of species of Pratylenchus in Northeastern North America

J.L. Townshend[1], *J.W. Potter*[1], *and C.B. Willis*[2]

Pratylenchus crenatus, P. hexincisus, P. neglectus, P. penetrans and *P. scribneri* are sympatric through the upper Great Lakes basin of North America. However, the distribution of *P. crenatus* and *P. penetrans* extends into the St. Lawrence River basin, northeastern United States, and the Maritime Provinces of Canada.

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Pratylenchus crenatus, P. hexincisus, P. neglectus, P. penetrans et *P. scribneri* sont des espèces sympatriques qui peuplent le bassin supérieur des Grands Lacs, en Amérique du Nord. Toutefois, la distribution de *P. crenatus* et de *P. penetrans* s'étend au bassin du St. Laurent, au nord-est des États-Unis et aux provinces maritimes du Canada.

Species of the genus *Pratylenchus* associated with horticultural and field crops in northeastern North America, have received much attention. The five most common species are *Pratylenchus crenatus* Loof, *P. hexincisus* Taylor and Jenkins, *P. neglectus* (Rensch), *P. penetrans* (Cobb), and *P. scribneri* Steiner. We are reporting the geographic distribution of these five species in northeastern North America (Figs. 1 & 2) as determined from examination of relevant literature (5, 6, 7, 8, 9, 10, and 11). We considered *P. pratensis* reported earlier than 1960 to be *P. crenatus* following Loof's (3) revision of *Pratylenchus*.

Pratylenchus penetrans, P. crenatus, P. neglectus, P. scribneri, and *P. hexincisus* are common in all the states in this study west of the Pennsylvania-Ohio border (Figs. 1 & 2). *Pratylenchus hexincisus* is limited in this area (Fig. 2). The ranges of *P. neglectus* and *P. scribneri* extend eastward into Pennsylvania, New Jersey, and New York (Fig. 2). The range of *P. neglectus* extends northward into southern and eastern Ontario. The ranges of the sympatric species, *P. penetrans* and *P. crenatus*, are the most extensive (Fig. 1), and extend northeast beyond the ranges of the other three species into the St. Lawrence River basin, northeastern United States, and Canada's Maritime Provinces.

Sympatry indicates a common tolerance of climatic and soil conditions, and the presence of suitable hosts for the nematode species sharing the same area. As *Pratylenchus* species are distributed less widely than their hosts in northeastern North America, we suspect that environment is a more important determinant of geographic ranges than is host plant distribution.

The optimal temperature for reproduction of *P. crenatus* is considered to be 10-15°C (1); in tropical Venezuela, this nematode is found only at high altitudes (2800 m and up) in the Andes Mountains, under temperature conditions typical of the temperate zone (4). In Japan, *P. penetrans, P. crenatus,* and *P. neglectus* are found primarily on the northern islands of Hokkaido and Honshu where the annual mean air temperature ranges from 15°C on Honshu to 10°C or less on Hokkaido (2). Similarly, in northeastern North America, a 5°C annual mean isotherm coincides with the known northern limit of the ranges of the above species and the 10°C isotherm coincides with the southern limit of the geographic area studied. The 5°C annual mean isotherm also coincides with the northern extent of an area having 120 or more frost-free days. A more critical examination of temperature reveals that the 21°C July isotherm coincides with eastern and northern limits of the range of *P. scribneri* and *P. hexincisus*. Furthermore, the geographical area in which *P. scribneri* and *P. hexincisus* occur has 160 or more frost-free days per year. It seems that mean annual temperature and frost-free days probably define the geographical limits of *Pratylenchus* species in northeastern North America.

Several other species of *Pratylenchus* which are found infrequently or rarely and occur in the central and western portions of the area studied are *P. alleni* Ferris, *P. coffeae* (Zimmermann), *P. pratensis* (de Man), *P. subpenetrans* (Taylor & Jenkins), *P. thornei* Sher & Allen, *P. vulnus* Allen & Jensen (only in greenhouses), and *P. zeae* Graham. Of these species only *P. thornei* and *P. pratensis* occur in southern Ontario, having been identified twice (8). In the province of Quebec, *P. fallax* Seinhorst and *P. flakkensis* Seinhorst occur rarely (11).

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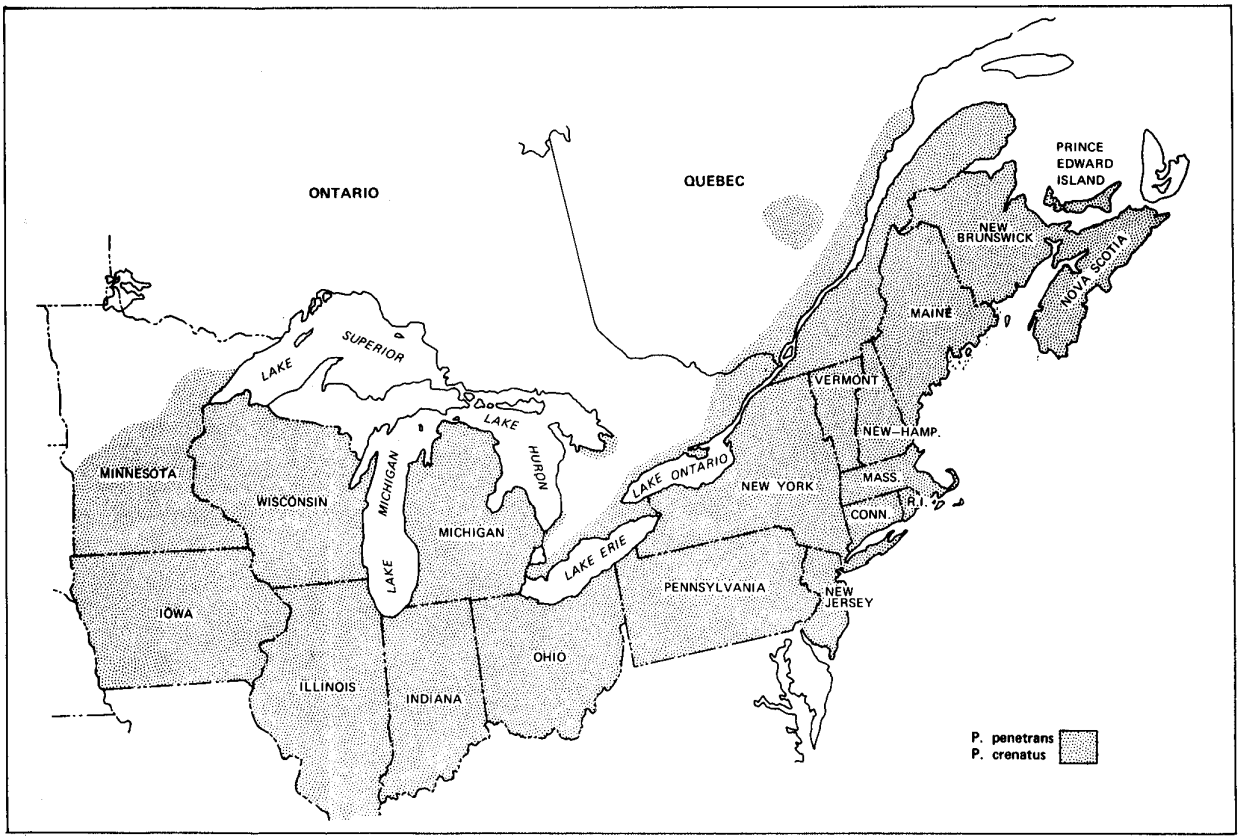

Figure 1. Distribution of *Pratylenchus penetrans* and *P. crenatus* in northeastern North America. The shading is not intended to imply that a nematode species is uniformly distributed throughout a state or province.

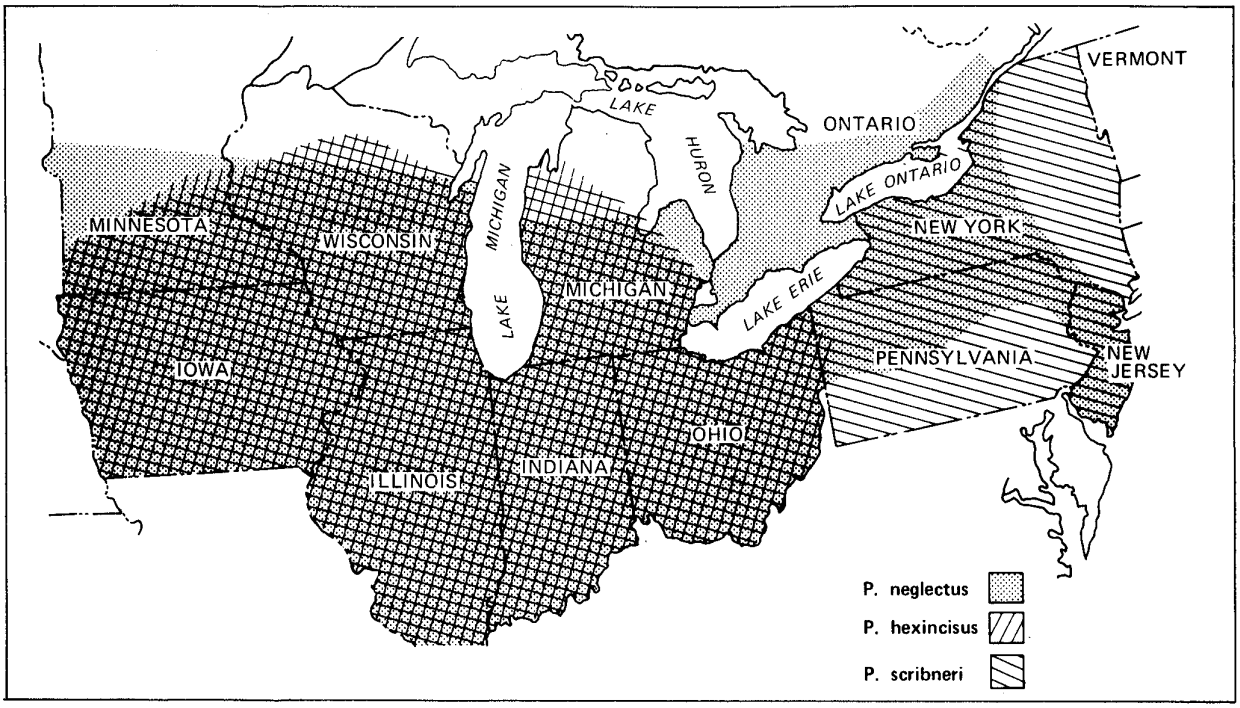

Figure 2. Distribution of *Pratylenchus neglectus, P. scribneri,* and *P. hexincisus* in northeastern North America. The shading is not intended to imply that a nematode species is uniformly distributed throughout a state or province.

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Fan-mould of carnation caused by *Phialophora cinerescens*[1]

A.T. Bolton

The fungus, *Phialophora cinerescens* (Wollenw.) van Beyma, was isolated for the first time in Canada. This pathogen causes fan-mould of carnation (*Dianthus caryophyllus* L.) and was obtained from plants in a greenhouse near Norval, Ontario. Inoculations with the pathogen, both by infesting the soil and dipping the roots before planting, produced typical symptoms of the disease in rooted carnation cuttings, but in a much shorter time than that described in the literature.

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Le champignon *Phialophora cinerescens* (Wailenw.) van Beyma a été isolé pour la première fois au Canada. Cet agent de la moisissure des oeillets (*Dianthus caryophyllus* L.) a été trouvé chez les plants provenant d'une pépinière située près de Norval (Ontario). Les inoculations de ce pathogène dans le sol et le trempage des racines dans une solution pathogène ont donné les symptômes caractéristiques de la maladie chez les oeillets racinés, mais en beaucoup moins de temps que les autres expériences signalées dans la bibliographie.

Phialophora cinerescens (Wollenw.) van Beyma was isolated from carnation (*Dianthus caryophyllus* L.) plants growing in a greenhouse near Norval, Ontario. This is the first report of the fungus in Canada. Fan-mould caused by *P. cinerescens* has been reported from several European countries (Hellmers 1958, Wickens 1935) and the United States (Nilsson and Dimock 1964). The fungus attacks the plant mainly through the roots and proceeds upward through the vascular system. The movement of the fungus is quite slow and the incubation period is reported to be about 2 months (Hellmers 1958).

The symptoms of the disease vary, but, usually, the most conspicuous symptom is the dry, straw-like appearance of the stems and leaves. Under natural conditions, the disease usually begins in a single plant and gradually spreads to healthy plants, hence the name "fan-mould".

Materials and methods

P. cinerescens, collected and isolated from Ontario grown carnations, was used to inoculate rooted cuttings of the cultivars Scania 3C and U. Conn. Sim #1. The fungus was grown on potato dextrose agar for 21 days and a suspension of the conidia in distilled water (1.5 million/ml) was prepared. A mixture of pasteurized soil, sand, and peat (2:1:1) was infested with the pathogen by incorporating the suspension at a rate of 100 ml/liter of mixture. The infested mixture was placed in 12-cm plastic pots and 4-week-old rooted cuttings planted therein. A second group of rooted cuttings was immersed for 1 hour (roots only) in the spore suspension and then planted into 12-cm pots containing only the soil-sand-peat mixture.

Additional studies were carried out simulating conditions under which carnations are produced commercially. The soil-sand-peat mixture was used to fill a greenhouse bed and rooted carnation cuttings, previously inoculated by immersing their roots for 1 hour in a spore suspension, were planted into this mixture. This experiment was repeated 3 months later. Greenhouse temperature was maintained at 21°C night and 25°C day, although during the second test (July-September) day temperatures reached 30°C several times. Water soluble 20-20-20 fertilizer was applied at 7-day intervals during the experiments.

Results

In the pot experiments, symptoms first appeared 21 days after inoculation when the plants had been immersed in the spore suspension, and 26 days after inoculation when the plants were grown in infested soil-sand-peat. In both cases, plants were completely necrotic 49 days after inoculation. At this time, the fungus was readily isolated from stem sections from ground level to within 5 cm of the tips of the plants. The pathogen was present in the roots, but the abundance of secondary organisms made isolation difficult.

In the bench experiments, there was no significant difference in disease development between the two tests and, consequently, the data were averaged. Symptoms first appeared 17 days after inoculation and, 42 days later, 90% of the plants (137/150) were severely diseased and 53% of these were completely necrotic. Initial symptoms appeared as a bluish discoloration and wilting of the lower leaves and, 14 days later, 58% of the plants exhibited an average of six leaves with definite

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Table 1. Rate of disease development of carnation plants inoculated with *P. cinerescens* (av. of 2 tests)

Days after inoculation	Disease categories*				
	0	1-7	8-13	14-20	>20
17	118	32	0	0	0
24	98	42	10	0	0
31	63	48	39	0	0
38	27	40	75	8	0
45	0	14	60	68	8
52	0	1	17	86	46
59	0	0	13	64	73

*Based on number of leaves per plant showing symptoms.

wilting and discoloration (Table 1). Thirty-eight days after inoculation, 82% of the plants showed symptoms of varying severity (Fig. 1). Within 45 days of planting, 100% of the plants exhibited typical fan-mould symptoms.

Discussion

The Ontario isolate of *P. cinerescens*, the cause of fan-mould of carnation, appears to require a much shorter incubation period than those described in the literature. Hellmers (1958) reported that lower leaves began wilting 2 months after inoculation and that all plants had completely wilted after 5-6 months. Wickens (1935) reported the incubation period of the fungus between 7 and 17 weeks when the plants were inoculated either by infesting the soil or directly through wounds in the stems. He observed shorter incubation periods when the plants were inoculated during the summer and attributed this to higher temperatures in the greenhouse. Nilsson and Nelson (1964) found that symptoms appeared 25 days after spore suspensions were injected directly into the stems. They observed that die-back of the pathogen in the host occurred at higher temperatures. Nilsson and Dimock (1964) reported that "infected plants may remain symptomless for several months." They found that, where the temperature rose above 80°F (26.7°C), disease development ceased.

The significance of the shorter incubation period of the Ontario isolate has not yet been determined. No differences were observed in length of incubation period or disease development between plants inoculated and grown in March-May when temperatures were maintained between 21 and 25°C and those grown in July-September when, occasionally, the temperatures inadvertently rose to 30°C. The possibility exists, however, that this isolate represents a new, more virulent strain of the fungus. The isolate from Ontario probably originated outside Canada and was brought into the country in infected cuttings. With the importation of rooted carnation cuttings both from the United States and Europe, there is imminent danger of the fungus being introduced into numerous greenhouses in Canada. The eradication of the pathogen from infested soil is very difficult, especially where the plants are grown in bottomless beds in the ground. Control studies are now being carried out at Ottawa.

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Figure 1. Carnation plants growing in a greenhouse bed 38 days after inoculation with *P. cinerescens* using the root-dip method.

Occurrence of rubbery brown rot of stored carrots in Alberta

D. Stelfox and A.W. Henry[1]

A Phytophthora disease of carrots (*Daucus carota* L. var. sativa DC.) occurred in a cooperative storage in southern Alberta in 1970 and 1971. The same disease was found in stored commercial carrots on a farm near Edmonton in 1975. The causal fungus was associated with a rubbery brown rot and proved to be pathogenic when inoculated into immature and mature carrots and unwounded roots at low temperature. Infection was obtained when the organism was inoculated into several other species of horticultural plants.

Can. Plant Dis. Surv. 58: 87-91. 1978

En 1970 et 1971, le mildiou de la carotte (*Daucus carota* L. var. sativa DC.) s'est manifesté dans un entrepôt du sud de l'Alberta. La maladie est reparue en 1975 dans un lot de carottes commerciales entreposées dans une ferme des environs d'Edmonton. Le champignon causal associé à une pourriture brune caoutchouteuse s'est révélé pathogène par inoculation sur des carottes mûres et non mûres. A basse température, il s'attaque également aux racines saines. D'autres espèces de plantes horticoles ont été infectées par inoculation.

Rubbery brown rot disease of carrot (*Daucus carota* L. var. *sativa* DC.) under natural conditions was first described by Dowson (1934) and resulted in serious losses of the vegetable in transit. Symptoms of the disease are initially a water-soaked appearance of affected taproot tissues which later become firm and dark brown but remain watery (Dowson 1934; White 1945; Rader 1952). In storage and in transit affected root portions may be covered by a dense white surface mycelium (Dowson 1934) overlaying the cortical tissues which generally contain oospores. Of the several *Phytophthora* spp. previously reported as attacking carrots, only *P. cactorum* (Leb. & Cohn) Schroet. and *P. megasperma* Drechs. caused decay under natural conditions (Rader 1952). This note deals with a Rubbery Brown Rot of carrots caused by a *Phytophthora* sp. which differs in several respects from those species previously reported to attack the crop.

Stored carrots of the cultivar Imperator II from 6 grower-members of a southern Alberta vegetable cooperative were affected with a rubbery type of brown rot (Henry et al. 1971), in early winter 1969-70. The following winter stored carrots of 5 growers in the same cooperative were similarly affected. All stored carrots involved in the disease outbreak were grown under irrigation. Losses, were heaviest the first year of the outbreak, reaching an estimated 20% by mid-January in several large storage pallets. No symptoms or signs of the disease were reported by handlers during digging and washing operations.

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The next reported occurrence of the disease in commercial stored Imperator II carrots was near Edmonton, in December 1975. A grower had received bulk shipments of carrots for repacking from the southern Alberta cooperative carrot storage. Only 2 of his 4 affected fields had been irrigated. The soil, however, had received prolonged heavy rainfall during August of the growing season.

The Phytophthora-infected carrots in Alberta generally contained dark brown, firm, water-soaked areas sometimes in wide bands appearing anywhere on the root. The rot most commonly occurred near the middle and crown areas accompanied by a dense growth of white surface mycelium (Fig. 1A). Roots in advanced stages of decay were darker colored with a moist glistening surface, and tended to collapse readily. Interior rotted portions were usually brown, rubbery, and without noticeable leakage. Advanced stages of the rot were usually accompanied by fungi such as *Pythium* spp., *Botrytis* spp., *Fusarium* spp. and *Mucor* spp.

Materials and methods

To isolate the causal organism associated with the rubbery brown rot symptoms several procedures were used, the most successful being to break apart the edges of discolored tissues and aseptically transfer underlying darkened tissue to an antibiotic medium (Tsao 1970).

Pathogenicity tests were done at 20-0°C on surface-sterilized whole carrots and carrot slices. Five mm cork borer plugs of 14-day-old inoculum grown on cornmeal agar (CMA) were placed on freshly cut carrot slices. These surface-inoculated slices were incubated in sterile, moistened petri dishes. Inoculum plugs of a same size were placed at the bottom of 5 mm holes bored 10 mm deep at 3 positions along the length of whole carrots. Tissue plugs were replaced and inoculated areas

were tape-wrapped. The surface of inoculated whole carrots was moistened with sterile distilled water and placed inside tightly closed 1.5 mil polyethylene bags.

The potential pathogenicity of carrot isolates 980-1 and 1157 on alternate hosts was tested on selected tissues of 28 species of horticultural and legume plants. Inoculations involved inserting mycelium-bearing artificial media into plant tissue through toothpick and scalpel wounds. Inoculated host material was then incubated at 15°C and after 5 days results were recorded and reisolations attempted.

Contaminated field soil was suspected of being a possible source of inoculum for infection of immature carrots, particularly in low flooded areas. Experimental studies using pot-growing seedling carrots in inoculated soil were carried out in growth rooms at 20°C to test this hypothesis. In one experiment roots of seedlings up to 12 weeks of age were exposed to inoculated soil. Inoculum included blended sporangia-bearing cultures grown on CMA and introduced to pots through soil tubes. Other inoculum involved chopped infected carrot slices pushed into the soil near seedling roots. In another experiment 12 week-old seedlings were root-dipped in a slurry of sporangia-bearing inoculum before planting.

The possibility that feces from animals ingesting diseased carrots might spread inoculum was also investigated. Cattle manure and Richardson ground squirrel (*Spermophilus richardsonii* Sabine) fecal pellets were collected from animals fed Phytophthora-infected carrots. A slurry was prepared, using a 1:1 mix by volume, of feces and sterile sand covered in plastic dishes to a depth of 1-2 cm with sterile distilled water. Six day-old carrot and lettuce seedlings and leaf discs were floated as baits for 96 hours over the slurry incubated at room temperature.

The role of badly decayed carrots in disease transmission during storage was investigated. Affected carrots in commercial storage frequently produced sufficient aerial mycelium to bridge the space separating adjacent roots. During 2 trials each involving 6 replicates naturally-infected carrots from a commercial storage were bundled alongside healthy mature and immature roots. These were stored in moistened closed polyethylene bags and incubated at 5°C.

Fields of growers whose carrots were Phytophthora-infected in storage in 1970 and 1971 were sampled the following two growing seasons. Immature and mature carrots were lifted from the soil and placed in portable coolers for rapid transport to the laboratory. Following surface-sterilizing of underground parts, tissue was removed from taproots and rootlets then cultured on antibiotic media.

Results and discussion

Affected carrots from southern Alberta consistently yielded a slow-growing *Phytophthora* sp. on differential media. Edmonton area carrots yielded several isolates morphologically similar to those obtained from southern Alberta. Growth occurred readily on a variety of agar media on which non-septate mycelium with frequent knobby hyphal swellings was produced. Looping, skeining and a spidery mycelial growth often occurred. Sporangia formed abundantly on a variety of agar media without flooding. Sexual fruiting by oospores failed to occur on ordinary culture media. No Phytophthora oospores were found at any time in affected carrot tissue.

After 1 week incubation at 20°C inoculated carrot slices darkened slightly and became somewhat rubbery. Large liquid droplets appeared over the cut surface of core tissue. Three days later, infected carrot slices became quite soft and darkened noticeably. Within 1 week, whole inoculated carrots developed a soft water-soaked shiny appearance adjacent to cork borer plugs. A dense white weft of mycelium gradually developed over the darkened surface of infected tissue.

After 2 weeks incubation at 15°C inoculated slices and whole carrots developed symptoms similar to those which appeared within 1 week at 20°C.

Within 6 weeks at 5°C inoculated material (Fig. 1B) developed obvious rubbery brown rot symptoms. After 17 weeks incubation smaller carrot slices (Fig. 1C) were badly decomposed.

At 0°C noticeable darkening of affected tissue was visible within 7 weeks, following inoculation. Typical symptoms were well established after 13 weeks incubation but surface mycelium developed sparsely.

In each of the inoculation tests the fungus was recovered from darkened areas of affected tissue plated on an antibiotic medium.

Results of inoculating 28 other plant species indicated that the fungus has a wide host range. Positive results were obtained on ripe apples, green pears, bean pods, broccoli flower stalks, Brussels sprouts, cabbage stems, cauliflower curd and stems, cucumber fruits, pea pods, pepper fruits, potato tubers, radish roots, turnip roots and tomato stems and fruits. No infection followed inoculation of clover seedlings, beet roots, parsnip roots, and celery stalks.

None of the growth room pot-soil inoculations resulted in infection, even when carrot seedlings were flooded for 96 hours, following soil or root inoculation.

The fungus was not recovered from any test animal fecal slurry baits nor from antibiotic media smeared with test animal feces. The fungus was recovered from control samples involving "seeded" sterilized feces used as apple plugs and as plate smears. It was also recovered from lettuce leaf discs floating in petri dishes over a "seeded" fecal slurry.

Forty percent of previously-healthy carrots placed in contact with diseased carrots in moistened closed bags appeared brown and glistening (Fig. 1D) within 6 weeks. Aerial mycelium, although sparser than that

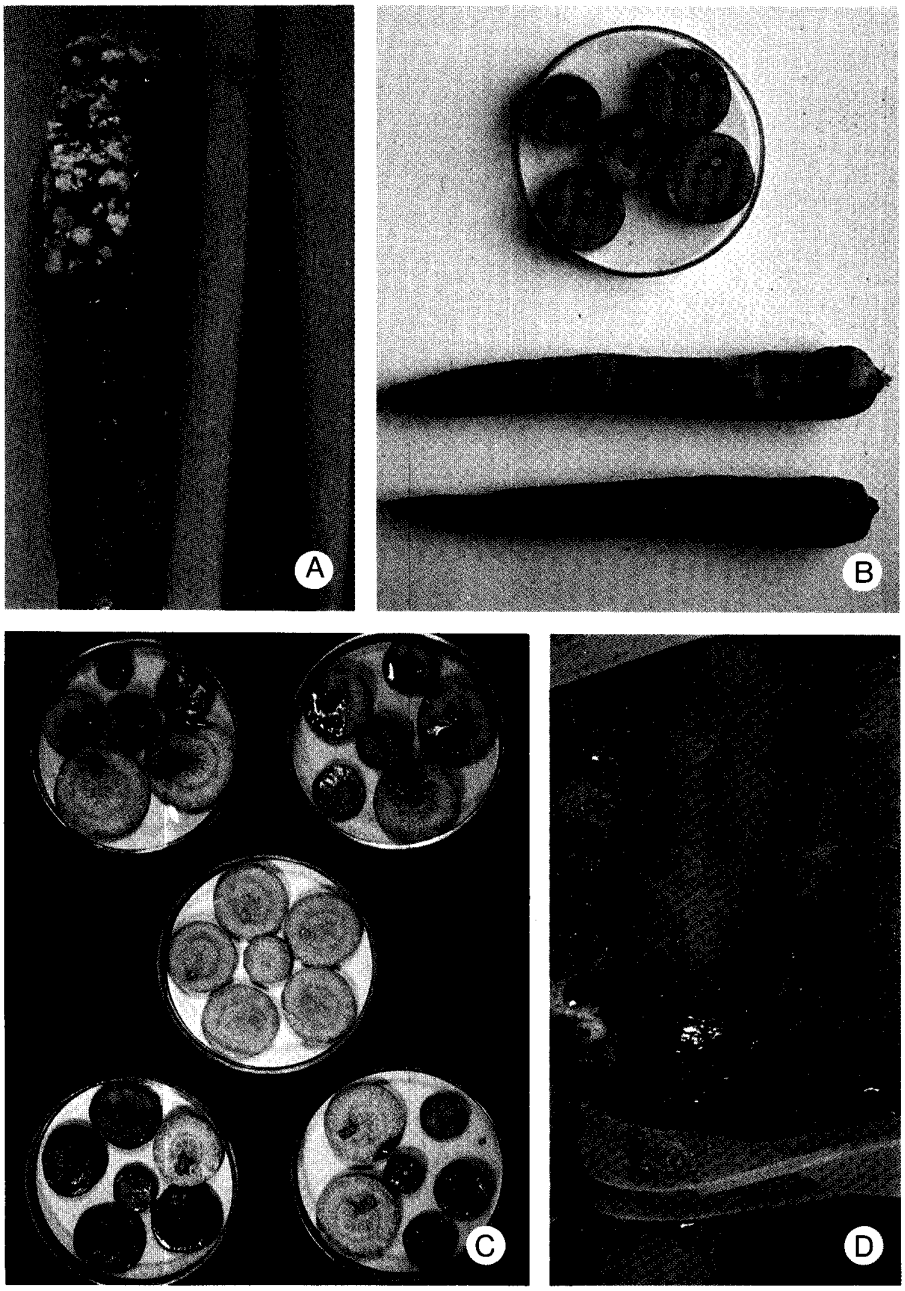

Figure 1. (A to D) Symptoms and signs of rubbery brown rot of stored carrots. (A) Dark brown discoloration is often accompanied by development of dense white mycelium. (B) Effects of artifical inoculation of whole carrots and slices. (C) A shiny liquid surface develops on infected carrot slices (control plate in centre). (D) Rot has spread from naturally-infected carrot (left) to immature and mature roots (right).

produced under natural storage conditions, nevertheless spread from carrot to carrot. The rubbery brown rot extended inward to a depth of 2-5 mm on newly-infected roots. Isolates obtained from them were identical to those from the naturally-infected host. In some cases, a *Pythium* sp. was isolated from the original carrot and was transmitted singly or jointly to the adjacent host. When this occurred aerial mycelium was more dense and flocculent than with the carrot infected with *Phytophthora* alone.

Field-sampled carrots from which root tissue was plated in the laboratory yielded no *Phytophthora*. The pathogen was not detected during weekly sampling beginning August 15, 1971. Nor was infection found in roots examined during the growing season of 1972.

Symptoms associated with Rubbery Brown Rot of carrots in Alberta are similar to those reported for the disease involving *P. cactorum* or *P. megasperma*. The species involved in our isolates, however, differs from these 2 species in several respects. Most noticeable is the absence of oospore production by the Alberta carrot Phytophthora in infected tissue or in cultures on ordinary media. Other differences are growth patterns and growth rates, as well as the knobby appearance of mycelium in our isolates. Species identification may not be achieved until the fungus is induced to reproduce sexually.

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Barley smuts in Manitoba and eastern Saskatchewan, 1975-77[1]

P.L. Thomas

Losses from barley smuts in Manitoba and eastern Saskatchewan were calculated to be 0.9% in 1975, 0.6% in 1976 and 0.5% in 1977. The incidence of *Ustilago nuda* remained low, despite the predominance of a biotype that was virulent on all varieties that were commercially important in the survey area. Bonanza appears to be more susceptible than Conquest to the current population of surface-borne smuts.

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Les pertes causées par les charbons aux cultures d'orge du Manitoba et de l'est de la Saskatchewan ont été évaluées à 0.9% en 1975, 0.6% en 1976 et 0.5% en 1977. La fréquence de *Ustilago nuda* demeure faible malgré la dominance d'un biotype qui manifeste de la virulence envers toutes les variétés commerciales importantes. Bonanza semble être plus sensible que Conquest à la population actuelle de charbon portée à la surface des grains.

Annual losses due to the barley smut fungi (*Ustilago nuda* (Jens.) Rostr., *U. nigra* Tapke, and *U. hordei* Pers. (Lagerh.)) in Manitoba and Saskatchewan were less than 1% during the period 1969-74 (1). The major change in the distribution of smut, during this period, was an increase in incidence on six-rowed varieties, accompanied by a decrease on two-rowed varieties. A new biotype of *U. nuda*, virulent on varieties possessing the Jet type of resistance, was first detected in 1972 and was found to be widespread in 1973.

Surveys were conducted in Manitoba and eastern Saskatchewan in 1975, 1976 and 1977. The objectives of these surveys were to estimate losses caused by the smut fungi on barley, to observe changes in the incidence of the biotype of *U. nuda* virulent on Jet and to collect smutted spikes to test for virulence patterns on varieties of current commercial importance.

Incidence of smut in farm fields

An estimate of the percentage of smutted plants was made while walking an ovoid path of approximately 100 m in each field. Levels of smut greater than trace were estimated by counting plants in a 1 m^2 area at at least two sites on the path.

Smut was found in a majority of fields examined each year (Table 1). Both the proportion of fields affected and the mean percentage of smutted plants decreased in 1977, despite the high proportion of fields that were affected in 1976. This reduction was probably due to a decrease in infection by *U. nuda* and *U. nigra* (Table 2). The mean percentage of plants infected by *U. hordei* appears to have increased slightly. The two-rowed varieties continued to exhibit less smut than the six-rowed varieties.

Virulence of *U. nuda*

The method of inoculating barley with *U. nuda* was described previously (1).

The collections of *U. nuda* from 1974-77 were screened on Conquest, to determine those that were capable of infecting varieties with resistance from Jet. The results, compared to those from 1972-73 (1), are shown in Table 3. The biotype that is virulent on Conquest has become predominant in the survey area. However, the number of farm fields affected by *U. nuda* remains low (Table 2). Therefore, the predominance of this biotype, despite its virulence on all varieties of commercial importance, does not appear to pose a threat to barley production.

The survey collections of *U. nuda* from 1975-77 were also screened on CI 13662, a variety carrying the *Un8* gene for resistance to loose smut. None of the collections smutted this variety, indicating that *Un8* can be used when breeding for resistance to *U. nuda*.

Virulence of *U. hordei* and *U. nigra*

According to reports by the three Pool Elevator Companies, the varieties Bonanza, Conquest, Fergus and Herta accounted for at least 90% of the area sown to barley in Manitoba from 1972-77. The survey collections of *U. hordei* and *U. nigra* from 1974-76 were therefore screened on these varieties to detect the potential effects of current strains of smut on these varieties. Inoculations were done as described previously (1), using 200 ml of inoculum, in a Waring Blendor, for each 200 seeds. The infection data for each year were averaged (Table 4) because (a) the bulk of the data could be reduced in this manner, (b) the individual collections yielded data that were similar in infection level and pattern to those found for the 1972 collections (1), and (c) the averages

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Table 1. Incidence of smut in barley in Manitoba and eastern Saskatchewan, 1975-77

Year	Number of fields examined		% of fields affected			Mean % smutted plants		
	2-rowed	6-rowed	2-rowed	6-rowed	All varieties	2-rowed	6-rowed	All varieties
1975	43	80	56	80	72	0.2	1.2	0.9
1976	42	102	55	86	77	0.1	0.9	0.6
1977	19	39	21	74	57	0.2	0.7	0.5

Table 2. Incidence of three species of *Ustilago* on barley in farm fields, in Manitoba and eastern Saskatchewan, 1975-77

Ustilago species and type of barley affected		% fields affected			Mean % smutted plants		
		1975	1976	1977	1975	1976	1977
U. nuda	2-rowed	21	19	0	tr*	tr	0
	6-rowed	15	13	5	0.4	tr	tr
	all varieties	16	15	3	0.3	tr	tr
U. nigra	2-rowed	14	29	0	0.1	tr	0
	6-rowed	65	67	23	0.4	0.4	tr
	all varieties	47	56	16	0.3	0.3	tr
U. hordei	2-rowed	35	14	21	0.1	tr	0.2
	6-rowed	40	58	46	0.5	0.5	0.7
	all varieties	38	45	38	0.3	0.3	0.5

*tr = trace, <0.1%

Table 3. Infectivity to Conquest barley of *U. nuda* samples collected from farm fields in Manitoba and eastern Saskatchewan, 1972-77

Year	# of samples	% of samples infecting Conquest
1972	18	17
1973	55	22
1974	23	43
1975	21	57
1976	21	57
1977	4	50

illustrate the infection potential of the natural populations.

The results from 1974-76 for the two-rowed varieties corroborate those from 1972 in showing that Fergus is less susceptible, to the surface-borne smuts, than Herta. In four years of tests, *U. hordei* caused 31-63% less smut on Fergus than on Herta, while *U. nigra* caused 48-71% less.

The six-rowed variety Conquest was consistently less smutted than Bonanza, ranging from 17-25% less for *U. hordei* and 25-40% less for *U. nigra* (Table 4). The two varieties were previously thought to have the same reaction to smut because the relatively low level of infection rendered their difference in resistance difficult to recognize when dealing with individual collections. The difference in resistance would help to explain the previous report of an increase in smut on six-rowed varieties versus two-rowed varieties (1), because the area sown to Bananza in Manitoba increased from zero in 1969 to 34% in 1977 while Conquest decreased from 61% to 20% during the same period (data reported by the Federal Grain Company 1969-71 and the three Pool Elevator Companies, 1972-77).

The yearly variation in mean percentage infection on individual varieties (Table 4) probably reflects differences in the environmental conditions under which the tests were grown, rather than variations in virulence levels caused by different biotypes in the survey collections.

Table 4. Infectivity on four barley varieties of samples of the surface-borne smuts collected from farm fields in Manitoba and eastern Saskatchewan, 1972-76

Year	% infection by *U. hordei*					% infection by *U. nigra*				
	# of collections	Bonanza	Conquest	Fergus	Herta	# of collections	Bonanza	Conquest	Fergus	Herta
1972	26	12	9	7	19	21	8	6	8	28
1974	69	8	6	6	10	57	10	6	8	16
1975	43	12	10	9	13	59	18	12	11	21
1976	82	16	12	9	23	79	15	10	18	43

Conclusions

These survey results show that a majority of fields are affected each year, by strains of smut fungi that are capable of causing serious losses. However, losses from barley smuts continue to be less than 1% per year. The factors that will maintain this low yield loss are: environmental conditions that decrease the incidence of smut, effective use of seed-treatment fungicides by the growers and the release and promotion of resistant varieties.

Acknowledgments

Most of the 1977 smut samples were kindly collected by J. Nielsen and D.J. Samborski. Mrs. Vicki Bailey helped perform the technical aspects of this study.

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Cereal diseases in the Maritime Provinces, 1976

K.S. Clough and H.W. Johnston[1]

1976
Disease surveys illustrated the severity of previously reported cereal diseases. An unidentified non-pathogenic leaf spotting of barley was reported.

Can. Plant Dis. Surv. 58: 95-96. 1978

1976
Les enquêtes phytosanitaires ont mis en évidence le degré de sévérité de maladies des céréales déjà signalées auparavant. On a relevé sur l'orge la présence de taches foliaires non identifiées d'origine non pathogène.

The cereals grown in the Maritime Provinces, barley, oats, wheat and rye, were observed in experimental plots and in growers' fields from the time of planting until harvest. The weather in late May and June was warmer and drier than usual, but in July rainfall was higher than the norm and maximum daily temperatures were lower. A summary of climatic data is given in Table 1. The higher than average May rainfall total is attributable to heavy rainfall in early May before seeding. There were no hot humid spells until late August. This weather pattern may help to explain to some extent the atypical disease situation.

Table 1. Climatic data - Charlottetown 1976

	May	June	July	August
Total rainfall (mm)	116.5 (78.2)	60.4 (78.9)	101.6 (74.2)	87.2 (90.2)
Mean daily maximum temperature °C	15.2 (14.0)	21.5 (19.5)	22.7 (23.6)	23.1 (22.8)

Figures in brackets are the norms from data collected from 1941-1971.

Barley

Diseases on this crop were not as severe as usual. The cool wet July promoted the spread of scald incited by *Rhynocosporium secalis* (Oud.) Davis. This disease is rarely present in the Maritimes in recordable quantities but this year there was moderate infection in some fields. Winter barley, observed in the Annapolis Valley of Nova Scotia was severely infected by this organism. Moderately severe powdery mildew incited by *Erysiphe graminis* DC. ex Merat f. sp. *hordei* Marchall was observed in one field of Laurier barley in Colchester Co., Nova Scotia. In previous years only trace amounts of mildew have been observed on barley. The common barley pathogen, *Bipolaris sorokiniana* (Sacc. in Sorok.) Shoem. which causes root rot, seedling blight and spot blotch was not severe. Symptoms of spot blotch were observed on some of the later varieties and late plantings, but most of the barley senesced before 5% leaf spot coverage was recorded on flag and sub-apical leaves. Root rot and seedling blight severities were considerably lower than those experienced in previous years. The low infection by *B. sorokiniana* is attributed to the low inoculum levels reached after last year's unusually dry summer. The weather this summer was often wet but was too cool to promote rapid growth and sporulation of this fungus and therefore the incidence spot blotch was slight. Net blotch-like symptoms were prevalent on some later plantings of Loyola barley but isolations indicated that *B. sorokiniana* rather than *Pyrenophora teres* Died. Drechsl. was present. Isolates of *B. sorokiniana* from these leaves gave typical spot blotch symptoms when used to inoculate greenhouse-grown Loyola barley. It is suggested that the net blotch-like symptoms were an atypical expression of *B. sorokiniana* infection. Brown flecking and spotting symptoms appeared on certain barley cultivars particularly Herta between growth stages 5 and 9 (Feekes-Large Scale). These were not attributed to a pathogen. We consider them to be physiological in origin. On Laurier barley large chlorotic areas developed on the leaves. The centre of the lesions was marked by a necrotic spot. Further necrotic spots appeared towards the margins of these areas. These symptoms were not observed on other barley cultivars but were widespread on Laurier barley in the Maritimes and were also reported in Ontario (W.L. Seaman, personal communication). The cause of these symptoms has not been determined.

Oats

Septoria avenae Frank infection of oats was widespread in all observed areas of the Maritimes and appeared to

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be less affected by altered weather patterns than other cereal leaf diseases. Overall yield loss attributed to this disease was considered to be substantial.

Barley yellow dwarf was severe in northern New Brunswick but of infrequent occurence in Nova Scotia and P.E.I. Low levels of the disease in Nova Scotia and Prince Edward Island were attributed to reduced aphid populations early in the spring due to unfavourable weather conditions. Seeding dates in northern New Brunswick are later than those in other areas of the Maritimes and this may have also attributed to the severity of the disease there.

Wheat

Mildew (*E. graminis*) was recorded in most fields of spring wheat, but it was not severe except in areas where winter wheat was present nearby. *Septoria nodorum* (Berk.) was moderate to severe on leaves and glumes. *Fusarium culmorum* (W.G. Smith) Succ. was frequently identified causing some culm rot, moderate to severe head blight and in some instances node breakage. Both *Septoria* and *Fusarium* were considered to be more severe than in previous years.

Mildew and septoria were observed on winter wheat but were not considered to be severe.

Fall Rye

This crop is usually relatively disease-free, however, in early July, sooty moulds, caused by *Cladosporium* sp. and *Alternaria* sp. were present on leaves and heads of fall rye. Ergot-infected heads were infrequently found.

Cereal diseases in the Maritime Provinces, 1977

K.S. Clough and H.W. Johnston[1]

1977
Scald and net blotch of barley are apparently increasing in severity in the Maritimes. Little difference in severity of other cereal diseases was noted.

Can. Plant Dis. Surv. 58: 97-98. 1978

1977
La tache pâle et la rayure réticulée de l'orge semblent gagner en gravité dans les Maritimes. On ne note que peu de changement dans l'évolution de la gravité des autres maladies ces céréales.

Barley, wheat, oats, and rye were observed on experimental plots and growers' fields from May until harvest in August and early September. Most seeding was carried out in May. The weather in June and July was highlighted by above average precipitation and cool temperatures. Sunshine duration was 30% below normal in June but slightly above normal in July. June was a poor month for crop growth because of heavy rains. In August temperatures and sunshine duration were above normal.

Barley

Barley diseases were prevalent and this was reflected in yields which were approximately 10-15% lower than in 1976 when disease development was slight. The cool wet weather in June and July promoted the development of leaf scald, caused by *Rhyncosporium secalis* (Oud.) Davis. This disease appears to be increasing in severity in the Maritime provinces, however, it rarely affected the upper two leaves except in crops that were seeded early and reached growth stage 8 (Feekes-Large Scale) in mid-June. Crops seeded in late May were infected with scald during growth stages 5 to 7 but infections rarely reached the top three leaves. Spread of infection appeared to cease in late June.

The most significant leaf diseases on barley in 1977 were net blotch caused by *Pyrenophora teres* (Died.) Drechsl. and spot blotch cause by *Bipolaris sorokiniana* (Sacc. in Sorok.) Shoem. Some early infections of spot blotch at growth stages 2 and 3 were reported on Volla barley in New Brunswick but in general both these diseases became apparent after flag leaf emergence when senescent lower leaves and leaf sheaths provided a medium for saprophytic growth of these fungi and therefore became a source of inoculum. In many areas net blotch was more prevalent than spot blotch; for example, in Prince Edward Island, net blotch disease readings ranged from 10 to 50% on the second leaf at growth stage 10.5.1. Spot blotch readings were consistently less than 5%. In spore traps, conidia of *P. teres* were 10 to 20 times more numerous than those of *B. sorokiniana*. Both diseases were more severe in late plantings and in fields where barley had been grown continuously for three years or more.

Physiological leaf spots were not common but were observed occasionally on two-row varieties. The striking lesions reported on Laurier barley in 1976 (1) were rarely seen.

Barley yellow dwarf was present to a lesser degree in 1977 than in 1976. This disease was limited to slight to moderate degrees of severity in late-seeded cereal fields.

Common root rot was present in all barley fields examined to varying degrees of severity. Root rot losses from experimental fields varied from 10-40% of potential yields. In addition to *B. sorokiniana*, considerable numbers of *Fusarium* spp. were isolated from diseased barley roots.

Wheat

Powdery mildew of wheat caused by *Erysiphe graminis* DC. ex Merat f. sp. *tritici* Marchal was endemic in all areas but yield losses were severe on spring wheat only in areas of winter wheat production or where high levels of nitrogen fertility were used.

Septoria nodurum Berk. caused moderate to severe symptoms of leaf blotch and glume blotch in spring and winter wheats. Frequent rains in July provided ideal conditions for the splash dispersal of conidia and by the first week in August the disease was visible in most fields of spring wheat. Exceptions were the fields with low fertility and poor stands. It was particularly severe in fields where wheat had been grown the previous years.

Head blight, caused by *Fusarium* sp. was common in wheat. Sooty moulds often appeared on blighted heads.

Take-all in spring wheat caused by *Gaeumannomyces graminis* var. *tritici* Walker, was common in areas where Opal wheat had been cultivated frequently in past years. This disease is of increasing concern where growers are producing wheat each year. Affected crops showed

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numerous small patches of diseased plants throughout the fields.

Oats

Septoria avenae Frank. infection was widespread and ranged from slight in mixed grain fields to moderately severe in fields of pure oats. *Dreschlera avenacea* (Curt ex Cke.) Shoem. levels on oat seeds reached some 70% for New Brunswick and, on oat leaves, accounted for an unknown but probably considerable proportion of symptoms classified locally as 'Septoria'.

Winter Cereals

In 1977 winter wheat production was confined to the Annapolis Valley whereas small acreages of fall rye were grown in all three provinces. Winter survival was poor, rye fared slightly better than wheat but the numerous freeze-thaw cycles took their toll on both these crops. Snow mould was not a factor in poor survival. During the growing season rye was generally healthy. Small amounts of ergot were found at the edges of some fields. Wheat showed symptoms of powdery mildew, *Septoria* leaf blotch and glume blotch and *Fusarium* head blight.

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Prevalence of six fungal pathogens associated with seeds of rape and turnip rape in Western Canada in 1976[1]

G.A. Petrie

Commercial seed lots of rape (*Brassica napus*) and turnip rape (*B. campestris*) from the year 1976 were examined for six fungal pathogens and the results compared with those of an earlier study conducted between 1967 and 1973. The six species were *Alternaria brassicae, A. raphani, Fusarium roseum, Botrytis cinerea, Sclerotinia sclerotiorum,* and *Albugo candida (A. cruciferarum)*. The prevalence and incidence of all these, with the exception of *A. brassicae,* were higher in 1976 than in 1967-73. A considerable increase in *A. raphani* occurred on seed from southern Alberta and from Manitoba but levels of *A. brassicae* remained relatively static or even declined, except in the Peace River area of Alberta. *B. cinerea* occurred in 74% of seed samples from northern Alberta, indicating the possibility of an increase in seedling emergence problems. In that area also there was a large increase in *S. sclerotiorum* occurring in or on the seed itself, as opposed to its occurrence as sclerotia mixed with the seed. Oospores of *A. candida* were found in a much higher percentage of Alberta and Saskatchewan samples of *B. campestris* in 1976 than in 1967-73; mean infestation levels, as spores per g of seed, and the proportion of heavily infested samples also increased.

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Nous avons examiné la mycoflore pathogène de lots de semences de colza (*Brassica napus*) et de navette (*B. campestris*) de la campagne 1976, et comparé les résultats avec ceux d'une étude antérieure réalisée entre 1967 et 1973. Nos travaux recherchaient particulièrement six espèces: *Alternaria brassicae, A. raphani, Fusarium roseum, Botrytis cinerea, Sclerotinia sclerotiorum* et *Albugo candida (A. cruciferarum)*. La fréquence et la densité d'infestation de chacune de ces espèces se sont révélées plus fortes que dans la période d'observation précédente, sauf dans le cas de *A. brassicae*. On a noté une nette recrudescence de *A. raphani* dans les semences en provenance du Manitoba et du sud de l'Alberta, mais la fréquence de *A. brassicae* est demeurée relativement stationnaire, et a même baissé, sauf dans la zone de la rivière de la Paix en Alberta. *B. cinerea* a été trouvé sur 74% des échantillons du nord de l'Alberta, ce qui laisserait prévoir une augmentation des troubles de levée des semis. Cette région accuse aussi un fort accroissement de *S. sclerotiorum* à la surface ou à l'intérieur des graines, plutôt que sous forme de sclérotes mélangés à la semence. Les oospores de *A. candida* étaient beaucoup plus fréquents dans les échantillons de *B. campestris* de l'Alberta et de la Saskatchewan que dans la période 1967-1973; les taux moyens d'infestation, établis d'après le nombre de spores par gramme de semences, ont également augmenté, de même que la proportion d'échantillons fortement infestés.

The results of a survey of seed-borne fungi of oilseed crops in Western Canada conducted between the years 1967 and 1973 have been published recently (5, 6). This paper reports the results of a similar study in which seed lots of rape (*Brassica napus* L.) and turnip rape (*B. campestris* L.) from the year 1976 were examined for pathogenic fungi as part of an ongoing periodic investigation of levels of pathogens in crucifer seed in the Prairie Provinces. Data for the following six pathogens will be presented; the diseased caused by each follows its Latin binomial: *Alternaria brassicae* (Berk.) Sacc. (alternaria black spot), *A raphani* Groves & Skolko (alternaria black spot), *Fusarium roseum* Lk. emend. Snyder & Hansen (mostly 'Acuminatum') (seedling blight and footrot), *Botrytis cinerea* Pers. ex Fr. (damping-off and seedling blight), *Sclerotinia sclerotiorum* (Lib.) de Bary (sclerotinia stem rot), and *Albugo candida* (Pers. ex Lév.) Ktze. (*A. cruciferarum* S. F. Gray) (white rust and staghead).

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Materials and methods

Seed lots of approximately 15 g each drawn at random from country grain elevators throughout the Prairie Provinces were obtained from the Canadian Grain Commission. On a provincial basis, total numbers of samples were as follows: 205 from Saskatchewan, 173 from Alberta, and 57 from Manitoba. Distribution of samples by crop district or agricultural reporting area is shown in Table 1. The crop districts recognized were those illustrated by Williams (9).

Subsamples of 200-300 seeds were plated on an agar medium as previously described (8) and, in the case of the lots of *B. campestris* seed, 5 g subsamples were also examined for oospores of *Albugo candida* by means of a washing and filtration technique (6).

Results

Percentages of samples infested by all of the pathogens except *Albugo candida* are presented in Table 1. The average % of seeds infested per sample for the two *Alternaria* species is given in Table 2 and these data for *Botrytis cinerea, Fusarium roseum* and *Sclerotinia sclerotiorum* in Table 3. Manitoba results were not

Table 1. Percentages of rapeseed samples from Saskatchewan, Alberta, and Manitoba infested by five fungal pathogens of rape in 1976

Province & C. D. or A. R. A.*	No. of samples plated		Pathogen					
			Alternaria brassicae	*Alternaria raphani*	One or both**	*Botrytis cinerea*	*Fusarium roseum*	*Sclerotinia sclerotiorum*
Saskatchewan								
1-3	10		10.0	70.0	70.0	10.0	30.0	0.0
5	24		41.7	79.2	79.2	12.5	29.2	0.0
6	22		9.1	54.6	54.6	4.6	9.1	0.0
7	18		27.8	94.4	100.0	11.1	11.1	0.0
8A	23		69.6	95.7	100.0	8.7	39.1	4.4
8B	34		20.6	70.6	73.5	14.7	50.0	0.0
9A	33		66.7	60.6	84.8	3.0	30.3	0.0
9B	41		48.8	70.7	90.2	4.9	34.1	0.0
Provincial total	205	Av.	40.5	73.2	82.4	8.4	31.2	0.5
Alberta								
1	1		0.0	0.0	0.0	0.0	0.0	0.0
2	20		20.0	100.0	100.0	25.0	35.0	0.0
3	6		33.3	83.3	83.3	33.3	33.3	0.0
4	65		56.9	75.4	78.5	32.3	43.1	1.5
5	30		80.0	93.3	93.3	50.0	53.3	1.3
6	16		87.5	87.5	93.8	50.0	75.0	12.5
7	35		91.4	100.0	100.0	74.3	54.3	14.3
Provincial total	173	Av.	65.3	87.3	89.0	44.5	48.6	5.2
Manitoba								
1+2	9		0.0	22.2	22.2	0.0	11.1	0.0
7-9	10		10.0	40.0	40.0	0.0	40.0	0.0
3-6	12		8.3	25.0	25.0	8.3	8.3	0.0
10+11	17		11.8	47.1	47.1	0.0	11.8	0.0
12-14	9		66.7	88.9	100.0	22.2	77.8	0.0
Provincial total	57	Av.	17.5	43.9	45.6	5.3	26.3	0.0

* Crop district or agricultural reporting area (Alberta).
** Refers to *Alternaria* spp.

included in Table 3 due to the rather sporadic low levels of infestation found.

A large majority of the samples from Saskatchewan were *B. napus*. The 1976 results for *Alternaria* spp. were similar to those recorded between 1968 and 1972 for this crop species [ref. (5), Table 2], with the exception that the levels of *A. raphani* were higher in 1976 than in any of the years covered in the earlier study. This increase in *A. raphani* was even more marked in Alberta samples, which were almost entirely *B. campestris* [comparing Tables 1 and 2 with ref. (5), Table 3]. Much heavier infestations of both *A. brassicae* and *A. raphani* occurred in the Peace River area (A.R.A. 7) in 1976 than in either 1969 or 1970 [ref. (5), Table 9], but much lower levels of *A. brassicae* were found in A.R.A. 6 in 1976. A large increase in *A. raphani* in A.R.A.'s 2 and 3 was also noted in that year. Manitoba samples were largely *B. napus*. A large increase in 1976 in the levels of *A. raphani* was noted here as well [comparing Tables 1 and 2 and ref. (5), Table 4].

Fusarium roseum occurred in a relatively large number of Saskatchewan samples, comparable to the high levels of 1972 [Table 1 and (5), Table 14]. It was much more prevalent in Alberta and Manitoba samples than in previous years [Table 1 and ref. (5), Table 15]. The infestation levels within samples (Table 3) are averages for infested samples only and are not directly comparable with those reported in the earlier paper. However,

Table 2. Mean % seeds infested per sample by *Alternaria* spp.; 1976 seed lots from Saskatchewan, Alberta, and Manitoba

Province & C. D. or A. R. A.*	All samples			Infested samples only		
	Alternaria brassicae	*Alternaria raphani*	One or both	*Alternaria brassicae*	*Alternaria raphani*	One or both
Saskatchewan						
1-3	0.1	0.9	0.9	0.5	1.2	1.3
5	0.4	1.9	2.3	0.9	2.4	2.9
6	0.2	0.7	0.9	2.3	1.3	1.7
7	0.3	1.3	1.6	1.0	1.4	1.6
8A	0.8	2.1	2.9	1.2	2.2	2.9
8B	0.1	1.2	1.3	0.5	1.7	1.7
9A	1.5	1.9	3.5	2.3	3.2	4.1
9B	0.7	1.4	2.1	1.4	2.0	2.3
Provincial average	0.6	1.5	2.1	1.4	2.0	2.5
Alberta						
2	0.2	5.6	5.8	0.8	5.6	5.8
3	0.3	5.3	5.5	0.8	6.3	6.6
4	1.2	1.8	3.0	2.1	2.4	3.8
5	2.3	2.2	4.4	2.8	2.3	4.7
6	1.5	8.8	10.3	1.7	10.0	10.9
7	6.0	21.0	26.9	6.6	21.0	26.9
Provincial average	2.2	6.9	9.1	3.4	7.9	10.3
Manitoba						
1+2	0.0	0.1	0.1	0.0	0.5	0.5
7-9	0.1	0.2	0.3	0.5	0.5	0.6
3-6	<0.1	0.2	0.2	0.5	0.7	0.8
10+11	0.1	2.2	2.3	1.0	4.7	4.9
12-14	2.1	4.6	6.6	3.1	5.1	6.6
Provincial average	0.4	1.5	1.9	2.1	3.3	4.0

*Crop district or agricultural reporting area (Alberta).

most *Fusarium* infestations of farm seed samples encountered since 1968 have been light.

Considerably more *Botrytis cinerea* occurred in Alberta samples in 1976 than in those from the other two provinces (Tables 1 and 3). Levels of infestation in Manitoba samples were comparable to those in seed lots from Saskatchewan. Over 74% of samples from the Peace River area of Alberta were infested by this species. Infested samples from Saskatchewan were more prevalent in 1976 than in four previous years [Table 1 and ref. (5)].

Sclerotinia sclerotiorum was not detected in Manitoba samples and rarely detected in those from Saskatchewan. However, it was found in over 5% of Alberta seed lots, including 12.5% of those from A.R.A. 6 and 14.3% of those from A.R.A. 7 (Table 1). The average infestation level for samples from A.R.A. 7, considering infested samples only, was 1.2% (Table 3). This is a substantial increase over earlier years. Most of this represented infestation of the seed itself as opposed to the occurence of sclerotia in the samples (see 4). Recently sclerotia have been found commonly in newly harvested rapeseed (3). However, results reported here and earlier (4, 5) indicate that they are much less common following commercial cleaning of the seed and those present are relatively small, as one would expect.

Oospores of *Albugo candida* were found in a much higher percentage of samples of *B. campestris* in 1976 than in almost all other years for which data are available, both in the case of Saskatchewan and Alberta seed [Table 5 and ref. (6), Tables 7 & 8]. The average infestation level for 1976 for Saskatchewan (28 spores per g of seed) was higher than in any of six previous years, with the exception of 1968 in which it was 41

Table 3. Mean % seeds infested per sample by *Botrytis cinerea, Fusarium roseum,* and *Sclerotinia sclerotiorum;* seed lots from Saskatchewan and Alberta*

Province & C. D. or A. R. A. **	Fungal pathogens		
	Botrytis cinerea	*Fusarium roseum*	*Sclerotinia sclerotiorum*
Saskatchewan			
1-3	0.5	0.6	0.0
5	0.5	1.4	0.0
6	0.5	0.5	0.0
7	0.5	0.5	0.0
8A	1.7	0.6	0.5
8B	0.3	0.6	0.0
9A	0.5	0.9	0.0
9B	0.5	0.6	0.0
Provincial average	0.6	0.7	0.5
Alberta			
2	0.5	0.6	0.0
3	0.5	0.5	0.0
4	1.0	1.4	0.5
5	1.5	1.1	0.5
6	1.3	3.3	0.5
7	4.7	1.6	1.2
Provincial average	2.3	1.6	0.9

* Infested samples only
** Crop district or agricultural reporting area (Alberta).

Table 4. Oospores of *Albugo candida* detected in seed lots of *Brassica campestris* grown in Saskatchewan, Alberta, and Manitoba in 1976

Province & C. D. or A. R. A.*	No. of samples washed	Oospores per g of seed	
		Av.	Max.**
Saskatchewan			
1-3	5	24.6	49
5	11	56.7†	509
6	5	15.3	40
7	9	47.7#	354
8	13	33.4	116
9A	12	11.6	43
9B	17	10.1	31
Provincial average (72 samples)		27.7	509
Alberta			
1&3	7	116.4††	598
2	17	38.1	397
4	53	46.1	519
5	27	37.2	186
6	16	39.7	342
7	32	172.6	1964
Provincial average (152 samples)		72.8	1964
Manitoba			
Provincial average (29 samples)		6.9	52

* Crop district or agricultural reporting area (Alberta).
** Max. = highest no. oospores in any sample.
† Omitting highest value, mean no. oospores = 11.5 per g.
# Omitting highest value, mean no. oospores = 9.4 per g.
†† Omitting highest value, mean no. oospores = 36.1 per g.

spores per g [Table 4 and ref. (6), Table 4]. The same was true of Alberta, except that the 1969 value of 92 spores per g of seed exceeded the 73 spores per g recorded in 1976 [Table 4 and ref. (6), Table 5].

Relatively low levels of oospore inoculum were detected in Manitoba samples in previous years and 1976 was no exception (Tables 4 and 5). Mean infestation levels for the various crop districts in Saskatchewan (Table 4) were similar, if extremely high values at variance with those for other samples in the district were omitted (see footnote, Table 4). The same was true for agricultural reporting areas in Alberta (Table 4).

The percentages of samples in each of 10 infestation severity categories are presented in Table 5. When these data are compared with those in Tables 7 and 8 of the earlier paper (6), it is apparent that with few exceptions a considerably larger number of heavily infested samples occurred in 1976 than in the years from 1967 to 1973. Most samples had fewer than 43 spores per gram of seed. If one arbitrarily considers samples with 44 or more spores per gram as being heavily infested, then 12.5% of the 1976 Saskatchewan seed lots and 25.7% of those from Alberta were in this category. The 1967-73 averages for Saskatchewan showed 6.5% of the samples heavily infested; the comparable figure for Alberta was 13.1%. Manitoba samples did not exhibit this increase [Table 5 and ref. (6), Table 9]. The highest level of infestation found in any 1976 seed lot was 1964 spores per g in a sample from Donnelly, Alberta (A.R.A. 7). The most heavily infested Saskatchewan sample was one from Margo in C.D. 5 with 509 spores per g. A seed lot from Inglis with 52 spores per g was the most heavily infested one originating in Manitoba.

Discussion

It is quite apparent that the prevalence and incidence of almost all of the fungal species considered here were higher in 1976 than in the earlier study (5, 6), at least over large portions of the rape-growing area. A considerable increase in *Alternaria raphani* was noted on seed

Table 5. Oospores of *Albugo candida* in seed samples of *Brassica campestris* from the three Prairie Provinces in 1976 - Percentage of 253 samples in each of 10 infestation severity categories

Province	No. of oospores per g of seed									
	0	Tr-3	4-11	12-43	44-86	87-129	130-323	324-645	646-1290	Over 1290
Saskatchewan	1.4	26.4	23.6	36.1	8.3	1.4	0.0	2.8	0.0	0.0
Alberta	2.0	16.5	16.5	39.5	9.2	4.0	5.9	5.3	0.7	0.7
Manitoba	10.4	55.2	17.2	13.8	3.5	0.0	0.0	0.0	0.0	0.0
3-province average*	2.8	23.7	18.6	35.6	8.3	2.8	3.6	4.0	0.4	0.4

*Values for all samples in each category

originating in southern Alberta and in Manitoba, whereas levels of *A. brassicae* remained relatively static or even declined, with a few exceptions such as A.R.A. 7 in Alberta. There is increasing evidence that *A. raphani* is a less serious pathogen than *A. brassicae*. *A. raphani* can produce rather superficial infections on some species of *Brassica* which are only slightly affected by *A. brassicae*, and it is better able to survive saprophytically on non-host species (1, 5).

It should be noted that the common occurrence of *Botrytis cinerea* on seed from the Peace River area of Alberta could contribute substantially to seedling emergence problems and post-emergence damping-off in the absence of seed treatment. The increased levels of *A. candida* oospore infestations in seed lots is also worthy of re-emphasis. Recent data (Verma and Petrie, unpublished) indicate that seed-borne oospores can substantially increase the percentage of plants with systemic infections of the inflorescence.

In certain areas, timely rainfall may have contributed to the higher levels of pathogens on seed in 1976. For example, many reporting stations in Alberta recorded above normal precipitation in August, but the reverse was true in Saskatchewan (2). Another factor to be considered, however, is the progressive build-up of inoculum of a wide array of disease-causing fungi in the soil and on weed species with the continued intensive cultivation of rape on the prairies. A good example of a wild crucifer species which now appears to function efficiently as a reservoir for a number of fungi attacking rape is wild mustard, [*Brassica kaber* (DC.) Wheeler var. *pinnatifida* (Stokes) Wheeler]. In addition, there have been recent examples of the rather sudden advent of serious new races or strains of some pathogens, often with unfortunate results [ref. (7) and unpublished data].

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Fungi associated with pole rot of cigar tobacco in Quebec[1]

S.K. Gayed

Botrytis cinerea, Rhizopus reflexus, Alternaria alternata, Fusarium tricinctum are the most common fungi associated with pole rot of cigar tobacco in Quebec. Apparently, this is the first trial to identify these fungi on cigar tobacco, and the first record of *R. reflexus* in Canada. A laboratory technique was devised to test the pathogenicity of these fungi on injured and uninjured green leaf disks of mature cigar cultivars Ottawa 705 and Resistant Havana 211. The most virulent pathogen was *B. cinerea*, and the least virulent was *F. tricinctum*. Only *B. cinerea* caused rot to uninjured leaf disks of both cultivars.

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Botrytis cinerea, Rhizopus reflexus, Alternaria alternata, Fusarium tricinctum sont les champignons les plus fréquemment associés à la maladie de la fermentation (chauffage) à la pente sur le tabac à cigare au Québec. Il semble que cette étude soit le premier essai d'identification de ces champignons sur le tabac à cigare, et aussi la première mention de la présence de *R. reflexus* au Canada. Nous avons mis au point une technique de laboratoire pour apprécier la pathogénicité des champignons sur des disques intacts ou blessés de feuille verte des cultivars Ottawa 705 et Resistant Havana 211 à maturité. Le pathogène le plus virulent est *B. cinerea* et le moins virulent *E. tricinctum*. Sur les deux cultivars, *B. cinerea* a été le seul à causer le chauffage à la pente sur les disques de feuille intacte.

Introduction

Cigar tobacco is grown mainly in the Montcalm, L'Assomption and Joliette counties in Quebec. In early to mid-September the plants are cut, left to wilt in the field, and 5-6 plants are speared on a lath. Laths are loaded into a curing barn equipped with bottom, side, and head ventilators to help in air circulation and reduction of humidity during curing.

Pole rot (barn rot, pole sweat, or shed burn) is a common disease that infects cigar tobacco during curing particularly under humid conditions. Fungi develop on the stem and the leaves of the tobacco plants. There is no record on the identity of these fungi and their relative pathogenicity to cigar tobacco. The present work includes a survey carried out in the cigar area in Quebec between 1969-1973 to identify these fungi, and also comments on their relative pathogenicity under laboratory conditions to injured and uninjured leaves of cigar tobacco.

Materials and methods

Samples of diseased cigar tobacco plants were collected from the St. Jacques Tobacco Co-operative, and from 20 farms in the area. The fungi were microscopically examined and cultured on potato dextrose agar (PDA) and identified.

A laboratory test was used to compare the virulence of the fungi on green leaves of mature cigar tobacco (*Nicotiana tabacum* L.) cv. Ottawa 705 (O-705) susceptible to pole rot and those of the Resistant Havana 211 (RH-211) both grown at the Delhi Research Station. Leaf disks, 5 cm in diameter, were cut from similar positions of the lamina of leaf No. 6 and 7 from the base of mature plants. The disks were surface sterilized by immersing in a 0.5% calcium hypochlorite suspension for 3 minutes and then rinsed in sterile water. Each leaf disk was slightly injured in the center with a dissecting needle. The four fungi were grown on PDA and 6-mm disks were cut from the edge of the actively growing fungus. The fungal disks were placed on the injured centers of the wet leaf disk, with the mycelium-bearing surface facing the leaf disk. Leaf disks that were not inoculated served as checks. For each treatment and check 15 leaf disks were prepared. The disks were then inserted in the slots of slide magazines each with 30 slots (Fig. 1). The magazines were placed in a saturated atmosphere in humidity chambers. After 12 days incubation at 22-25 C, the rot on each disk

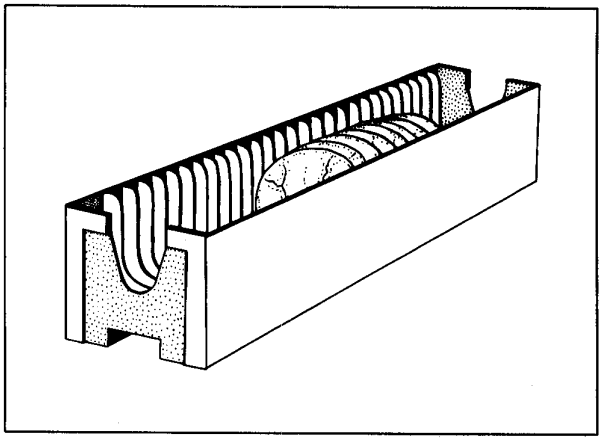

Fig. 1. A diagram of the slide magazine used with the inserted tobacco leaf disks.

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Fig. 2. A longitudinally split stem of cigar tobacco cv. Ottawa 705 infected with *B. cinerea*. Notice the densely growing mycelium, spores, and the black sclerotia attached to the pith tissue.

was visually rated and the average per cent rot-coverage on the 15 replicate disks represented the disease index of the treatment. The test was repeated.

An identical test was carried out using uninjured leaf disks from mature 0-705 and RH-211 plants grown in pots under greenhouse conditions in order to minimize leaf injury by natural causes.

Results and discussion

Botrytis cinerea Pers. was the most common fungus associated with pole rot. Greyish mycelium and spores covered a considerable part of the stem and the fungus reached the pith of the stem particularly through the injury caused by spearing. In many areas the fungus produced masses of mycelium and spores as well as sclerotia (Fig. 2). Leaves of infected plants, particularly those of the susceptible cultivar 0-705 were soggy, thin, and partially decomposed.

Anderson reported *B. cinerea* and *Sclerotinia sclerotiorum* (Lib.) de Bary as the major fungi causing pole rot of air-cured tobacco in Connecticut (2). From the present study there are two facts supporting *B. cinerea* and not *S. sclerotiorum* as the major fungus on cigar tobacco in Quebec; first is the firm attachment of the sclerotia to the plant tissue and second, all trials to stimulate the germination of the collected sclerotia in order to produce the perfect stage of the fungus were unsuccessful.

Rhizopus reflexus Bain was common in 1969 in association with *B. cinerea*. The mycelium of *R. reflexus* is fluffy and carries tiny black sporangia. Sporangia of this species are smaller than those of *Rhizopus arrhizus*, Fischer, the cause of pole rot of flue-cured tobacco (4). Apparently *R. reflexus* is not a common fungus in other parts of the country since it has not been previously recorded in Canada (1,3).

Table 1. Pole rot index induced by four different fungi on cigar tobacco cv Ottawa 705 (susceptible) and cv Resistant Havana 211 under laboratory conditions on injured and uninjured leaf disks

Fungus	Pole rot index[1] on tobacco leaf disks			
	Injured[2]		Uninjured[3]	
	0-705	RH-211	0-705	RH-211
Botrytis cinerea	99	84	30	12
Rhizopus reflexus	77	1	0	0
Alternaria alternata	75	37	0	0
Fusarium tricinctum	71	8	0	0
Uninoculated	0	0	0	0

[1] Average of 2 trials, each consists of 15 leaf disks. Pole rot index is the average per cent coverage of the tobacco leaf disks with rot.

[2] Injury was made on leaf disks from field-grown plants by a dissecting needle.

[3] Uninjured leaf disks were cut from greenhouse-grown plants.

Alternaria alternata (Fr.) Keissler grew in the form of dark or blackish areas on the stem and leaves of infected plants also in association with *B. cinerea* and other fungi.

Fusarium tricinctum (Cda) Sacc. was characterized by its white growth on infected plants, and was noted as the dominant fungus in samples from three farms in the St. Jacques area in 1972.

Laboratory studies proved that the 4 fungi caused severe damage to injured leaf disks of the susceptible cv 0-705, whereas injured leaf disks of the resistant RH-211 were severely damaged by *B. cinerea*, moderately

by *A. alternata*, slightly by *F. tricinctum*, and hardly any damage was caused by *R. reflexus* (Table 1). On the uninjured leaf disks only *B. cinerea* was able to cause rot, and the other 3 fungi failed to cause any damage during the 12-day period of the experiment. Rot caused by *B. cinerea* on the uninjured leaf disks of the susceptible cultivar was more than double that on the resistant cultivar (Table 1). Thus, injury of the susceptible cigar tobacco cultivar does not only increase the damage caused by the dominant pathogen *B. cinerea* but also increases damage caused by *Alternaria, Fusarium* and *Rhizopus*. The nature of this susceptibility is not known and further work is needed.

Acknowledgements

The technical assistance of Mr. D. A. Brown and Miss F. Sabo is gratefully acknowledged. *Rhizopus reflexus* Bain and *Fusarium tricinctum* (Cda) Sacc. were kindly identified by Dr. J. J. Ellis, ARS Peoria, Ill. Thanks are also due to Dr. P. P. Lukosevicious, L'Assomption, Quebec for all the facilities provided during the survey.

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Verticillium wilt in Canadian redbud

H.J. Thorpe and W.R. Jarvis[1]

Verticillium wilt, caused by *Verticillium dahliae*, is recorded in Canadian redbud, *Cercis canadensis*, for the first time in Canada.

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Le verticilliose, causé par le *Verticillium dahliae*, est enregistré dans le gainier du Canada, *Cercis canadensis*, pour la première fois au Canada.

In July 1978, at the Harrow Research Station in Essex County, S.W. Ontario, a 10-year-old, 2-m specimen Canadian redbud tree, *Cercis canadensis* L., showed wilting and death of the leaves of some branches. Many of the branches had leaves with incurved laminae, showing the paler green adaxial surface. As the disease progressed, the leaves drooped and interveinal chlorosis appeared, followed by light-brown necrosis at the tip and the margin, which soon spread over the entire leaf. The dead leaves remained for a short time, and then dropped off.

In section the petioles and wood showed vascular browning typical of Verticillium wilt and isolations from petioles and one-and two-year-old wood on acidified potato-dextrose agar yielded colonies of *Verticillium dahliae* Kleb. Mycelium was seen in microscopic sections of the vessels.

Although pathogenicity of these isolations was not tested, we presume that *V. dahliae* was the probable cause of the wilt. The Canadian redbud is rare in Canada and restricted to the extreme southwest of Ontario between Lake St. Clair and Lake Erie (1) but it has a wider distribution in the eastern United States (3). We know of no record of *V. dahliae* on *Cercis* spp., save one of *Verticillium* sp. on *C. canadensis* in Ohio (2), and no other wilt disease of *Cercis* spp.

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