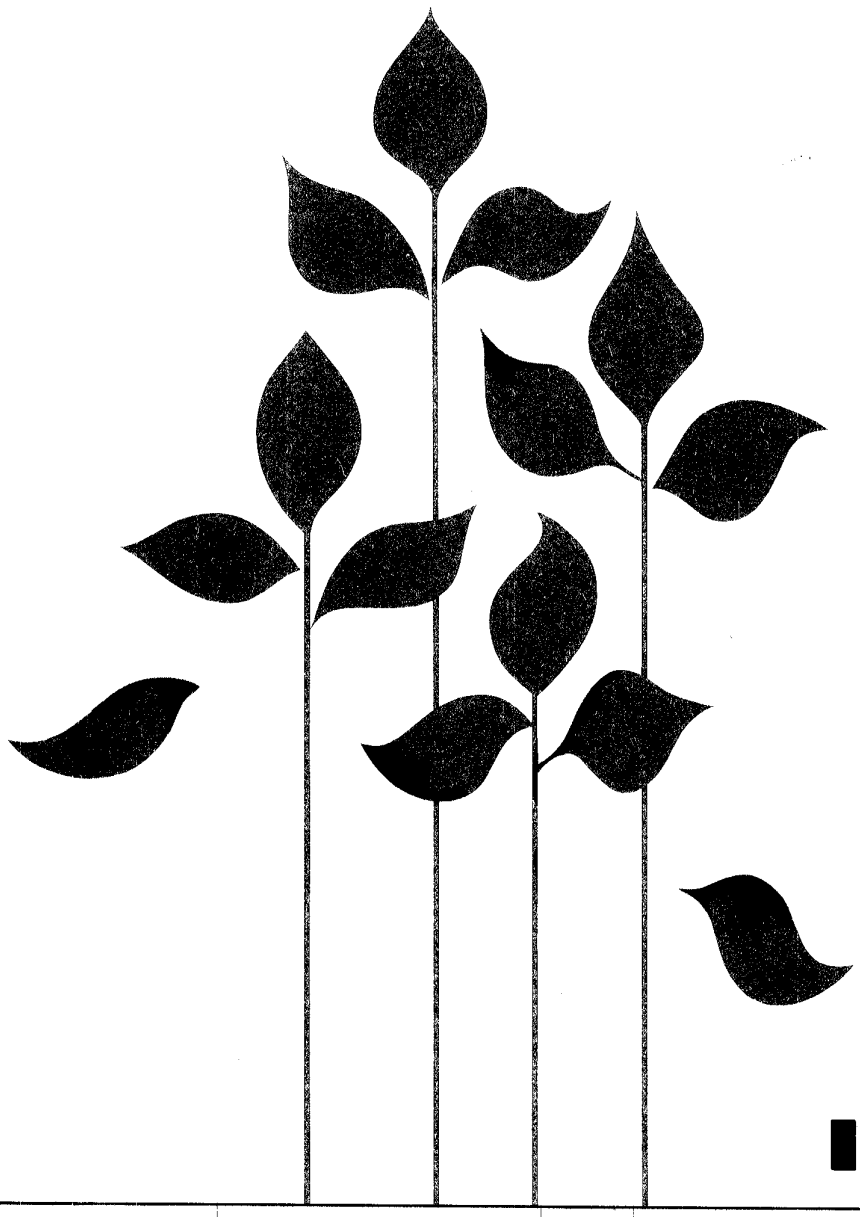
Canadian Plant Disease Survey

Volume 55 • Number 1 • 1975



Agriculture Canada

Canadian Plant Disease Survey

Volume 55, Number 1, 1975
CPDSAS 55(1) 1-44(1975) ISSN 0008-476X

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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.

Research Branch, Agriculture Canada
Editor: W.L. Seaman, Research Station, Agriculture Canada, Ottawa, Ontario K1A 0C6

Fababean diseases in Saskatchewan in 1973

D.L. McKenzie and R.A.A. Morrall[1]

A survey of fababean [*Vicia faba*], involving 28 commercial fields in widely separated parts of the Province and experimental plots at three localities, was done throughout the 1973 growing season. Quantitative data were collected at the end of the season and isolations were made from seed samples collected after harvest. The major diseases were powdery mildew, ascochyta blight [*Ascochyta fabae*], and fusarium and rhizoctonia root and foot rots. Powdery mildew in experimental plots at Saskatoon was identified as *Microsphaera penicillata* var. *ludens*, apparently a new record for this fungus on *V. faba*. Specimens of *Uromyces viciae-fabae* from similar plots appear to be a new biotype of the rust.

Can. Plant Dis. Surv. 55: 1–7. 1975.

En 1973, pendant toute la saison de végétation, une enquête sur les maladies de la féverole (*Vicia faba*) a été réalisée dans 28 champs de producteurs bien répartis dans la Province et dans des champs expérimentaux situés à trois endroits différentes. A la fin de la saison, les données quantitatives ont été recueillies et après la récolte on a fait des isolements à partir des échantillons de graines. Les maladies les plus importantes ont été le Blanc, l'Ascochytose (*Ascochyta fabae*) et les pourritures par *Fusarium* et *Rhizoctonia*. L'Oidium dans les champs expérimentaux à Saskatoon a été identifié comme *Microsphaera penicillata* var. *ludens*, apparemment signalé pour la première fois sur *V. faba*. Les échantillons d'*Uromyces viciae-fabae* dans d'autres champs expérimentaux à Saskatoon semblent être un biotype nouveau de cette rouille.

The diseases of several specialty crops in Saskatchewan have been studied for several years in our laboratory by means of field surveys (10,12). Fababean (*Vicia faba* L.) has been of particular interest since it was first grown in the Province in 1972. This crop was introduced to Canada about 4 years ago and several phytopathological problems have already been reported (5,7,10). The present paper deals with an extensive survey conducted in Saskatchewan in 1973. Substantial detail is presented because of the potential importance of fababean as a new protein crop in Canada, even though some aspects of the work are incomplete.

In 1972 about 500 acres of fababean were grown in Saskatchewan and a limited disease survey was done late in the season (10). The acreage was estimated to have increased to 2700 in 1973 and considerable fresh importation of seed into the province occurred. Disease surveys were begun early in the season in order to record seedling and other diseases which might not have been apparent later on. Sequential surveys of the same fields also permitted some study of the progression of disease with time.

The weather in much of Saskatchewan, especially during the early part of the growing season, appeared to be quite conducive to infection by foliar pathogens. In June at Saskatoon there were 17 days when at least some precipitation occurred (15). Many showers were followed by long periods of cool (10-15°C) temperatures and overcast skies. The late season weather at Saskatoon consisted of warm days and cool nights, with only occasional showers (15), but substantially more rainfall occurred in other parts of the province, including those where fababean was grown.

[1] *Department of Biology, University of Saskatchewan, Saskatoon, Saskatchewan, S7N 0W0.*

Methods

Twenty-eight fields representing about 30% of the total commercial acreage in Saskatchewan were surveyed. The majority were localized in either the irrigation area at Outlook (60 miles S of Saskatoon) or on dryland in the Laird district (40 miles N of Saskatoon). Other smaller 'groups' of fields on dryland occurred in the Kindersley district (120 miles WSW of Saskatoon), the Tisdale district (130 miles NE of Saskatoon) and in SE Saskatchewan. Thus, five separate districts of cultivation were recognized in the survey of commercial fields. In addition, visits were made to experimental plots at Saskatoon, Bellevue, and Nipawin.

Qualitative surveys were done throughout the growing season. Many fields and plots were visited three times, at about 1-month intervals; others were visited only once or twice (Table 1). At the end of the season quantitative data were collected in the fields; these surveys were done as nearly as possible just before swathing when the plants were still green.

Qualitative survey

The presence and approximate levels of diseases in the fields and plots were recorded. Additional information on variety, stage of crop development, weeds, insect pests, and soil moisture was noted. The observations were made while walking about 300 metres in a semicircular fashion through the crop. Normally only one area of a field was examined except where the topography was uneven; then both the high and low areas were examined. Isolations were always made from diseased plant material when the causal organism was unknown. Isolation routines included surface sterilization in 10%

Table 1. Summary of qualitative survey data from fields

District	Date	No. of fields examined	No. of fields where foliage diseases were present*				No. of fields where root, stem, and other diseases were present		
			Ascochyta blight	Lesions yielding *Alternaria* spp.	Powdery mildew †	Other	Fusarium root rot	Root lesions yielding *Coniella pulchella*	Other
Laird	14/6	2	0	0	0	0	0	0	0
	3/7	8	1	3	0	0	2	1	h
	16/8	9	7	9	3	a §	2	3	i
Kindersley	26/6	4	0	1	0	b	2	0	0
	31/7	4	0	4	0	c	2	0	j
	13/8	4	3	4	0	a	3	0	k
Outlook	29/6	9	0	9	0	d	6	4	l
	26/7	9	0	9	0	e	2	5	0
	29/8	8	0	8	8	f	5	1	m
Tisdale	11/7	2	0	1	0	g	0	0	0
	4/9	2	1	2	0	0	1	1	n
SE Sask.	20/8	4	2	4	3	0	2	1	o

* Diseases indicated were all present in trace levels except "other" on 16/8/73 at Laird, when the level was severe, and powdery mildew on 29/8 at Outlook when the level ranged from trace to moderate.

† For causal organism of powdery mildew, see text.

§ a-o Indicate the types of disease, or the organisms isolated, or both; the no. of fields to which each pertains follows in brackets:

a = herbicide injury (1);
b = chocolate spot (*Botrytis cinerea*) (1) & *Coniella pulchella* (1);
c = *Cladosporium* sp. (1);
d = herbicide injury (2), *Cladosporium* sp. (1), *Coniella pulchella* (3) & *Cephalosporium* sp. (1);
e = *Colletotrichum* sp. (1), *Cladosporium* sp. (3), *Coniella pulchella* (3) & *Cephalosporium* sp. (1);
f = rust (*Uromyces viciae-fabae*) (1);
g = *Coniella pulchella* (1);
h = root rot (*Verticillium* sp.) (1);
i = "yellows" (*Coniella pulchella, Fusarium* spp. & *Pullularia* sp., isolated from roots) (2), root rot (bacteria) (3), stem rot (*Sclerotinia sclerotiorum*) (2);
j = root rots (bacteria) (2), *Cephalosporium* sp. (1), *Pestalotia* sp. (1);
k = root rots (bacteria) (1), (*Pullularia*) (1), "yellows" (*Verticillium* sp., *Fusarium* sp., bacteria isolated from roots) (2);
l = root rots (*Scytalidium*) (1), (*Cephalosporium* sp.) (1);
m = root rots (*Rhizoctonia*) (4), (*Fusarium* & *Rhizoctonia* spp.) (4), (*Pythium* sp.) (1), (*Cephalosporium* sp.) (2), "yellows" (*Cephalosporium* sp. & *Verticillium* sp., isolated from roots (1);
n = stem rot (*Sclerotinia sclerotiorum*) (2);
o = unidentified fungi (2).

Javex (active ingredient 6% NaOCl), rinsing in sterile distilled water, and plating on potato dextrose agar (PDA).

Quantitative survey

Two areas, each about 150 metres from the edge of the crop, were sampled in each field. At each sample area 100 plants in a randomly chosen row were scored for root and stem diseases and the plants with symptoms were collected for making isolations. One leaf and one pod were picked about midway down the plant stem from each of the 100 plants and taken to the laboratory. These were used in the assessment of percentage leaf and pod area with lesions by means of assessment keys, as described in a previous paper (10).

Isolation from seeds

Samples of harvested seed were collected from many growers. Fifty seeds from each sample were surface sterilized for 5 min in 10% Javex, then rinsed in sterile distilled water and plated on PDA. Another group of 50 seeds from each sample was plated directly on PDA. The plates were incubated for 10 days at room conditions of temperature and light before examination and identifi-

cation of fungi that had grown. One sample of seed imported for planting in 1973 was obtained from a grower and plated in the same manner.

Results

Eight distinct diseases were found (Tables 1-4). Powdery mildew and fusarium and rhizoctonia root/foot rots were prevalent, while ascochyta blight, rust, chocolate spot, herbicide injury, and sclerotinia stem blight were present at relatively low levels. Also found were root rots from which various fungi and bacteria were isolated, and leaf spots from which *Alternaria* spp., *Cladosporium* spp., and *Coniella pulchella* Höhnel were the primary isolates (Table 1). Furthermore, plants with thick, brittle, chlorotic leaves were conspicuous in several fields. However, the precise etiology of these last three diseases is unclear.

Foliar diseases

Powdery mildew was observed late in the season in 14 of 27 fields (Table 1). Infection was greatest in the Outlook district, where the mean percentage leaf area diseased was 11.1 (Table 2) and the disease was present in all fields (Table 1). In other districts infection was very slight (Table 2) and there was no evidence of pod infection anywhere at the times of the survey. The causal organism of this disease is in doubt. Initially, it was believed that *Erysiphe polygoni* DC ex Mérat was the pathogen (3,10), although cleistothecia were not observed on infected leaves when surveys were made. However, a powdery mildew fungus collected in September on fababean in experimental plots at the University of Saskatchewan was subsequently identified as *Microsphaera penicillata* (Wallr. ex Fr.) Lév. var. *ludens* (Salm.) W.B. Cooke on the basis of its perfect state. By the time the identification was made, it was too late to check the identity of the fungus observed in commercial fields.

Ascochyta blight [*Ascochyta fabae* Speg.] was first observed on July 3 in the Laird district (Table 1). Pycnidia containing mature conidia were present in some of the leaf lesions. The disease was not found in other fields until late in the season, when 13 out of 27 fields were found to have at least trace amounts. The variety 'Erfordia' seemed more susceptible than others (Table 4); in one field lesions were prominent on the leaves, pods, and stems. However, it must be recognized that the sample size was small.

The rust fungus found in one field in the Outlook district was identified as *Uromyces viciae-fabae* (Grev.) de Bary. A second collection of rust was made in experimental plots in late August at the University of Saskatchewan, where two lines had severe infection of the lower leaves. This collection proved to be a new biotype of *U. viciae-fabae*, characterized by larger uredospores and the presence of amphispores in the uredosori (D.B.O. Savile, personal communication).

Botrytis cinerea Pers. was isolated from the leaves of one plant in a field in the Kindersley district early in the season but was not found later in any fields. No isolates of *B. fabae* Sard. were obtained at all from foliage, despite the fact that this pathogen has been reported to have been introduced to Canada (7). However, one isolate of *B. fabae* was obtained from seed samples (see below).

The leaf lesions from which *Alternaria* spp., *Cladosporium* spp., and *Coniella pulchella* were the prevalent isolates were found in most fields during all survey trips (Table 1). The lesions were distinct in morphology; they ranged in size from 0.1 to 1.0 cm and were oval to irregular in shape. The color varied from tan to brown to black, and there were usually brown, red-brown, or chlorotic margins. Further work on the isolates from these lesions is in progress.

Herbicide injury was observed in several fields in the Outlook district early in the season. However, during the final surveys it was found in only one field in the Laird district, where 27.5% of the plants were affected. The herbicide 'Dalapon' had been applied to the crop. Symtoms included puckering of the young leaves, browning of the adaxial side of older leaves, and severe stunting.

Root, stem, and other diseases

Root rots were the predominant diseases (Tables 1,3). Fusarium root rot was found throughout the season, and in 14 out of 27 fields at the end of the season. It was especially prevalent in the Outlook fields. *Rhizoctonia* sp. was isolated from root rot lesions only from the Outlook district late in the season, while a third fungus, *Coniella pulchella* was isolated relatively frequently in several districts throughout the season. However, the pathogenicity of *C. pulchella* and the other organisms isolated from roots (Table 1) remains to be established.

Sclerotinia stem rot was found in trace amounts in four fields late in the season. This constitutes a new Saskatchewan record for the causal organism, *Sclerotinia sclerotiorum* (Lib.) de Bary.

An abnormality entitled 'yellows' in Tables 1 and 3 was found late in the season. The symptoms included general chlorosis, thickened and turgid leaves, and occasionally browning of the vascular tissue of the taproot. The various organisms isolated from the taproot tissue included *Coniella pulchella, Fusarium* spp., *Verticillium* spp., *Cephalosporium* sp. and bacteria. No organisms were isolated from taproots that were not discoloured. Some of the symptoms suggest a viral, a mycoplasmal, or even a vascular wilt infection. Descriptions of pea leaf roll on fababean in Britain (8,16), and aster yellows in Alberta (C. Hiruki, personal communication) resemble the conditions of the affected plants in Saskatchewan fields. On the other hand, the occasional browning of vascular tissue in the taproot may indicate a wilt infection, although it could be part of a disease complex, or even the result of secondary invasion by the saprophytic soil microflora.

Table 2. Intensity of leaf and pod diseases in late season by district*

District	Percent area diseased							
	Powdery mildew on leaves		Ascochyta on leaves		Ascochyta on pods		Other leaf spots †	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Outlook	11.1	1.4-19.3	0		0		0.04 §	0.01-0.08
Laird	0.9	0 - 5.2	0.15	0-0.36	0.01	0-0.08	0.25	0.10-0.40
Kindersley	0		0.03	0-0.07	0		0.85	0.26-1.33
Tisdale	0		0.04	0-0.08	0		0.28	0.26-0.29
SE Sask.	0.5	0 - 0.9	0.03	0-0.06	< 0.01	0-0.01	0.12	0.12-0.24
Mean	2.5	0 -19.3	0.05	0-0.36	< 0.01	0-0.08	0.31	0.01-1.33

* See Table 1 for occurrence of diseases in fields and for sampling dates in each district.

† Miscellaneous leaf lesions from which *Alternaria* spp., *Cladosporium* spp., and *Coniella pulchella* were isolated.

§ Includes a trace of rust.

Table 3. Incidence of root, stem, and other diseases in late season by district*

District	Percentage of plants infected							
	Fusarium root rot		Other root rot †		"Yellows"		Sclerotinia stem rot	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Outlook	1.8	0-3.5	2.2		0.1	0-1.0	0	
Laird	0.2	0-1.0	0.4		0.4	0-0.1	0	
Kindersley	0.5	0-1.5	0.1		1.1	0-4.0	0	
Tisdale	0		0		0		1.0	0.5-1.5
SE Sask.	0.9	0-2.0	1.4		0		0	
Mean	0.8	0-3.5	0.8		0.4	0-4.0	0.2	0 -1.5

* See Table 1 for occurrence of diseases in fields and for sampling dates in each district.

† For organisms isolated, see Table 1.

Seed isolations

The prevalent seed-borne flora, as indicated in Table 5, comprised species of *Alternaria, Cladosporium, Penicillium*, and bacteria. *Ascochyta fabae* was isolated from four samples, three from the Laird district and one from the Tisdale district. Three of the samples of the variety 'Erfordia' were highly infected. All four of the samples came from fields that had the greatest amount of ascochyta blight. *Botrytis cinerea* was isolated at low frequencies from a large number of the samples (Table 5) and only seed from the Outlook district was entirely free of the fungus. Seed of the variety 'Erfordia' showed no infection with *B. cinerea* although there was a relatively high amount of contamination. *Botrytis fabae* was isolated from only one sample and only from surface-disinfected seed; the mean percentage of infected seeds in the sample was very low. This was a sample of the variety Thuringer from the Laird district.

The sample of imported seed showed 4% *Ascochyta fabae* in plating of non-surface-disinfected seed and 8% in surface-disinfected seed; the seed from the subsequent generation showed amounts of 2% and 34% respectively. In addition, this progeny seed was very severely discolored, and had a high rate of infection and contamination with *Aspergillus* sp. (near *Eurotium pseudoglaucum* (Blochwitz) Malloch & Cain), and *Penicillium cyclopium* Westling.

Discussion

The increase in acreage of fababean in Saskatchewan from 1972 to 1973 was accompanied by a significant increase in the number of diseases. In 1972 only fusarium and rhizoctonia root rots, powdery mildew, and leaf and pod spots of uncertain etiology were found (10). In 1973 several new diseases were found, including three caused by potentially destructive pathogens: *Ascochyta fabae, Uromyces viciae-fabae*, and *Sclerotinia sclerotiorum*. Thus, while diseases have not yet caused serious losses on fababean in Saskatchewan, our results, and those of other workers (5,7, and C.C. Bernier, personal communication) indicate that the cultivation of fababean in Canada will be marked by several pathological problems from the outset. This is undoubtedly partly the result of inadequacies in past plant quarantine practices in Canada, a subject that we have discussed elsewhere (11). Over the past few years substantial quantities of fababean seed were imported to Canada from Europe with virtually no inspection and certainly no testing. Most of the diseases known for a long time on fababean in Europe are now well established in Canada.

The intensity of several diseases in 1973 appears to have been controlled by both inoculum loads and environmental factors. For example, in 1972 when fababean was first grown in Saskatchewan, powdery mildew was found at low levels in the Outlook irrigation district (10). In 1973 powdery mildew had greatly increased in this district, while in other districts it was present at lower levels, comparable to those in 1972 at Outlook. In 1973 more primary inoculum at Outlook may have effected a greater infection in the district. However, the intensity of powdery mildew on dryland crops may never be as great as that on the Outlook crops because of the higher humidity and greater crop density with irrigation. On the other hand, the sprinkler system of irrigation may serve to curb powdery mildew (14,18).

The original powdery mildew inoculum may have been introduced with seed, or more likely, have come from a local source, since both *Microsphaera penicillata* var. *ludens* and *Erysiphe polygoni* have been reported on native *Vicia* spp. (3). The latter species parasitizes a large number of different plants including such common species in Saskatchewan as rapeseed and pea. Whatever the origin of the inoculum, the identity of the fungus is a matter of some interest. Our record of *M. penicillata* var. *ludens* appears to be the first on *Vicia faba*, at least for North America, but whether this is the species that was widely found in the survey remains to be determined. One of the present authors (R.A.A.M.) has regularly observed heavy powdery mildew infections on broad bean in his garden over the last 4 years; the causal organism has always been tacitly assumed to be *E. polygoni* and careful checks were not made. If two species of powdery mildew fungus do occur on *V. faba* in Saskatchewan, both may have to be accounted for in future breeding for disease resistance, thereby making the programs more complicated.

The presence of rhizoctonia root rot only in the Outlook district in both the 1972 and 1973 surveys may be related to the buildup of soil inoculum due to the alternate cultivation of rhizoctonia-susceptible crops. The field of fababean with the highest amount of rhizoctonia root rot in 1973 was planted in 1972 to potatoes which had abundant rhizoctonia infection (unpublished data). In other districts the major alternate crops are cereals and rapeseed, on which rhizoctonia infections are not as common. The low levels of ascochyta blight in both the four dryland, and the Outlook irrigation district were probably due to environmental effects and lack of inoculum respectively. In the dryland districts (particularly Laird) inoculum was obviously present, and, had the same been true at Outlook, some field infections would certainly have been noticed there too. Elsewhere, although the cool wet spring weather may have been conducive to primary infection, the relatively warm, dry summer and early autumn weather probably retarded extensive secondary spread. The variation of intensity of the disease in the Laird fields, shown by foliage lesions (Table 4) and seed infections, was probably mainly due to variations in the amount of initial seed-borne primary inoculum. However, the role of varietal differences in susceptibility, suggested (*inter alia*) by some observations in experimental plots at Nipawin, cannot be ruled out.

It is more difficult to speculate about some of the other diseases that were found in the survey. *Uromyces viciae-fabae* has been reported previously from Sas-

Table 4. Occurrence of ascochyta blight and powdery mildew by fababean variety

Variety and no. of fields examined	Powdery mildew			Ascochyta blight		
	No. of fields infected	Percentage leaf area diseased		No. of fields infected	Percentage leaf area diseased	
		Mean	Range		Mean	Range
Diana (11)	8	8.1	0-19.3	3	0.02	0 -0.08
Erfordia (2)	1	0.3	0- 5.2	2	0.33	0.29-0.36
Ackerperle (3)	1	0.2	0- 0.6	2	0.04	0 -0.10
Thuringer (3)	1	0.7	0- 2.0	3	0.17	0.08-0.23
Topas (2)	0			2	0.02	0.02-0.02
Maris Bead (1)*	0			0		
Unknown (5)	3	0.4	0- 0.9	2	0.03	0 -0.07

* Field had severe herbicide injury.

Table 5. Seed-borne organisms on seed* from commercial fields

Organism	Not surface disinfected		Surface disinfected	
	% of total samples of occurrence	Mean % of seeds contaminated or infected	% of total samples of occurrence	Mean % of seeds infected
Ascochyta fabae	12.5	0.5	16.7	3.3
Botrytis cinerea	25.0	1.3	33.3	0.8
Botrytis fabae	0.0	0.0	4.2	0.1
Alternaria spp.	95.8	64.0	95.8	18.9
Cladosporium spp.	95.8	19.4	75.0	4.9
Penicillium spp.	95.8	13.0	33.3	1.9
Aspergillus spp.	4.2	4.1	4.2	1.6
Fusarium spp.	58.3	2.3	12.5	0.3
Arthrinium sp.	41.6	1.9	29.2	1.1
Stemphylium sp.	8.3	0.3	12.5	0.3
Gliocladium sp.	4.2	0.1	0.0	0.0
Cephalosporium sp.	4.2	0.1	0.0	0.0
Nigrospora sp.	8.3	1.2	16.7	0.5
Epicoccum sp.	37.5	3.1	12.5	0.4
Chaetomium sp.	4.2	0.1	12.5	0.7
Paecilomyces sp.	4.2	0.3	4.2	0.1
Trichoderma sp.	8.3	0.3	0.0	0.0
Pestalotia sp.	0.0	0.0	4.2	0.1
Pullularia sp.	0.0	0.0	4.2	0.1
Thamnidium sp.	4.2	0.1	0.0	0.0
Bacteria	70.8	4.4	79.2	8.8

* 24 samples; 50 seeds plated/treatment/sample.

katchewan on native and cultivated plant species (2,3) but there may be a relatively low level of inoculum due to natural stabilization processes. Furthermore, the prevalent biotypes of the fungus may not be virulent on some fababean varieties. The origin of the new biotype found in plots at Saskatoon is enigmatic, since the two lines infected had both been imported and grown at Saskatoon in 1972, although no infection was noticed until 1973. However, the severity of infection of plants of the two lines (and the strict confinement of the rust to the two lines) suggests that careful attention will have to be paid to the disease in future. As for chocolate spot, *Botrytis cinerea* has also been previously reported in Saskatchewan on native and cultivated plant species (2,3,10,12) and inoculum of the fungus was obviously present in many of the crops (Table 5). Little infection occurred probably because this fungus is a weak pathogen of fababean (1,4). *B. fabae*, the more vigorous incitant of chocolate spot, had not previously been recorded in Saskatchewan. Hence, the trace of seed infection and lack of foliar infection probably indicates that an extremely low amount of inoculum was introduced with the seed. Yet it is surprising that no foliar infection was found since the disease required climatic conditions similar to ascochyta blight. Little can be said about the species of *Alternaria* and *Cladosporium*, and *Coniella pulchella*, isolated from leaves, at least until identifications and pathogenicity tests are complete. *Alternaria* spp. have been reported to cause leaf, pod, and stem blights of broad bean in other provinces (6,9,13), and *A. tenuis* has been reported as a secondary pathogen of broad bean in the United States (17).

In conclusion, this survey revealed a number of potentially serious pathological problems in fababean production in Saskatchewan. While this is a regrettable situation when the crop has been grown in the Province for only 2 years, control measures for many of the diseases are known and attempts to develop and expand fababean production should continue. However, the need for further pathological studies, both surveys and experimental studies on epidemiology, disease resistance, and control, is clearly evident.

Acknowledgments

The authors are indebted to Mrs. Lorraine Braun and Mr. Dan Janssen for technical assistance, and to Dr. Gordon Rowland, Crop Development Centre, Saskatoon, for advice and encouragement. Information about the location of fields and acreage of the crop was provided by Messrs. Blaine Sudom and Steve Pawlus and Mrs. Kathy Hughes of the Saskatchewan Department of Agriculture. Invaluable assistance in the identification and confirmation of specimens was provided by the following members of the Biosystematics Research Institute, Ottawa: Mrs. P. LeClair, Drs. D. Malloch, J.A. Parmelee, K.A. Pirozynski, D.B.O. Savile and R.A. Shoemaker. Financial assistance from the Saskatchewan Agricultural Research Foundation, and the National Research Council of Canada through a University Principal's Fund grant, is also gratefully acknowledged.

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Cooperative seed treatment trials - 1974[1]

J. T. Mills

Twenty-one seed treatment chemicals were tested in the field at two locations in Manitoba for their efficacy in controlling bunt of wheat [*Tilletia caries* and *T. foetida*], covered smut of oats [*Ustilago kolleri*], and covered smut of barley [*U. hordei*], and for their effects on the emergence of flax. Smut infection of untreated seed was low. Vitaflo 280 gave complete control of bunt and of the oat and barley smuts. Seventeen other treatments gave significantly reduced levels of cereal smuts. Flax emergence was significantly increased after seed treatment with Vitaflo 280, DPX 12, DPX 14, Busan 30, and RCH 364 (1 oz/bu rates). FNC 2512 at the 2% rate reduced cereal and flax emergence.

Can. Plant Dis. Surv. 55:8–11. 1975.

Vingt et un produits chimiques pour le traitement des semences ont été mis à l'essai en plein champ, à deux endroits différents au Manitoba, pour évaluer leur efficacité à combattre la carie du blé (*Tilletia caries* et *T. foetida*), le charbon couvert de l'avoine (*Ustilago kolleri*), et le charbon couvert de l'orge (*U. hordei*), et pour étudier leurs effets sur l'émergence du lin. L'infection par le charbon des semences non traitées a été faible. Le Vitaflo 280 a complètement détruit la carie et les charbons de l'avoine et de l'orge. Dix-sept autres traitements ont significativement réduit le niveau d'infection des charbons des céréales. L'émergence du lin a été significativement accrue après le traitement des semences au Vitaflo 280. DPX 12, DPX 14, Busan 30 et RCH 364 (à raison de 1 ozéboiss.). La dose de 2%, de FNC 2512 a réduit l'émergence des céréales et du lin.

Materials and methods

Table 1 lists the chemical composition, where available, and the product name and source of the materials used. Vitaflo 280 was included as a comparison standard.

Seeds of 'Norteno M67' wheat (*Triticum aestivum* L.), 'Random' oats (*Avena sativa* L.), and 'Herta' barley (*Hordeum distichon* L.) were used in the smut tests. 'Raja' flax (*Linum usitatissimum* L.) was used for emergence tests.

Prior to chemical treatment the cereals were inoculated with the appropriate dry smut spores at the rate of 1 g per 200 g of seed of wheat, oats, or barley. The chemical dosages used were those suggested by the manufacturer (Table 2). Each sample was hand-shaken in a glass jar to cover the seed uniformly with the chemical. After 3 days or more, 200 seeds were removed from each jar and placed in a paper envelope. Envelopes that contained seed of the same treatment were stored in polyethylene bags at at 15°C for up to 4 weeks before seeding.

Tests were carried out at Brandon and duplicated at Morden, Manitoba. There were four replicates at each location. Each replicate consisted of 200 seeds planted in a row 12 ft (3.7 m) long; all rows were planted 9 inches (23 cm) apart; plots were arranged in a randomized block design. Emergence of flax was recorded 3-4 weeks after seeding.

Wheat, oats, and barley were sown on 24 May and flax on 28 May at Brandon; all sowings at Morden took place on 30 May 1974.

The number of smutted heads in each row was recorded after the crop had headed and was expressed as a percentage of the number of heads in the untreated rows. The results are given as means of four replicates, at each planting site. The "LSD-05" was determined from the means of the treatments at each station.

Results and discussion

Smut infection of inoculated, untreated seed varied from 2% to 5% for wheat, from 7% to 11% for oats, and from 1% to 5% for barley.

The comparison standard Vitaflo 280 gave complete control of bunt, and of the oat and barley smuts. At both stations, 17 other treatments gave significantly reduced levels of cereal smuts.

The FNC 2512 treatments were omitted from the statistical analyses because cereal emergence at both stations was nil at the high dosage and a trace at the low dosage, making smut counts impossible.

Emergence of untreated flax checks varied from 47% to 59% (Table 2). Products that gave a significant increase in flax emergence at both stations were the wettable powders DPX 12 and DPX 14, the solutions Busan 30 (1 oz rate) and RHC 364 (1 oz rate), and the slurry Vitaflo 280 (3 oz rate). FNC 2512 applied at the 2% rate significantly reduced emergence of flax at both stations.

Acknowledgments

The writer thanks members of the staff of the Morden and Brandon Research Stations for their cooperation and assistance.

[1] *Contribution No. 643, Research Station, Canada Department of Agriculture, Winnipeg, Manitoba. R3T 2M9.*

Table 1. Seed treatment materials used in the cooperative tests

Treatment no.	Source*	Product name	Active ingredient
1		Untreated check	
2	Chipman	TF 3262	identity not available
3	Chipman	TF 3266	identity not available
4	Dow	M-4018 17.5 %	3,4,5-trichloro-, pyridinedicarbonitrile (Dowco 263)
5	DuPont	DPX 12	identity not available
6	DuPont	DPX 14	identity not available
7	FMC	Polyram liquid	metiram 22.5 %
8	FMC	Polyram lindane liquid	metiram 15.6 % lindane 10.9 %
9	FMC	Polyram lindane powder	metiram 53.5 % lindane 20.0 %
10	Hoechst	Sicarol 15 %	2-methyl-5, 6 dihydro-4-H-pyran-3-carboxylic anhydride (75 %) + maneb (50 %)
11	Interprovincial	Busan 25	2-(thiocyanomethylthio) benzothiazole (25 %)
12	Interprovincial	Busan 30	2-(thiocyanomethylthio) benzothiazole (30 %)
13	May & Baker	26019 RP 50%	(1-(isopropylcarbamoyl)-3-(3,5-dichlorophenyl hydantoin)
14	Nor-Am	SN 49137 50 %	identity not available
15	Nor-Am	SN 49182 50 %	identity not available
16	Rohm & Haas	RHC 364 39 %	identity not available
17	Standard	FNC 2512	identity not available
18	Uniroyal	Vitaflo 280	carbathiin 14.9% + thiram 13.2 %
19	Uniroyal	Uni-2060	identity not available
20	Uniroyal	Uni-2061	identity not available
21	Uniroyal	Uni-2063	identity not available
22	Uniroyal	Uni-2064	identity not available
23		Untreated check	

* Chipman Chemicals Ltd., Hamilton, Ontario; Dow Chemical of Canada Ltd., Sarnia, Ontario; E. I. DuPont de Nemours & Co., Inc., Wilmington, Delaware; FMC of Canada Ltd., Burlington, Ontario; Hoechst Chemicals Canada Ltd., Montréal, Québec; Interprovincial Cooperatives Ltd., Winnipeg, Manitoba; May & Baker (Canada) Ltd., Montréal, Québec; Nor-Am Agricultural Products Inc., Woodstock, Illinois; Rohm & Haas Co. of Canada Ltd., West Hill, Ontario; Standard Chemical Ltd., Montréal, Québec; Uniroyal Chemical Division, Elmira, Ontario.

Table 2. Effects of seed-treatment chemicals on smuts in wheat, oats, and barley and on emergence of flax at Brandon (B) and Morden (M), Manitoba, 1974

Treatment no.	Product name	Formulation*	Dosage oz/bu	Dosage g/kg	% smutted heads† Wheat B	Wheat M	Oats B	Oats M	Barley B	Barley M	Flax emergence % B	Flax emergence % M
1	Untreated check				5.5	2.1	7.0	10.1	0.9	4.9	59.0	49.3
2	TF 3262	SL	2.00	2.10	0.1	0.0						
			2.66	4.90			0.0	0.0				
			2.66	3.45					0.0	0.0		
			4.00	4.45							60.3	49.3
3	TF 3266	SL	2.25	2.35	0.0	0.0						
			3.00	5.50			0.0	0.0				
			3.00	3.90					0.0	0.0		
			4.00	4.45							62.3	47.3
4	M-4018	SL	0.60	0.65	1.0	0.4						
			1.20	1.30	0.1	0.0						
			0.34	0.65			1.2	0.0				

Table 2 (cont'd)

Treatment no.	Product name	Formulation*	Dosage oz/bu	Dosage g/kg	% smutted heads† Wheat B	Wheat M	Oats B	Oats M	Barley B	Barley M	Flax emergence % B	Flax emergence % M
			0.68	1.30			0.0	0.3				
			0.48	0.65					0.4	0.3		
			0.96	1.30					0.0	0.0		
			0.56	0.65							52.8	41.0
			1.12	1.30							58.5	55.8
5	DPX-12	WP	0.75	0.80	0.0	0.1						
			1.00	1.85			0.0	0.0				
			1.00	1.30					0.0	0.0		
			2.00	2.25							71.3	62.0
6	DPX-14	WP	0.75	0.80	0.3	0.1						
			1.00	1.85			0.0	0.3				
			1.00	1.30					0.0	0.0		
			2.00	2.25							74.5	72.3
7	Polyram liquid	SL	3.00	3.90					0.0	0.0		
8	Polyram lindane liquid	SL	3.00	3.15	0.0	0.0						
			3.00	3.90					0.0	0.0		
9	Polyram lindane powder	WP	2.00	2.10	0.0	0.0						
			2.00	3.70			0.2	0.4				
			2.00	2.60					0.0	0.0		
10	Sicarol	SL	1.50	1.55	0.3	0.0						
			2.00	2.10	0.7	0.2						
			1.50	2.75			0.1	0.1				
			2.00	3.70			0.1	0.0				
			1.50	1.95					0.0	0.0		
			2.00	2.60					0.0	0.0		
			1.50	1.70							47.3	46.5
			2.00	2.25							55.8	49.0
11	Busan 25	D	1.00	1.05	0.0	0.0						
			2.00	2.10	0.0	0.2						
			1.00	1.85			0.0	0.2				
			2.00	3.70			0.0	0.2				
			1.00	1.30					0.0	0.0		
			2.00	2.60					0.0	0.0		
			2.00	2.25							63.0	52.5
			4.00	4.45							63.0	55.5
12	Busan 30	SN	0.75	0.85							65.5	55.3
			1.00	1.10							65.3	55.8
13	26019 RP	WP	0.96	1.00	0.0	0.2						
			2.40	2.50	0.0	0.0						
			0.55	1.00			9.9	5.1				
			1.38	2.50			6.2	5.3				
			0.77	1.00					0.4	0.9		
			1.93	2.50					0.7	1.8		
			0.90	1.00							64.0	47.8
			2.25	2.50							65.8	45.0
14	SN 49137	WP	1.00	1.05	0.1	0.0						
			1.00	1.85			1.3	0.4				
			1.00	1.30					0.0	0.0		
			1.00	1.10							64.3	42.0
15	SN 49182	WP	1.00	1.05	0.0	0.0						
			1.00	1.85			0.3	0.7				

Table 2 (cont'd)

Treatment no.	Product name	Formulation*	Dosage oz/bu	Dosage g/kg	% smutted heads† Wheat B	Wheat M	Oats B	Oats M	Barley B	Barley M	Flax emergence % B	Flax emergence % M
			1.00	1.30					0.0	0.0		
			1.00	1.10							57.8	47.3
16	RHC 364	SN	0.50	0.55	0.0	0.0						
			1.00	1.05	0.0	0.0						
			0.50	0.90			5.7	5.5				
			1.00	1.85			1.1	0.5				
			0.50	0.65					0.9	2.1		
			1.00	1.30					0.1	1.1		
			1.00	1.10							68.0	55.8
			2.00	2.25							61.8	52.5
17**	FNC 2512 1 %	SN+									44.8	43.8
	2 %	SN+									14.5	9.0
18	Vitaflo 280	SL	1.50	1.55	0.0	0.0						
			1.50	2.75			0.0	0.0				
			1.50	1.95					0.0	0.0		
			3.00	3.35							70.5	63.5
19	Uni-2060	SL	2.30	2.40	0.2	0.0						
			1.75	3.20			0.0	0.0				
			2.30	4.25			0.0	0.0				
			2.30	3.00					0.0	0.0		
			3.00	3.35							55.5	41.5
			3.50	3.90							47.8	59.0
20	Uni-2061	SL	2.30	2.40	0.0	0.5						
			2.30	4.25			0.0	0.0				
			2.30	3.00					0.0	0.0		
			3.50	3.90							53.5	38.8
21	Uni-2063		1.75	1.85	0.0	0.0						
			2.30	2.40	0.0	0.0						
			1.75	3.20			0.0	0.0				
			2.30	4.25			0.0	0.0				
			1.75	2.30					0.0	0.0		
			2.30	3.00					0.0	2.8		
			3.50	3.90							54.8	48.0
22	Uni-2064	SL	1.50	1.55	0.1	0.0						
			1.50	2.75			0.0	0.0				
			3.00	3.35							53.5	49.8
23	Untreated check				3.6	3.2	10.5	11.7	2.3	4.5	57.3	47.0
LSD (0.05)					0.9	0.2	1.4	1.1	0.3	1.1	4.1	6.5

* Formulation code: D = dust, SN = solution, SL = slurry, WP = wettable pwder, SN+ = seeds dipped in solution for 10 sec then placed in sealed container overnight, air dried, then packaged.

† % smutted heads = $\frac{\text{number of smutted heads X 100}}{\text{number of heads in control}}$; B = Brandon, M = Morden.

Flax emergence based on mean of 4 reps each having 200 seeds planted.

** Treatment No. 17 was omitted from statistical analysis.

Pythium root rot of barley in southwestern Ontario

W. E. McKeen[1]

In southwestern Ontario *Pythium* species have been found in all barley fields examined in 1973 and 1974. *Pythium* spp. may cause decay of the root system of barley plants at any stage of development, resulting in significant reductions in yield. The ability of the barley plant to regenerate an adequate new root system varies with the length of time the soil is wet, the developmental stage of the plant, and the fertility of the soil. Barley, spring and winter wheat cultivars, and corn hybrids were susceptible while oats were highly resistant.

Can. Plant Dis. Surv. 55:12–14, 1975.

Dans le sud-ouest de l'Ontario, on a découvert des espèces du genre *Pythium* dans tous les champs d'orge étudiés en 1973 et 1974. Les *Pythium* spp. peuvent causer la pourriture du système radiculaire des plants d'orge à tout stade de développement, ce qui entraîne des réductions appréciables des rendements. L'aptitude du plant d'orge à regénérer un nouveau système radiculaire satisfaisant varie en fonction de la durée de mouillage du sol, du stade de développement du plant et de la fertilité du sol. L'orge, les cultivars de blés de printemps et d'hiver et les hybrides de maïs se sont révélés sensibles, et l'avoine s'est avérée très résistante.

Introduction

For many years only small acreages of barley were grown in southwestern Ontario, partly because yields were not satisfactory. During the last 15 to 20 years there has been a greater desire by farmers to grow barley because of a potential increase in productivity of barley resulting from changing agronomic practices, including use of new cultivars, increased use of commercial fertilizer, and tile drainage. As a result, barley has replaced oats in many instances and barley acreage in Ontario between 1962 and 1972 increased from 80,000 to 375,000 acres (5). However, although yields have risen, they are much lower than anticipated by farmers, and hoped for by barley breeders.

Plant pathologists in Ontario have paid little attention to root degeneration of barley. The assumption has been that the root rot problem of barley in Ontario is similar to that of barley grown in the prairie provinces and consequently conclusions and recommendations, frequently, have been copied from or based on reports from western Canada.

Reports in the *Canadian Plant Disease Survey* on root decay of barley indicate that *Cochliobolus sativus*, which causes common root rot, is the major root pathogen. For example, Harper and Piening (3) reported that in 1971 common rot caused an estimated loss of 6.0% in south and central Alberta.

In the last 40 years browning root rot (caused by *Pythium* spp.) of barley has been reported only three times in the *Canadian Plant Disease Survey*. In 1967 (1) it was found in one field at Lethbridge and one at Granum, Alberta; in 1944 (4) in one field at Indian Head, Saskatchewan; and in 1930 (2) in 3 of 98 fields examined in Saskatchewan.

The Field Crop Recommendation of the Ministry of Agriculture and Food in Ontario (6) indicates the consensus of the root rot situation in Ontario when it states "*Helminthosporium* root rot and blight is frequently serious in barley". Browning or *Pythium* decay is not mentioned.

Observations and results

Because I observed the destruction of the root system of barley plants in a few fields during the last 10 years and because barley yields were inconsistent, I examined the roots of barley plants in several fields from Huron, Middlesex, and Perth counties, which have large acreages of barley. Root degeneration occurred during and following emergence, during development, and at maturation if the soil became wet. There was a direct correlation between soil moisture content and the amount of root degeneration. If decay was severe during and prior to emergence, a poor stand resulted (Figure 1). At later stages of development the plants did not die but, as a result of loss of a large portion of the root system, the plants were readily pulled from the soil; frequently only a few short stubby roots remained around the seed, and tillering was minimal (Figure 2).

Field observations in Lambton, Oxford, and Elgin counties indicated that the disease situation was similar to that in Middlesex, Huron, and Perth counties.

After the moisture content lowered in soil there was a regeneration of roots unless the plants were very young. Frequently the plants developed an adequate root system and made a striking recovery, especially if the soil had received a generous amount of fertilizer. If the fertility of soil was low the plants became yellowish and stunted. If there was a heavy stand, often the soil did not

[1] *Department of Plant Sciences, The University of Western Ontario, London, Ontario.*

Figure 1. A field of young barley; most of the barley plants in the central part of the field have died due to decay of the root system by a species of *Pythium*.

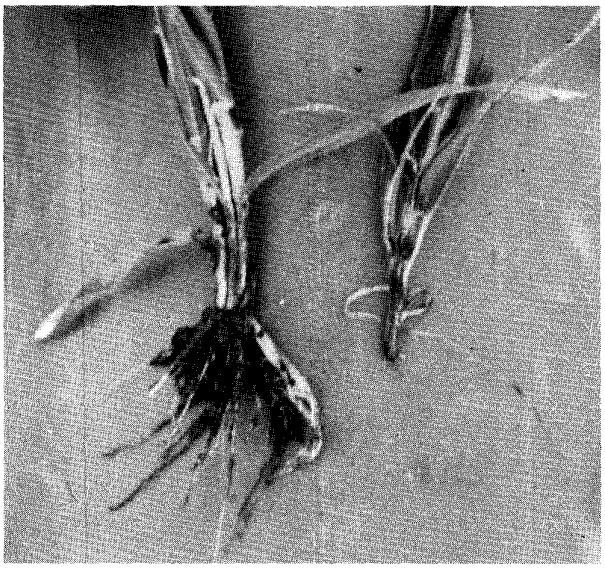

Figure 2. Pythium root rot of barley; the plant from a *Pythium*-affected field (right) has only two tillers and a few stubby roots; the plant from a healthy field (left) has several tillers and a well-developed root system.

dry for a considerable length of time, particularly as the crop approached maturity, and consequently a large root system did not form because the growing roots continued to become necrotic.

Numerous microscopic observations of diseased roots showed that oogonia and sporangia were present in most roots. Isolations on nutrient media proved that species of *Pythium* were present in the necrotic roots. *Fusarium* spp., *Mucor* spp., *Cochliobolus sativus* (Ito and Kurib.), Drechs. ex Dastur, and other fungi were occasionally observed.

Barley plants grown in sterilized soil inoculated with *Pythium* isolates showed the same disease syndrome as the one observed in the field. A heavy inoculum prevented emergence. Root decay occurred at all stages of development. *Pythium* infected barley roots in 3 to 5 hours, sporangia began to form immediately following infection, and zoospores were produced and liberated within 24 hours. The the life cycle is very short.

In the laboratory, spring and fall wheat, and corn were susceptible and oats were resistant to the *Pythium* isolates.

Discussion and conclusions

Pythium spp. appear to be major causes of root rot of barley in southwestern Ontario while in western Canada the most important root pathogen is *C. sativus*. The difference may be due in part to more rainfall and poorer drainage in Ontario.

Barley should be planted on well drained soil with sufficient fertilizer, especially nitrogen, for optimum growth.

Barley varieties resistant to *Pythium* should be sought and a protectant fungicide for the seed should be used. A systemic fungicide effective against *Pythium* would be ideal.

Because *Pythium* species are widely distributed throughout southwestern Ontario and because they cause root degeneration of several commonly grown agricultural plants, the importance of *Pythium* cannot be overemphasized. One may hope that the solution to this barley root rot problem may be as readily corrected as was the browning root rot disease of wheat in western Canada (7).

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Virus infection of potato seed stocks in Ontario under commercial insect-control practices

R. G. Rowberry and G. R. Johnston[1]

Seed stocks in Canada's Elite Seed Potato Program are in the field for 5 consecutive years before reaching the table-stock grower. This may be too long a period to prevent considerable reinfection of virus-free stocks by contact viruses such as virus X and, in an area like southern Ontario, by potato leaf roll virus. To test this hypothesis, clones of Sebago that were free from virus X and clones of Sebago and Kennebec free from visible symptoms of virus infection were grown in the field in southern Ontario. Plants showing symptoms of tuber-borne diseases in the field and in greenhouse tests were removed from the program. The Kennebec clones were eliminated within 3 years; the X-free Sebago clones were reduced to 17% and the other Sebago clones to 27% of their original populations in 5 years. Replicated yield trials of all clones were carried out, with virus-free Sebago included for the last 2 years; no differences in yield were observed among clones or among classes of seed.

Can. Plant Dis. Surv. 55: 15–18. 1975.

Dans le cadre du Programme canadien d'amélioration de la pomme de terre de semence Elite, les stocks de semences sont évalués en plein champ pendant 5 années consécutives avant d'atteindre les producteurs de pommes de terre de consommation. Il est possible que cette période soit trop longue pour prévenir une forte réinfection des stocks indemnes par les virus de contact comme le virus X et, dans une région comme celle du sud de l'Ontario, par le virus de l'enroulement des feuilles. Pour vérifier cette hypothèse, certains clones de Sebago exempts du virus X et d'autres de Sebago et de Kennebec exempts de symptômes visibles de virose, ont été cultivés en plein champ dans le sud de l'Ontario. Les plants qui ont manifesté des symptômes de maladies transmises par les tubercules, dans les essais de terrain et de serre, ont été retirés du Programme. Les clones de Kennebec ont été éliminés en moins de 3 ans; ceux de Sebago exempts du virus X ont été réduits à 17% et les autres clones de Sebago, à 27% de leur peuplement original en 5 ans. On a effectué des essais de rendements à répétitions de tous les clones, la variété Sebago indemne pour les 2 dernières années; on n'a constaté aucune différence de rendement entre les clones ni entre les classes de semences.

The introduction of the Elite Seed Potato Program in Canada has raised several questions concerning the possibility of maintaining the required standards in the seed throughout the many stages of production.

There are four stages before the seed reaches the commercial seed grower and two more from the seed grower to the producer of table stock as follows:

Pre-elite	Foundation
Elite I	Certified
Elite II	Table stock
Elite III	

Pre-elite stocks, originally selected from the best commercial seed available, are tested for bacterial ring rot and indexed in the greenhouse for visible virus symptoms. Those which pass inspection are planted the following season to produce Elite I. This is done either on Elite Seed Farms or, as in Ontario, by Elite Seed Growers under contract and is continued to the production of the Elite III, the seed dropping one grade each year. Elite III seed is sold to commercial seed growers who increase it through the Foundation and Certified stages to sell to the producer of tablestock and processing potatoes.

The introduction of virus-free pre-elite seed has improved the quality of seed entering the program but has not altered the fact that the seed has a long and hazardous road to follow before it reaches the tablestock grower. The quality of the seed at this latter stage is governed by several factors: the quality of the seed entering the program, which we have dealt with; the calibre of the seed growers throughout the program; the quality of the inspection service; last and perhaps the most important is the disease environment in which it is grown.

Southern Ontario, where most of the seed potatoes are produced in the province, has long been believed to be a poorer environment for seed production than northern Ontario, because of the higher population of the green peach aphid (*Myzus persicae*). This has recently been confirmed by McEwen (F.L. McEwen, personal communications). Prevailing winds bring swarms of winged aphids into southern Ontario from Michigan, Ohio, and western New York; these aphids; together with our overwintering population, make leaf-roll virus a major problem to all seed growers. It was decided, therefore, to investigate the rate of infection of a "clean" population under conditions which were typical of the major seed-growing areas of the province.

Materials and methods

This experiment was conducted at the Horticultural Research Station, Cambridge (formerly Preston) in a Fox sandy loam which is typical of many of the potato-growing areas of Ontario.

[1] *Associate Professor, Department of Horticultural Science, and Research Scientist, Agriculture Canada, c/o Department of Horticultural Science, Ontario Agricultural College, University of Guelph, Guelph, Ontario N1G 2W1.*

In 1966, when the investigation began, no virus-free seed was available. We were fortunate, however, to obtain 103 tubers of virus X-free Sebago from Dr. N. S. Wright, Agriculture Canada, Vancouver, B. C., and 3 from Dr. N. R. Thompson, Michigan State University, East Lansing, Michigan. So that we could compare yields among these clones and also between them and commercial seed, we also selected one tuber from each of 15 superior-looking Sebago clones and from 14 Kennebec clones in Foundation (old system) seed blocks at Cambridge.

To increase each clone to the point where we had enough seed for a yield trial, they were planted in tuber units in the field and rogued for visible virus diseases, blackleg, and rhizoctonia. The X-free and Foundation potatoes were planted in separate blocks at this stage to avoid premature contamination. The plants were hilled soon after emergence and sprayed with a herbicide; irrigation pipes were installed and left in place and a fungicide/insecticide program was applied by air-blast sprayer from an adjacent roadway, so that there was no unnatural spread of virus. Great care was taken not to touch the surrounding plants while roguing.

The vines were killed each year when most of the tubers had reached "A" size (4-12 oz:113-340 g). Each unit was harvested individually and two small tubers from each were split and grown in the greenhouse in the winter of 1966-67 to check for visible virus symptoms and, in the case of the X-free clones, for virus X using *Gomphrena globosa* as the indicator plant. Those clones which became reinfected with virus X, but were free from visible symptoms of virus and other diseases, were retained and increased separately. One clone of Elite I from the Ontario seed program was added to those surviving the roguing and indexing and all were planted in the field in 1967 in the same manner. The program was repeated in 1968 so that there was enough 6-8 oz (170-227 g) seed produced of each clone to give sufficient 1.5-2.0 oz (42-56 g) seed pieces to plant 3 replicates of randomized single 20 ft (6.1 m) rows in 1969. Virus X-free and X-infected plots were separated by X-free guard rows of the same cultivar.

In 1969 we also obtained a few tubers from a single clone of virus-free Sebago from Dr. Wright and these were planted separately for increase.

The experiment was repeated in 1970 and 1971 with 4 replicates and including the virus-free clone. The same precautions were taken as before, with the addition of virus-free guard rows for the virus-free plots. When the yield trial began diseased plants were not rogued but were staked and in 1969, which corresponded to the Elite III-to-Foundation stage, were harvested separately. If the remaining plants produced enough seed, the clone was replanted the following year, providing that it met the standards for the class.

The insect-control program until 1969 was DDT weekly in the early part of the season and thiodan weekly from early July until the tops were killed. The green peach aphid appears in late July in this area. Systemic insecticides applied in granular form at planting time have been found to be of little value against aphids in this area because the effectiveness has worn off by the time the aphids appear.

Following the withdrawal of DDT, thiodan was used weekly from crop emergence until early July at which time it was alternated with meta-systox. In 1970, the agricultural oil "Corntrol" was added to the spray material on the recommendation of Bradley (1) to help in the control of aphid-transmitted viruses.

Results

Disease incidence

It was necessary to rogue 24 of the British Columbia X-free Sebago clones in the field in 1966, 16 for leaf roll, 4 mosaic, 2 blackleg, and 2 rhizoctonia. No Ontario clones were removed from the field, but 1 Kennebec, 5 Sebago, and 1 Michigan X-free clone were discarded in the greenhouse because of leaf roll (Fig. 1).

In the 1967 growing season only 3 B.C. Sebago clones were rogued in the field but in the greenhouse 24 were rejected for mosaic, together with 3 Foundation Kennebec and 3 Foundation Sebago for mosaic and 1 of each for leaf roll.

The numbers were further reduced in 1968. Two Foundation Sebago clones were rogued for leaf roll; 3 Foundation Kennebec and 2 X-free B.C. Sebago clones had mosaic. In the greenhouse 1 B.C. X-free and the remaining Kennebec clones were discarded for leaf roll and 1 Michigan and 3 B.C. clones were found to be infected with virus X and were transferred to the Foundation group.

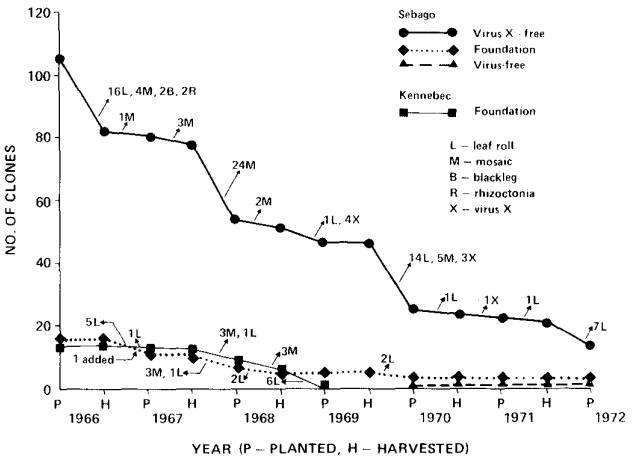

Figure 1. Disease status of potato clones grown in the field in southern Ontario 1966-72; numbers and letters indicate the number of clones discarded because of disease during screening in the field and greenhouse.

Table 1. Yields of Foundation, virus-free, and virus X-free Sebago potatoes, 1969-71

Year	Seed planted	Yield in cwt/acre and (t/ha) Total	Ont. No. 1
1969	X-free	284.1 (31.8)	260.6 (29.2)
	Foundation	292.7 (32.8)	266.9 (29.9)
		N.S.	N.S.
1970	X-free	238.9 (26.8)	221.8 (24.8)
	Foundation	260.2 (29.1)	243.1 (27.2)
	Virus-free	212.4 (23.8)	197.2 (22.1)
		N.S.	N.S.
1971	X-free	204.2 (22.9)	178.2 (20.0)
	Foundation	200.3 (22.4)	175.8 (19.7)
	Virus-free	200.7 (22.5)	175.0 (19.6)
		N.S.	N.S.

As described above, no plants were removed from the field in 1969, but diseased units were staked and harvested separately for inclusion in yield data. In the greenhouse, however, 14 B.C. X-free and 2 Ontario Foundation Sebago clones were rejected for leaf roll. Five B.C. clones were discarded for mosaic and 3 were relegated to the X-infected (Foundation) class. Similar patterns were repeated in 1970 and 1971, so that following the 1971 field and greenhouse screening there remained only 14 B.C. X-free, 1 virus-free, and 12 X-infected clones. Of the last, 9 were originally X-free, 2 were Foundation (old system), and 1 was from the Elite program. All of these clones were Sebago, the last of the Kennebec having been eliminated in 1969.

Yields

Table 1 shows that there were no differences in total yield or in yield of Ontario No. 1 tubers among classes in any year. The analysis of variance also showed that there were no differences among the clones within the classes.

Discussion

The standards used in inspecting and roguing these plots were those of the Elite Seed Program (2). No visible disease is allowed in Elite I and II seed, but there is unlimited roguing. In the third inspection for Elite III there is a tolerance of 0.1% for all viruses and 0.25% for all diseases. For the final (2nd) inspection of the Foundation grade these figures are the same as for Elite III but for the Certified grade they are 1.0% and 2.0% respectively.

Because unlimited roguing is allowed in the Elite I - III stages (1967-69) a clone was removed if, after roguing, there was not enough seed left to plant the necessary plots the following year. In the Foundation and Certified stages (1970-71) a clone was removed if the percentage infection exceeded that permitted under the regulations.

It can be argued that this experiment is no longer relevant because eventually we shall be using virus-free seed and therefore there will be no spread of tuber-borne viruses in a crop. Within limits this is true for the so-called contact diseases which are spread by mechanical means, but it is most certainly not true for the leaf roll virus, which is spread by aphids. However, in view of the freedom from virus X within the bulk of the population studied and the care taken to avoid its spread by other than natural means, it would seem that a valid comparison can be made between this and the spread of similar viruses in an allegedly virus-free population.

A proven method of preventing leaf roll is killing the vines before the aphid vector appears. This was not done because we were following regular Ontario practice, which is to kill the vines when the plants have produced a marketable yield. In most areas this would not occur by the time the aphids appear, thus emphasizing the fact that if seed growers are to produce seed free from leaf roll, they must receive a price that is high enough to compensate for the low yields caused by early vine killing.

If we ignore the 24 B.C. clones rogued in the field in 1966 and count the program from 1967, the period from then until 1971 corresponds to the time taken for a seed-lot to pass through the Elite program from Elite I to tablestock. Thus out of the original 82 Sebago clones only 14 were left to plant as Certified seed and harvest as tablestock in 1971. This is a reduction of about 83% in 5 years, or, on average, 17% of the original population per year, in spite of an above-average insect-control program. It will be noted that the amount of infection did not increase in 1969, 1970, and 1971, even though diseased plants were left in the field until harvest.

These findings support the view of McEwen (3) that southern Ontario is a poor location for increasing virus-free potato stocks, but if such a program is to be carried out successfully a very high level of care will be needed by both growers and professionals.

The yield results differ from many of those quoted by Wright (5), who reported that an increase usually is obtained when potatoes are freed from virus X. However this is not always so (4) and Wright himself failed to obtain an increase at one location, thus indicating that other, environmental, factors are involved.

The lack of yield differences among the clones was to be expected. Clones of a vegetatively reproduced cultivar are genetically identical and under the same growing

conditions all yields should be the same. Differences in yield would only be induced by disease or mutation, and in the latter case, of course, we are dealing with a new cultivar. In 25 years of selecting and testing clones in the Scottish seed program, Hardie (J. L. Hardie, personal communication) has found that all plants which remained true-to-type maintained their yield potential and that no mutants equalled the nuclear stocks in performance.

If clonal selection is to be a factor in improving the yield of potatoes, widespread testing of disease-free stocks would seem to be necessary to ensure that real differences are obtained.

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Prevalence of oospores of Albugo cruciferarum in Brassica seed samples from western Canada, 1967-73[1]

G. Allan Petrie

Oospores of *Albugo cruciferarum* (*A. candida*), the white rust fungus, were found in 468 of 585 seed samples of *Brassica campestris* (turnip rape) and in 20 of 25 samples of *B. napus* (rape) produced in western Canada between 1967 and 1973. The latter species is completely resistant to the disease. Turnip rape samples from Alberta generally had the heaviest infestations and those from Manitoba, the lightest. The most heavily infested sample (Falher, Alberta, 1969) had over 1500 oospores per gram of seed. With one exception, yearly provincial averages ranged from 6 to 41 spores per gram of seed; in 1969 the average for Alberta samples was 92 spores per gram. Although samples from the moister parts of the Prairies usually had higher infestation rates, samples from more southerly regions were also consistently infested.

Can. Plant Dis. Surv. 55: 19–24. 1975.

On a trouvé des oospores du champignon de la rouille blanche, *Albugo cruciferarum* (*Brassica campestris*), dans 468 des 585 échantillons de semences de navette (*Brassica campestris*) et dans 20 des 25 échantillons de colza (*B. napus*) produits dans l'ouest du Canada de 1967 à 1973. La dernière espèce est parfaitement résistante à la maladie. Les échantillons de navette de l'Alberta ont généralement eu les taux d'infection les plus élevés et ceux du Manitoba, les plus faibles. L'échantillons le plus gravement infecté (Falher, Alberta, 1969) contenai plus de 1500 oospores par gramme de semences. Sauf une exception, les moyennes provinciales annuelles ont varié de 6 à 41 spores par gramme de semences; en 1969, cette moyenne a été de 92 spores par gramme pour les échantillons de l'Alberta. Bien que les échantillons provenant de parties plus humides des Prairies ont présenté des taux d'infection plus élevés, ceux des régions situées plus au sud ont également été infectés.

Staghead (white rust) caused by *Albugo cruciferarum* S. F. Gray [*A. candida* (Pers. ex Lev.) Ktze.] has appeared dramatically in turnip rape (*Brassica campestris* L.) on relatively weed-free land on which the crop had never been grown previously and which was many miles from other *Brassica* fields. Oospores sown with the seed would appear to be the most likely source of infection. A recent study (7) has shown that oospores of this fungus will germinate in large numbers following a period of washing in water. This lends weight to the idea that oospores are the important primary inoculum source. Even a small number of oospores in a seed sample might be sufficient to establish significant numbers of infections in a crop. These considerations prompted an investigation of the prevalence of oospores of *Albugo* in samples of *Brassica* seed, the results of which are presented in this paper.

Methods

De Tempe (2) in comparing different means of recovering spores from seed samples concluded that filtration techniques were the most accurate, those involving centrifugation being difficult to standardize. Therefore, although attempts were made initially to use a centrifugation method similar to that of Cherewick (1), the technique outlined below was also developed. Ultimately this second method was the one employed in the processing of 610 *Brassica* seed lots (Table 1) which were a representative sampling of those used in a previous study of seed-borne fungi (5, 6).

Table 1. No. and source of *Brassica campestris* seed samples* washed for oospores of *Albugo* 1967-73

Year	Alberta	Saskatchewan	Manitoba	Total
1967	2	2	1	5
1968	24	32	5	61
1969	38	82	1	121
1970	54	98	23	175
1971	31	95	23	149
1972	6	18	2	26
1973	13	29	6	48
Total	168	356	61	585

* Twenty-five *B. napus* samples were also washed, giving a total of 610 samples.

For the common *B. campestris* cultivars, a 5 g subsample from each lot of seed was washed briefly in 10 ml of

[1] *Contribution No. 580, Research Station, Agriculture Canada, Saskatoon, Saskatchewan, S7N 0X2.*

Table 2. A comparison of the results of washing three subsamples from each of 17 seedlots

Sample no.	Avg no. oospores per microscope field for replicate no. 1	2	3
193	10.1	18.2	9.8
522	1.2	2.2	1.5
536	1.1	8.5	0.8
545	0.6	0.4	0.4
547	2.5	1.7	2.9
1501	4.7	5.2	5.2
1544	0.5	0.8	0.7
1689	3.4	3.0	2.9
1737	1.1	0.7	0.9
1796	1.8	1.4	16.7
2062S	5.3	5.6	5.1
2062A	0.2	0.1	
2063A	0.5	0.5	0.5
2064S	0.9	0.4	0.5
2067A	tr	0.4	
2067S	1.4	0.8	0.3
2041A	1.2	0.4	0.3

water containing a drop of the wetting agent Tween 20. To compensate for greater seed size, 7.5 g subsamples of *B. campestris* 'Yellow Sarson' and 6 g subsamples of *B. napus* L. were taken. The seeds were caught in a sieve as the wash water was poured into a Millipore filtering apparatus. The spores were collected by suction on a 2.5 cm filter disc which was then dried and cleared with mineral oil. The numbers of spores in 10 microscope fields (magnification 80 X) were recorded and the averaged counts multiplied by 30.5 to convert them to numbers of spores per g of seed. To express the results on an oospore per seed basis the number of spores per g of seed was divided by 430, the average number of seeds per g in several 1 g subsamples from several lots. A number of seed lots representing a range of infestation rates were sampled a second and a third time to obtain an indication of the variation to be expected among

Table 3. Distribution of oospores in washings of 15 *Brassica campestris* seed samples; spores in 10 microscope fields counted following deposition on filter paper

Sample no.	Rep. no.	No. of oospores per microscope field Range	Mean	S.D.
39		3 - 12	6.4	2.72
77		2 - 14	6.3	3.53
193	1	6 - 14	10.1	2.47
	2	5 - 12	9.8	2.20
	3	13 - 26	18.2	3.79
257		2 - 7	4.4	1.64
374		5 - 20	8.7	5.06
530		18 - 46	28.2	9.95
536		3 - 14	8.5	4.30
555		11 - 23	15.7	6.55
1501	1	2 - 9	4.7	2.00
	2	3 - 9	5.2	1.87
	3	2 - 10	5.2	2.66
1689	1	2 - 6	3.4	1.35
	2	1 - 7	3.0	1.63
	3	1 - 6	2.9	1.52
1713		6 - 18	12.0	3.22
1715		2 - 8	4.3	1.77
2062S	1	2 - 9	5.3	2.16
	2	3 - 8	5.6	1.78
	3	3 - 10	5.1	2.38
R-500S		3 - 9	4.4	1.78
2069		2 - 6	3.6	1.43

subsamples. Standard deviations were calculated for many of the more heavily infested samples to give an indication of the variation in spore numbers between microscope fields.

Results

The filtration technique was generally reliable for rapid quantitative screening of large numbers of *Brassica* seed samples for the presence of oospores (Tables 2 & 3). Without exception much poorer recovery of oospores was obtained using centrifugation. Starting from the same artificially introduced spore load, it was shown that the recovery of oospores by the latter technique was

Table 4. Oospores (no./g seed) detected in seed samples of *Brassica campestris* grown in Saskatchewan Crop Districts 1-9, 1968-73

Crop District	1968		1969		1970		1971		1972		1973		2- to 6-year avg
	Avg	Max.*	Avg	Max.	Avg	Max.	Avg	Max.	Avg	Max.	Avg	Max.	
1-4					5	6	9	34			1	1	7
5	24	40	25	265	7	62	14	55	68	162	4	12	24
6			9	24	4	12	4	12			50	134	17
7			15	49	4	12	6	18			6	12	8
8A	28	101	2	15	14	143	12	34	3	3	7	18	11
8B	140	308	11	31	10	31	9	24	19	43	7	21	33
9	26	76	51	668	5	21	11	40	4	6	6	15	17
Provincial average	41		22		8		10		19		12		19

* Max. = Highest no. oospores in any sample.

greatly influenced by the amount of dirt naturally present in a seed sample; the more grit present the higher the spore counts. When the filtration method was employed, more extraneous matter could be present before results were affected through the spores being hidden from view. The variability noted in some of the results when filtration was used (Tables 2 & 3) appeared to be due in large part to inability to adequately disperse clumps of spores during washing of the seeds.

Albugo spores were detected in approximately 77% of the 356 *B. campestris* samples from Saskatchewan. The highest average infestation rate, 41 spores per g of seed, occurred in 1968 (Table 4). Thereafter, the averages ranged from 8 per g in 1970 to 22 per g in 1969. The highest spore load found in any Saskatchewan sample, 668, occurred in 1969. This seed lot was from Leask in Crop District 9. The 2- to 6-year averages for crop districts reveal somewhat lower spore loads in samples from the southern districts (Nos. 1-4) and the west central district (No. 7) than in those from other districts (Table 4). However, 8 of 10 1970 and 1971 turnip rape samples from Crop Districts 1-4 contained oospores, the highest level being 34 per g. It is perhaps surprising that Crop District 8A in the northeast had a relatively low average. [The Canadian prairie crop districts and their subdivisions were illustrated by Williams (8)]

Oospores were detected in 20 of 25 *B. napus* seed samples tested, all of which were from Saskatchewan. Infestation ranged from a trace to 12 spores per g, with an average of 3 per g. This is of interest, as the author has never observed white rust infections on *B. napus* cultivars in the field and they have been immune upon inoculation in the greenhouse.

Oospores were found in 87% of the 168 Alberta samples. Those from 1969 were among the most heavily infested of any examined in the course of the study (Table 5). Over 1500 spores per g occurred in a sample from Falher and 860 per g were found in one from Beaverlodge. Both localities are in Alberta Agricultural Reporting Area (ARA) 7. In ARA 4, a sample from Viking had 479 spores per g. The highest infestation in other years was 366 spores per g in a 1970 sample from Bon Accord in ARA 5. The 3- and 4-year averages for ARAs 2-7 indicate a considerable increase in the average number of spores per sample going from south to north (Table 5).

Infestation of Manitoba samples never exceeded 50 per g (Table 6). Slightly in excess of 72% of the 61 Manitoba seed lots had detectable oospore infestation.

In Tables 7 to 9 the samples from Alberta, Saskatchewan, and Manitoba, have been grouped in a number of infestation severity categories. Infestations heavier than one spore per 10 seeds occurred in 13.1% of the total Alberta samples, 6.5% of those from Saskatchewan, and 3.3% of those from Manitoba. In 1968, 31.2% of the Saskatchewan samples had in excess of this level of

Table 5. Oospores (no./g seed) detected in seed samples of *Brassica campestris* grown in Alberta, 1968-71

ARA*	1968 Avg	1968 Max.†	1969 Avg	1969 Max.	1970 Avg	1970 Max.	1971 Avg	1971 Max.	4-y avg
1					3	9	12	12	
2	6	12	19	73	6	34	8	15	10
3	34	82	6	18	5	9	21	49	17
4	9	9	104	479	11	37	32	64	49§
5	14	49	20	73	62	366	38	70	34
6	101	195	23	76	25	104	19	46	42
7	1	1	318	1577	26	64	7	21	117§
Provincial average	23		92		24		18		39

* ARA = Agricultural Reporting Area.

† Max. = Highest no. oospores in any sample.

§ 3-y average.

infestation. The percentage of heavily infested samples declined to 1.0 in 1971, increasing only slightly thereafter. Yearly fluctuations of this magnitude did not occur in the Alberta and Manitoba samples.

Samples of *B. campestris* cultivars Echo, Span, and R-500 (Yellow Sarson) from the 1973 cooperative rapeseed varietal tests were compared for levels of oospore infestation. R-500 has generally been the most susceptible to infection in the greenhouse and field; Echo and Span were usually similar in reaction. In the present experiment, seed from 10 locations across the Prairies was sampled. Averages for spores per g were 20 for R-500, 14 for Span, and 8 for Echo. However, relative amounts of infestation in samples of the three cultivars from different stations varied considerably.

Alternaria spores and spore fragments occurred in extremely large numbers in the washings of several of the 610 samples. Many belonged to *Alternaria brassicae* (Berk.) Sacc. Conidia of *Helminthosporium* and *Curvularia* were among the more easily recognizable ones that occurred less frequently.

Table 6. Oospores (no./g seed) detected in seed samples of *Brassica campestris* grown in Manitoba, 1970-71

Crop District	1970 Avg	1970 Max.*	1971 Avg	1971 Max.
10, 11	3	9	20	34
13, 14	12	49	5	15
Others	4	9	14	37
Provincial avg	6		14	

* Max. = highest no. oospores in any sample.

Discussion

It is evident that *Albugo* oospores occur commonly in *Brassica* seed samples throughout the Prairies. The actual inoculum levels may be considerably above the apparent levels, for upon germination a single oospore may release in the order of 40 to 60 zoospores. In addition, pieces of staghead material (hypertrophied inflorescence) up to several mm across have been observed in seed lots. Such pieces would not be accounted for by the washing technique as all but the smallest would be screened out with the seed. Their presence reemphasizes the need for proper cleaning of seed. Infection in the form of mycelium within the seed coat might also be of some importance. In sections of pods bearing oospore-containing blisters, hyphae have been seen within the cotyledons of embryos (unpub-

Table 7. Percentage of 356 Saskatchewan samples of *Brassica campestris* seed of eight infestation severity categories

Year	No. of oospores per g of seed: 0	Tr - 3	4 - 11	12 - 43	44 - 86	87 - 129	130 - 323	Over 323
1968	18.8	12.5	12.5	25.0	21.9	3.1	6.2	0
1969	30.5	29.3	12.2	19.5	4.9	0	2.4	1.2
1970	23.5	32.6	23.5	18.4	1.0	0	1.0	0
1971	17.9	22.1	22.1	37.9	1.0	0	0	0
1972	22.2	22.2	16.7	33.3	0	0	5.6	0
1973	17.3	41.4	6.9	27.6	3.4	0	3.4	0
1967-73	22.8	27.2	17.7	25.8	3.9	0.3	2.0	0.3

Table 8. Percentage of 168 Alberta samples of *Brassica campestris* seed in each of 10 infestation severity categories

Year	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
1968	0	29.2	25.0	33.3	8.3	0	4.2	0	0	0
1969	13.2	18.5	23.7	26.3	10.5	0	0	2.6	2.6	2.6
1970	20.4	22.2	16.6	27.7	7.4	1.9	1.9	1.9	0	0
1971	6.5	16.1	12.9	48.4	16.1	0	0	0	0	0
1972	33.3	33.3	16.7	16.7	0	0	0	0	0	0
1973	15.4	46.2	23.0	15.4	0	0	0	0	0	0
1968-73	13.1	23.8	19.0	31.0	8.9	0.6	1.2	1.2	0.6	0.6

lished data). Although this could represent any of a number of fungi (4), the likelihood of it being *Albugo* infection is great.

In surveys conducted between 1970 and 1972 (3), it was found that up to 46% of the plants in fields of turnip rape had systemically infected branches. There is a possibility that many of these infections originated with oospores sown with the seed. The oospore load in the seed should now be related to the production of stagheads and other symptoms in the field. Soil-borne oospores could also add to the inoculum potential. The prevalence of these in fields following turnip rape has yet to be investigated.

In some instances the oospores found in samples of the resistant host, *B. napus* might have come from infected *B. campestris* plants occurring in fields of the former. Such mixtures have frequently been observed. Alternatively spores might have been introduced in handling and cleaning seed prior to receipt of the samples. It is thought that careful washing of the filtration apparatus between samples minimized contamination during processing in the laboratory.

Rapeseed is grown much more intensively in central and northern prairie crop districts than in the drier southern ones. However seed from southern areas was frequently infested, and *Albugo* would appear to be more prevalent

Table 9. Percentage of 61 Manitoba samples of *Brassica campestris* seed in each of six infestation severity categories

Year	No. of oospores per g of seed: 0	Tr - 3	4 - 11	12 - 43	44 - 86	Over 86
1970*	43.5	21.7	26.0	4.4	4.4	0.0
1971*	8.7	21.8	26.0	43.5	0.0	0.0
1967-73	27.8	24.6	21.3	23.0	3.3	0.0

* 23 samples.

in samples from these regions than are pathogenic *Alternaria* spp. (5). Therefore, there do not appear to be areas on the Prairies where seed free of *Albugo* infestation might be consistently produced. The effectiveness of seed treatment chemicals in reducing the incidence of *Albugo* is being investigated.

The results presented strongly support the view that in western Canada seed-borne oospores are an important source of primary infection for the white rust fungus *A. cruciferarum*. A research effort directed to substantially lowering the levels of this form of inoculum might be rewarded by significantly improved turnip rape seed yields.

Acknowledgment

The technical assistance of Marjorie M. Richardson is gratefully acknowledged.

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A foot and root rot disease of tomato caused by Fusarium oxysporum

W. R. Jarvis, H. J. Thorpe[1], and B. H. MacNeill[2]

A widespread and serious foot rot disease of tomato which occurred in the greenhouse crops of the Leamington area of Ontario in the spring of 1974 was caused by *Fusarium oxysporum* of undetermined forma specialis. Isolates were pathogenic to cultivars resistant to races 1 and 2 of *F. oxysporum* f. sp. *lycopersici*. The fungus caused cortical rotting in the hypocotyl where adventitious roots arose, as well as a root rot. Vascular discoloration was present in the stem, but only for short distances from the rotted zone, though wilting reminiscent of that caused by *F. oxysporum* f. sp. *lycopersici* occurred.

Can. Plant Dis. Surv. 55: 25–26. 1975.

Un genre de pourridie grave et répandu de la tomate qui s'est manifesté dans les cultures de serre de la région de Leamington (Ont.) au printemps de 1974, a été causé par *Fusarium oxysporum* de la forme indéterminée specialis. Les isolats de ce champignon se sont révélés pathogènes pour les cultivars résistants aux races 1 et 2 de *F. oxysporum* f. sp. *lycopersici*. Ce champignon a causé la pourriture du cortex de l'hypocotyle où poussent les racines adventives, ainsi qu'un genre de pourridié. On a constaté une décoloration vasculaire de la tige, mais seulement sur de courtes distances depuis les zones de pourriture, même s'il s'est produit un flétrissement comparable à celui causé par *F. oxysporum* f. sp. *lycopersici*.

Symptoms

In the spring of 1974 and again in the fall our attention was drawn to a widespread wilt of tomatoes in greenhouses of the Leamington area, southwestern Ontario, the cultivars affected being WR25, Vendor, and MR13, with some crops affected to the extent of about 30%. The same syndrome occurred simultaneously at Cleveland, Ohio (Dr. J. M. Farley, personal communication). The disease was characterized by a sudden wilt, particularly in sunny weather, the upper leaves wilting first, the lower leaves then turning golden-yellow from the tip and dying. These symptoms, however, followed a chocolate-brown cortical rot at soil level and reddish-brown vascular discoloration extending upwards for 4 or 5 cm. Primary, secondary, and tertiary roots, as well as the initial tap root, had dark reddish-brown lesions, many confluent with hypocotyl lesions.

Causal organism

Isolations from naturally infected plants consistently yielded *Fusarium oxysporum*, usually alone. The fungus was identified mycologically by Dr. R.A. Shoemaker, Biosystematics Research Institute, Ottawa, and chemotaxonomically in the Guelph laboratory by means of the benomyl-plate test (3). The fungus, for the most part, was limited to the discolored sites on hypocotyl and stem; in this respect it differed from the wilt pathogen *F. oxysporum* f.sp. *lycopersici* which is systemic in its host (2). The disease resembles the root rot described in California (1), except for the limited leaf necrosis noted under Ontario conditions.

Inoculations

Small numbers of seedlings of the cultivars WR25, MR13, and Vendor raised in infested soil damped off about 1 week after emergence. Those that survived had brown lesions in the transition zone, ranging from only slight discoloration to complete rotting of the tap root. When these survivors, 16 days old, were repotted into steamed compost, most quickly developed adventitious roots, but 4 weeks after potting, the lesions had enlarged, often resulting in the total destruction of the true root system, the breakdown of the lower hypocotyl cortex, and reddish-brown discoloration extending 2-4 cm up the vascular system. Some of the adventitious roots also developed brown lesions at the tip and these often extended back to the hypocotyl where annular cortical lesions then formed. In some cases several cortical lesions surrounding infected roots had coalesced into large brown lesions 2-3 cm above the basal lesion. In young roots infected from the tip, the stele became discolored early and the lesion progressed faster there than in the cortex. The metaxylem often rotted out completely leaving a hollow stele that extended into the hypocotyl vascular system.

When seedlings, 25, 32, or 39 days old, were inoculated by pouring a spore suspension into the soil around them, small discrete (<0.5 mm) superficial brown lesions were formed at soil level, but they have not been seen to develop further. Also, annular cortical lesions sometimes appeared in the hypocotyl around symptomless adventitious roots; infection appeared to have occurred in the ruptured hypocotyl epidermis and cortex as the root broke through. Here, the lesion progressed along the endogenous root, rotting its cortex as well as the neighboring hypocotyl cortex until it reached the hypocotyl vascular system; then the vascular system of both stem and root became discolored. Root tips and

[1] *Research Station, Agriculture Canada, Harrow, Ontario, NOR 1GO*

[2] *Department of Environmental Biology, University of Guelph, Guelph, Ontario N1G 2W1*

secondary root initials were also sites of aggressive infection.

Seedlings, 27 days old, inoculated by the bare-root-dip method and planted into sterilized potting compost were usually quickly killed by large lesions on the tap root and hypocotyl, though some survived by means of adventitious roots above the lesions. The highly aggressive nature of the isolate could be modified by lowering the inoculum level. When the fungus was grown in Czapek's-vermiculite medium and then added at high dilutions to natural soils, the onset of symptoms could be delayed until the plants began to produce flowers, a situation comparable to that encountered in growers' greenhouses. In such plants the fungus was found to be somewhat more systemic than when the inoculum level was high, and could be reisolated from the fifth node of the host.

Epidemiology

A limited analysis of the distribution and spread of the disease made in the fall in commercial ground beds suggests that infection was at random from the soil and that the disease then spread along the rows. Wilted plants often bore lesions with profuse sporulation from soil level to about 5 cm upwards but occasionally to as much as 30 cm. It seems likely that spores could be readily dispersed along and across rows by water from mobile irrigation systems.

Control

There is no control measure yet known; commercial steaming, either by buried tile ducts or by surface application beneath plastic sheets, and Vorlex fumigation have failed to eradicate the disease between spring and fall crops, though the incidence in some cases was considerably lower in the fall crop. The locally important cultivars so far tested, WR25, MR12, MR13, Vendor, and Walter, together with Bonny Best, were all susceptible when inoculated by the root-dip method. The susceptibility of other cultivars is unknown.

Conclusions

This disease appears to be distinct from the epinasty caused by *F. oxysporum* f. sp. *lycopersici* (4) in that here cortical necrosis and limited vascular discoloration are different symptoms. Further, the fungus seems to be limited in its invasion of the plant. If the fungus is *F. oxysporum* f. sp. *lycopersici*, then it is a new race, both on the grounds of cultivar host range and of symptoms.

Acknowledgments

We are indebted to Mr. J. C. Fisher, Ontario Ministry of Agriculture and Food, who first drew our attention to the disease, to Dr. R. A. Shoemaker, Biosystematics Research Institute, Ottawa, for identifying the fungus, and to Dr. V. A. Dirks for statistical advice.

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A new record of stem and bulb nematode in Ontario

S.G. Fushtey and C.B. Kelly[1]

Ditylenchus dipsaci, the stem and bulb nematode, was detected in onions (*Allium cepa*) grown near Cookstown, Ontario, in 1973 and in onions and garlic (*A. sativum*) in the same area in 1974. Care must be taken to avoid introducing the nematode into the nearby onion growing area at the Bradford Marsh.

Can. Plant Dis. Surv. 55: 27–28. 1975.

On a décelé la présence du nématode des tiges et des bulbes, *Ditylenchus dipsaci*, chez les oignons (*Allium cepa*) cultivés près de Cookstown (Ont.) en 1973, et chez des oignons et de l'ail (*A. sativum*) cultivés dans la même région en 1974. Il faut prendre soin de ne pas introduire ce nématode dans la région avoisinante de culture d'oignons du marais Bradford.

In Ontario the stem and bulb nematode *Ditylenchus dipsaci* (Kuhn 1857) Filipjev 1936 has been reported to occur on onions at the Point Pelee Marsh (Mountain, 1957) and at the Erieau Marsh (Johnson and Kayler 1972). Observations made by the present authors during 1973 and 1974 have established that a third onion-growing region, a small marsh area near Cookstown, should be added to the record.

In late summer of 1973 a sample of abnormal onion (*Allium cepa* L.) bulbs was brought to our laboratory for disease diagnosis. The onions bore symptoms suggesting onion bloat in that the outer layers of scales were split, especially near the base, and the scales at the neck were softer than normal. Microscopic examination with the aid of staining and clearing techniques showed these outer scales to be heavily infected with the stem and bulb nematode. The grower was notified of the diagnosis and advised not to grow onions on that field and to follow recommended controls as outlined in the Ontario Ministry of Agriculture and Food Factsheet, Agdex 258/628, 'Bulb and Stem Nematode in Ontario'. The following summer the authors visited the grower's farm and found heavily infected onions and garlic growing in a field adjacent to that which produced the diseased bulbs the previous year. When other onion fields in the area were examined, nematode-infected plants were found in only one field about 2 miles distant from the original find.

The prevalence of this pest in the Cookstown area has yet to be determined but the occurrence on two farms is cause for concern particularly because of its proximity to the large onion-growing region of the Bradford Marsh. The Bradford Marsh is still considered to be free of this pest and care must be taken to prevent its introduction.

The nematode survives in dry soil, in dried foliage, in dried onion scales, and even on onion seed. In this form it is easily carried from place to place with soil adhering to implements; soil drifted by the wind; dried onion leaves, scales, and soil in trucks, wagons, and unclean containers; on infested seed and in setts. It is therefore

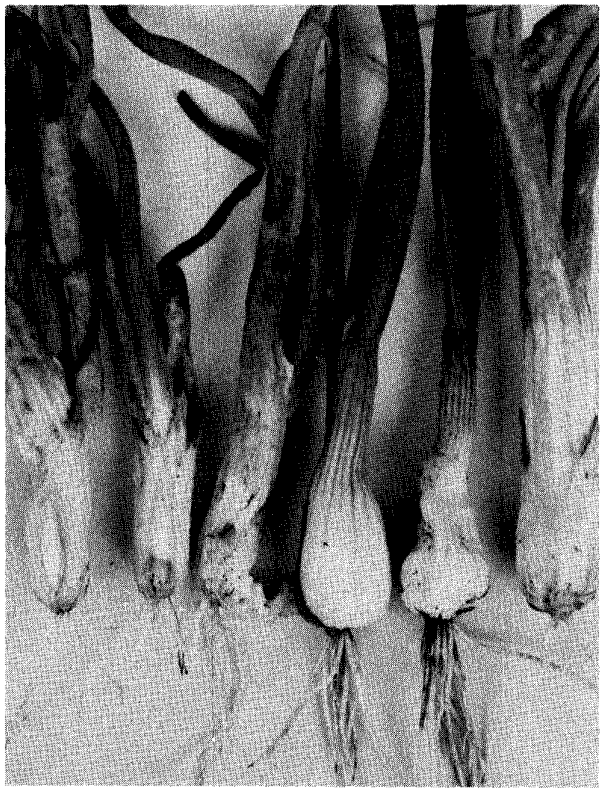

Figure 1. Diseased young onion plants collected from one of the fields at the Cookstown marsh. Note the irregular swelling and distortion of the leaves with the outer leaves dying back from the tips; also splitting of the outer scales on the developing bulbs. Onions affected to this extent in early growth usually die by mid summer.

[1] *Department of Environmental Biology, University of Guelph, Guelph, Ontario N1G 2W1*

Figure 2. Diseased onion bulbs in later growth. Note splitting of the outer layers of scales and swelling of the inner layers which tend to bulge out through the split. The split extends into the root region which often gives rise to distorted, leaf-like shoots as shown in the bulb on the right.

Figure 3. Cross-section of a diseased onion bulb cut just below the neck. Note the porous nature of the outer layers, in this case extending nearly to the centre of the bulb. This is the reason for the soft, spongy texture of diseased bulbs in the neck region. This kind of tissue is very susceptible to attack by fungi and bacteria and may begin to rot in the field but will certainly rot in storage.

important that movement of farm equipment and materials from the Cookstown to the Bradford area be avoided. If movement is necessary, all items should be thoroughly cleaned and disinfected. It is important that growers check the source of their seed and setts to insure that they are clean. Finally, growers should inspect their fields periodically and report occurrence of plants which bear symptoms of this disease in order that any introduction may be recognized early and curbed before it becomes widespread.

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Effect of temperature on the development of Godronia cassandrae f. vaccinii cankers on lowbush blueberry[1]

C. L. Lockhart

Lesion development on lowbush blueberry (*Vaccinium angustifolium*) artificially inoculated with *Godronia cassandrae* f. *vaccinii* was greater on plants grown at 15°C days and 4.5°C nights than on those grown at 21°C days and 9.5°C nights. Inactive lesions on plants from 21°C days and 9.5°C nights became active when the plants were exposed to cool autumn temperatures in an unheated greenhouse.

Can. Plant Dis. Surv. 55: 29–30. 1975.

Le développement des lésions sur le bleuet nain (*Vaccinium angustifolium*) artificiellement inoculé avec *Godronia cassandrae* f. *vaccinii* a été plus considérable chez les plants cultivés à des températures diurnes et nocturnes de 15 et de 4.5°C respectivement que chez cultivés à des températures diurnes et nocturnes de 21 et de 9.5°C. Jusque-là latentes, les lésions des plants exposés aux températures diurnes et nocturnes de 21 et de 9.5°C respectivement sont devenues actives lorsque les plants ont été à aux températures fraîches d'automne en serre non chauffée.

In a previous study (1) *Godronia cassandrae* (Peck) f. *vaccinii* Groves (stat. conid. *Fusicoccum putrefaciens* Shear) was found to infect highbush blueberries (*Vaccinium corymbosum* L.) in the spring and in the autumn but not during the active growth period in the warm summer temperatures. This study reports on the effect of two temperature regimes on the development of *G. cassandrae* f. *vaccinii* cankers on the lowbush blueberry (*Vaccinium angustifolium* Ait.).

Inoculation experiments

An isolate of *G. cassandrae* f. *vaccinii* from lowbush blueberry (2) was used to inoculate actively growing 2-year-old lowbush blueberry seedlings by the wound incision method previously described (2). Forty plants were inoculated with the fungus and eight plants not inoculated served as controls. The plants were divided into two lots, placed in growth chambers (Controlled Environment Ltd., EY8VH) equipped with six 40-W fluorescent bulbs and eight 100-W incandescent bulbs and grown under the following regimes for 6 to 8 months:

1. 15°C days (16 h) and 4.5°C nights (8 h)
2. 21°C days (16 h) and 9.5°C nights (8 h)

Relative humidity was 92% during the day and 98% at night. The experiment was repeated three times. Data were analyzed using the 't' test.

After 6 to 8 months cankers on the lowbush blueberries artificially inoculated with *G. cassandrae* f. *vaccinii* averaged 7.9 mm long in 15°C day and 4.5°C night regime and 5.0 mm long in the 21°C day and 9.5°C night regime (Table 1). The low temperature regime favored a higher rate of successful inoculations (Table 2). At the higher temperatures the lesions had considerable callus tissue and appeared to be inactive, but many became active after the plants were transferred to an unheated greenhouse where cool autumn temperatures prevailed. There were no signs of fungal fruiting structures on any of the cankers.

Table 1. Length of lesions on lowbush blueberry stems 6 to 8 months after inoculation with *G. cassandrae* f. *vaccinii*

Temperature regime	Length of lesions (mm)			
	Test 1 (6 months)	Test 2 (8 months)	Test 3 (6 months)	Avg.
4.5° and 15° C	7.4	9.8	6.6	7.9
9.5° and 21° C	5.4	5.0**	4.6**	5.0

**Significant at P = 0.01

Table 2. Percentage of *G. cassandrae* f. *vaccinii* inoculations producing lesions

Temperature regime	Test 1	Test 2	Test 3	Avg
4.5° and 15°C	60	100	95	85
9.5° and 21°C	80	90	20	63

The effect of temperature on the growth of the fungus in vitro was determined on potato dextrose agar plates incubated at 11 different temperatures ranging from 0°C to 28°C and replicated four times. After 21 days the diameters of the colonies were measured. The fungus grew at temperatures from 0°C to 28°C with maximum growth at 14°C to 22°C (Fig. 1). By coincidence the temperature regimes selected for inoculation

[1] *Contribution No. 1546, Research Station, Agriculture Canada, Kentville, Nova Scotia.*

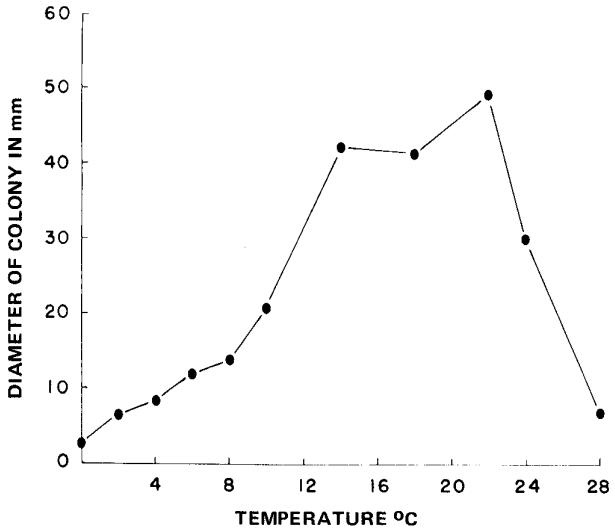

Figure 1. Influence of temperature on growth of *Godronia cassandrae* f. *vaccinii*.

experiments fall within the optimum growth range of the fungus in vitro but there was significantly less canker development at the higher temperature regime (Table 1). This indicated that growth and development of the fungus in vitro and in vivo may fall off sharply as indicated by the growth behavior of the fungus above 22°C (Fig. 1).

The slow development of *G. cassandrae* f. *vaccinii* on the lowbush compared to the highbush blueberry may explain the difference in the severity of the disease on the two types of blueberries. On highbush blueberry *G. cassandrae* f. *vaccinii* can completely girdle a stem in one season (3) but this has not been observed in these experiments or on 2-year-old shoots of lowbush blueberry plants in the field (2). The practice of burning lowbush blueberry fields every 2 or 3 years apparently destroys infected stems before the fungus becomes established in the basal area of the shoots. Consequently the canker is found mainly on plants in neglected lowbush blueberry fields.

Acknowledgment

The author is indebted to G. L. Moody for technical assistance.

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Diseases of flue-cured tobacco in Ontario and estimates of disease losses, 1972-73[1]

S. K. Gayed[1] *and M. C. Watson*[2]

In Ontario the major diseases of flue-cured tobacco (*Nicotiana tabacum*) are brown root rot caused by the root lesion nematodes *Pratylenchus* spp; pole rot caused by *Rhizopus arrhizus*; weather fleck induced by air pollution; and sore-shin caused by *Rhizoctonia solani*. In 1972 and 1973 the average annual yield loss from these and other tobacco diseases was estimated at 3.5%, representing a farm value of $5.5 million. Annual losses from pole rot and weather fleck were estimated at 1.3% and 0.73%, respectively. Brown root rot is controlled on most farms by soil fumigation at a cost of approximately $2.2 million per annum; despite these control measures losses averaged 0.4%. Blue mold caused by *Peronospora tabacina* has not been noticed in Ontario since 1966. Stalk rot (rattle box) caused by *Sclerotinia sclerotiorum* was recorded for the first time in Canada in 1970 but has not become a problem; and *Myrothecium verrucaria* is reported for the first time from tobacco seedlings. A comparison between the tobacco disease patterns in Canada and North Carolina is also discussed.

Can. Plant Dis. Surv. 55: 31–35. 1975.

En Ontario, les principales maladies du tabac jaune (*Nicotiana tabacum*) sont le pourridié brun causé par les nématodes radicicoles (*Pratylenchus* spp.), le chauffage à la pente attribuable à *Rhizopus arrhizus*, la moucheture causée par la pollution de l'air et la tige noire attribuable à *Rhizoctonia solani*. En 1972 et 1973, la baisse moyenne des rendements annuels attribuable aux troubles susmentionnés et à d'autres maladies du tabac ont été évalués à 3.5% de la production, soit une valeur à la ferme de 5.5 millions de dollars. Les pertes annuelles dues au chauffage à la pente et à la moucheture ont été estimées respectivement à 1.3 et 0.73% de la production. La plupart des producteurs de tabac luttent contre le pourridié brun par la fumigation du sol à un coût d'environ 2.2 millions de dollars par année; malgré ces mesures de lutte, les pertes ont atteint en moyenne 0.4% de la production. La moisissure bleue causée par *Peronospora tabacina* n'a pas été signalée en Ontario depuis 1966. La pourriture sclérotique attribuable à *Sclerotinia sclerotiorum* a été signalée pour la première fois au Canada en 1970, mais n'est pas devenue un problème; enfin, *Myrothecium verrucaria* a été signalé pour la première fois sur des plants de tabac. Le présent article établit également une comparaison entre les caractéristiques des maladies du tabac au Canada et en Caroline du Nord.

Flue-cured tobacco (*Nicotiana tabacum* L.) is a major crop in Ontario. About 85% of the crop is grown in Norfolk, Elgin, Brant, and Oxford counties, with the remainder in Essex, Middlesex, Kent, Simcoe, Bruce, Durham, and Northumberland counties. In 1971, 1972, and 1973 the acreage of flue-cured tobacco was 81,214, 86,633, and 104,679, respectively , with corresponding farm values of over $131 million, $130 million, and $180 million. This paper discusses observations on tobacco diseases during these three seasons, reports two new fungal records on tobacco in Canada, and compares disease patterns in Canada with those in North Carolina, which is the major flue-cured producing state in the U.S.A. This comparison is based on disease loss estimates for North Carolina (10) and Ontario.

Disease incidence and crop losses

Information on disease incidence and severity, and on crop losses incurred in the field and during curing, was collected mainly from about 350 farms in Norfolk, Elgin, Brant, and Oxford counties and from 50 farms in Middlesex, Essex, Kent, Simcoe, Bruce, Durham, and Northumberland counties. For seedbed diseases, about 150 greenhouses distributed throughout those counties were visited each season. Additional information on disease incidence and severity was collected through contacts with growers during office visits and telephone calls.

Diagnosis of damping-off, black root rot, and sore-shin was based in most cases on the microscopic examination of diseased tissue to confirm the presence of the causal fungus. Nematodes from diseased roots and soil samples were identified at the Agriculture Canada Research Station, Vineland, Ontario. Virus diseases were identified by their typical symptoms, otherwise samples were sent to the Research Station, Vineland, for precise identification through host range studies, electron microscopy, and serological tests. Weather fleck and pole rot were identified through their visible symptoms.

The spread of disease in the seedbed, field or kiln, the frequency of disease in the tobacco farms, and the losses in tobacco weight and quality due to disease were considered in estimating disease losses.

[1] *Contribution No. 98, Research Station, Agriculture Canada, Delhi, Ontario.*

[2] *Plant Pathologist, Research Station, Agriculture Canada, Delhi, Ontario*

[3] *Tobacco Specialist, Soils and Crops Branch, Ontario Ministry of Agriculture and Food, Delhi, Ontario*

Greenhouse diseases

Blue mold [*Peronospora tabacina* Adam] has not been noticed in Ontario since 1966.

Damping-off [*Rhizoctonia solani* Kühn and *Pythium* spp.] caused losses to tobacco seedlings estimated at 5-10% in 1972 and at 3-5% in 1973. No crop losses were incurred since growers had an excess of seedlings for planting their fields.

Black root rot [*Thielaviopsis basicola* (Berk. & Br.) Ferr.] caused slight infection in seedbeds that had not been properly sterilized. Black root rot infection did not affect the seedling supply for the field.

Root knot [*Meloidogyne hapla* Chitwood] caused damage in only a few greenhouses during 1971-73 due to improper sterilization of the seedbeds, but losses have been insignificant.

Field diseases

Black root rot [*Thielaviopsis basicola*] caused severe losses prior to 1969. Since then losses have been considerably lower due to the propagation of the cultivars Delhi 34 and 'Virginia 115', which are highly tolerant to black root rot. Losses were estimated at $300,000 and $504,000 in 1972 and 1973.

Brown root rot [*Pratylenchus penetrans* (Cobb), *P. neglectus* (Rensch.) Filipjev and *P. crenatus* Loof]. A recent survey indicated that these three species of the root lesion nematode are causing stunting to tobacco (8). Losses due to brown root rot were estimated at $500,000 and $738,000 in 1972 and 1973. About 90% of the growers fumigate their fields against nematodes. Cost of fumigation was estimated at $2 million and $2.5 million those 2 years, respectively.

Root knot [*Meloidogyne* Goeldi] and root cyst [*Heterodera* Schmidt] nematodes. Although root knot (2,8) and root cyst nematodes (7) are present in tobacco soil, their damage to tobacco is almost negligible. Apparently soil fumigation and the tobacco-rye rotation practiced by the vast majority of growers has been effective in suppressing the population of these nematodes.

Sore-shin [*Rhizoctonia solani* Kühn in 1972, caused losses of about $500,000 and replanting costs of about $500,000. Due to the relatively dry conditions that prevailed in 1973, losses were reduced to $396,000 and very little replanting was necessary. It should be emphasized here when comparing losses in 1972 and 1973, that the acreage of the 1973 crop was 15% higher than that of 1972.

Virus diseases. A few cases of tobacco mosaic virus, tobacco etch virus, tobacco ring spot virus, cucumber mosaic virus, and streak virus have been noticed during the last three seasons but their spread has been very limited. In 1972 a virus disease identified by host range and serological tests as having as the causal agent tobacco veinal necrosis virus (TVNV), which is a strain of potato virus Y, was reported on one farm in the La Salette area of Norfolk County; however the following season there was no trace of the disease on that farm or on the neighboring farms. In 1973 another case identified by host range and electron microscopy as potato virus Y (probably TVNV) was found on a farm in the Langton area, Norfolk Co., but the spread of the disease was very limited. Losses due to virus diseases were estimated at $400,000 in 1972 and at $144,000 in 1973 crops. Drier conditions which prevailed in the 1973 season might explain the relatively low losses in 1973.

Weather fleck [air pollution] is a physiological disorder and is mainly induced on mature leaves by high levels of ozone in the atmosphere. The present tobacco cultivars Virginia 115 and Delhi 34 are more tolerant to weather fleck than previously grown cultivars such as Hicks Broadleaf. Damage from weather fleck has been higher on farms close to Lake Erie. Losses were estimated at $1 million in 1972 and $1.35 million in 1973. In making loss estimates, decrease in weight and quality of flecked leaf, as well as depreciation of leaf quality as a result of harvesting immature leaves to avoid the disease, were considered.

Curing diseases

Pole rot [*Rhizopus arrhizus* Fischer] has caused the highest disease losses in recent years. Losses were estimated at $3.0 million, $2.0 million and $2.16 million in 1971, 1972, and 1973. In estimating disease losses, loss in weight of the cured leaf and the labor costs involved in discarding diseased areas in order to make the tobacco shipment acceptable to buyers were considered. The factors that have contributed to the pole rot problem will be discussed later.

Two new records of fungi on tobacco in Canada

Stalk rot or "rattle box" caused by *Sclerotinia sclerotiorum* (Lib.) de Bary was noticed for the first time on a tobacco farm in the Alllston area in 1970. The diseased field was isolated from the rest of the farm and was surrounded with high trees, which induced a higher relative humidity in that particular field. According to the grower, the disease had been noticed in that field for several seasons before 1970 but infection never extended to tobacco on the same or neighboring farms.

The disease on mature plants during August was characterized by the formation of a canker which extended close to the leaf base for more than 10 cm in length and spread in an oval pattern (Fig. 1). The brown margin of the canker enclosed light-colored, dead tissue with some dark grayish areas. When the diseased tissue was split longitudinally the stem was found to be hollow due to the breakdown of the pith tissue by the fungus, and white mycelium with loosely attached sclerotia were scattered in the pith cavity. Sclerotia were black in color and hard in texture and varied considerably in shape and size (Fig. 1). Large sclerotia were about 25 x 5 mm. When intact diseased plants were shaken the sclerotia rattled in the hollow stem and hence the name "rattle

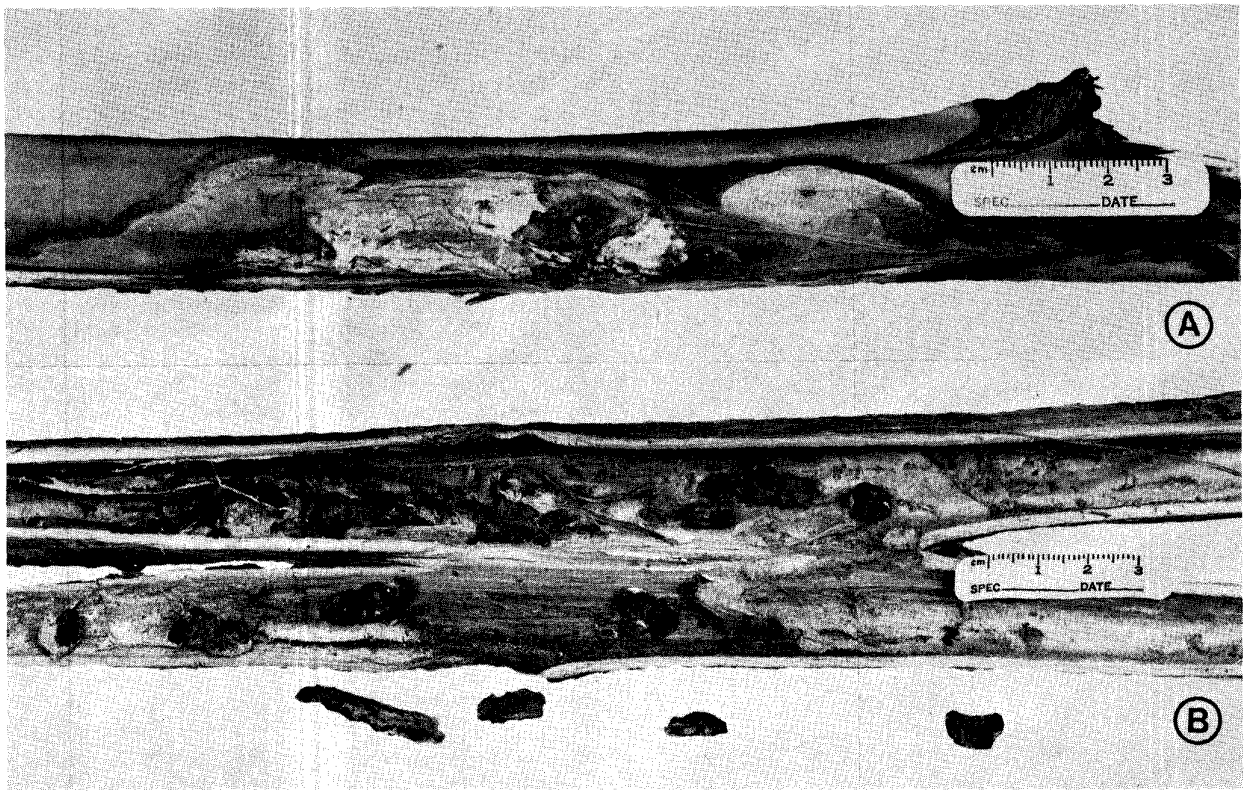

Figure 1. Stalk rot or "rattle box" of tobacco caused by *Sclerotinia sclerotiorum*, a) a canker formed on the stem of a tobacco plant, b) an infected stem split longitudinally showing the hollow pith with white patches of mycelium and loose sclerotia.

box''. The fungus was isolated and its identification was confirmed by Miss Mary E. Elliott. Stalk rot caused by *S. sclerotiorum* has been previously recorded in several other tobacco growing countries including the U.S.A. (Connecticut), Germany, India, Japan, Taiwan, Indonesia, and New Zealand (12).

Myrothecium verrucaria has been isolated from leaves of tobacco seedlings cv. Hicks Broadleaf and Delhi 34 grown on steam-sterilized muck soil in flats under greenhouse conditions during the winter months. Water-soaked areas appeared on 16-20 mm diam leaves that were close to or touching the soil surface. The water-soaked areas turned gray in color then brownish. Later, dark, cushion-like sporodochia emerged on the surface of infected areas (Fig. 2). The fungus was isolated on PDA and identified by Dr. S. J. Hughes as *Myrothecium verrucaria* (Alb. and Schw.) Ditmar ex Fr. Several trials have been made to reinfect injured and uninjured leaves of young tobacco seedlings with the isolated strain of *M. verrucaria* under different moisture conditions, but all trials to reproduce disease symptoms have been unsuccessful. *M. verrucaria* is a common saprophyte and might have colonized the young tobacco leaves under unidentified predisposing conditions. Apparently this is the first record of *M. verrucaria* being isolated from leaves of tobacco seedlings.

Discussion

The most serious diseases of flue-cured tobacco in Ontario, as manifested by disease loss estimates, were pole rot, weather fleck, and nematode induced injury. This pattern of disease severity differs slightly in the case of flue-cured tobacco grown in Quebec and in the Maritime Provinces, as well as of burley tobacco grown in Ontario and cigar tobacco grown in Quebec. In Quebec nematodes, black root rot, and gray tobacco (physiological disorder, are the common problems of flue-cured tobacco, whereas pole rot and black root rot are the main problems in cigar tobacco (personal communication, P.P. Lucosevicius, L'Assomption, Que., 1974). In the Maritimes, black root rot, sore-shin, nematodes, and pole rot are causing moderate losses to the flue-cured crop (personal communication, K. E. Lelacheur, Charlottetown, P.E.I., 1974). Virus diseases and pole rot are the main problems on burley tobacco in Ontario (personal communication W. A. Scott, Harrow, Ont., 1974). Pole rot of air-cured tobacco (cigar and

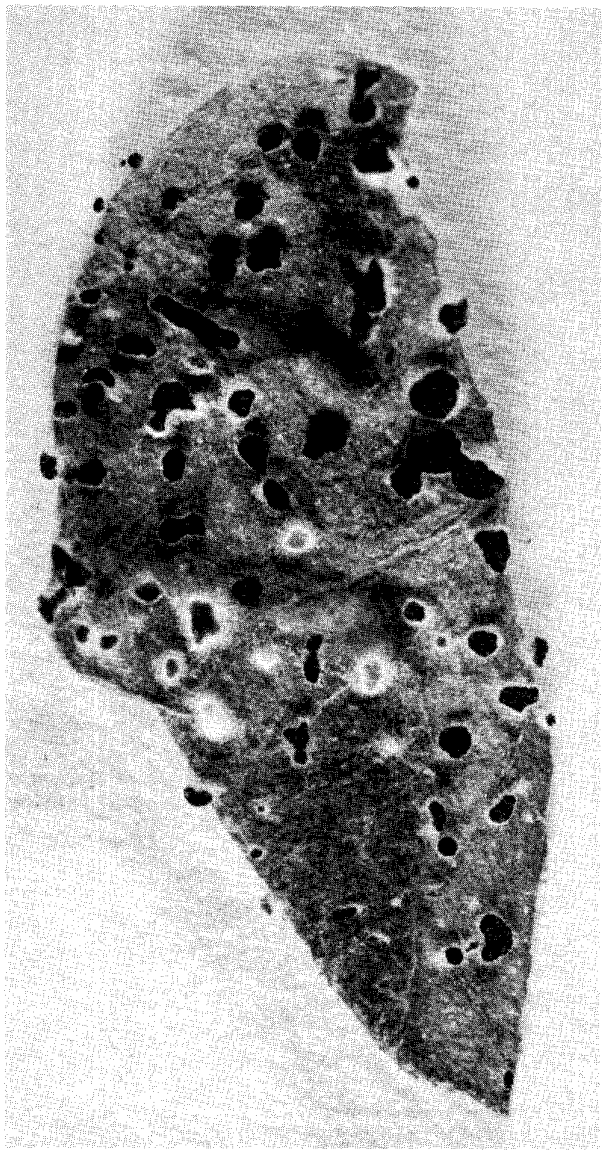

Figure 2. Surface view of a leaf of tobacco seedling showing sporodochia of *Myrothecium verrucaria.*

burley) is caused by different organisms and *R. arrhizus*, the main cause of pole rot of flue-cured tobacco, does not contribute to pole rot of air-cured tobacco, presumably due to the thermophylic tendencies of this fungus (3).

Disease patterns on flue-cured tobacco in Ontario (Ont.) and in North Carolina (N.C.) differ considerably. In N.C. losses due to pole rot in 1972 and 1973 (Table 1) were too low to specify and probably were included under "Miscellaneous leaf losses" (10). Similarly, losses due to weather fleck in N.C. were lower than in Ont. and might be attributed to differences in varietal susceptibility or in the ozone levels in the atmosphere at maturation or both. The main disease problems in N.C. are black shank, tobacco mosaic, and nematodes (10). The nematode problem in Ont. is almost totally due to the root lesion nematode, whereas in N.C. it is mainly due to root knot and partly due to the root lesion nematode. Black shank caused by *Phytophthora parasitica* has not been recorded in Ont. and losses due to viruses are relatively low compared to N.C. This might be due to a longer winter season in Ont. and a lower population of perennial weeds on which viruses might overwinter. Bacterial (Granville) wilt [*Pseudomonas solanacearum*]; fusarium wilt [*Fusarium oxysporum* f. sp. *nicotianae*] and brown leaf spot [*Alternaria alternata*] induce appreciable losses in N.C., but in Ont. bacterial wilt has not been recorded and losses due to fusarium wilt, brown leaf spot, and other pathogenic leaf spots are negligible. Losses due to black root rot are higher in Ont. than in N.C. (Table 1) presumably due to the relatively lower soil temperatures in the spring. Low soil temperature is known to increase severity of black root rot (5,7). Sore-shin caused appreciable losses in Ont. but its losses were negligible in N.C. during 1971-1973.

It is evident from this survey of tobacco diseases that disease patterns differ not only between widely separated tobacco growing areas, such as Ont. and N.C. which are about 720 km (450 miles) apart, but also differ within the same area at different periods of time. It is therefore essential from the economic point of view and in the scientific interest, as well, to follow such changes in disease pattern by carrying out regular qualitative and quantitative surveys. Blue mold and pole rot are good examples in this respect.

Blue mold was first reported in Ontario in 1938 and occurred sporadically until 1945; between 1945 and 1947 it was epidemic (1). At that time, infection was attributed to spore showers carried by favorable winds from exposed tobacco seedbeds in Kentucky and Ohio (4). Following the epidemic in 1947, the disease declined and has not been recorded during the past 7 seasons. Apparently the disease failed to get established in Ontario, most probably due to unfavorable winter conditions; moreover the source of inoculum has been checked due to effective control measures against the disease in both states.

Pole rot was not listed among diseases of Canadian tobacco in 1950 (6). However annual losses from pole rot in the 1970's were between 2 and 3 million dollars. During the past 23 years tobacco yield per acre has almost doubled, and it is possible that the introduction of vigorously growing cultivars, improved cultural practices, and the use of tying machines have led to heavier kiln loading, thus increasing humidity during curing. In addition, the utilization of mechanized tying has resulted in more injury of tobacco leaf butts. High relative humidity (3,11) and leaf butt injury (4) have been reported to enhance *R. arrhizus* spread and pole rot severity.

Table 1. Average disease losses expressed as percentage loss in yield and corresponding loss in dollars, of 1972 and 1973 crops of flue-cured tobacco in Ontario and North Carolina

	Ontario			North Carolina*	
Disease	Loss %	Loss ($'000)	Cost of Control ($'000)	Loss %	Loss ($'000)
Plant bed					
Damping-off and others	0.1		83	0.09	555
Field					
Black shank	0	0		0.76	4,883
Brown root rot	0.40	619	2,250	0.86	5,259
Black root rot	0.26	402		0.15	902
Granville wilt	0	0	0	0.14	864
Blue mold	0	0	0	0.04	184
Fusarium wilt	0.1			0.02	90
Brown spot	0.1			0.30	1,879
Miscellaneous leaf diseases	0.1			0.10	583
Sore-shin	0.29	448	250 (replanting)		
Miscellaneous root diseases	0	0	0	0.07	426
Mosaic				0.51	3,129
Other viruses	0.19	272	0	0.05	274
Weather fleck	0.73	1,175	0	0.05	257
Kiln					
Pole rot	1.30	2,080	0		
Miscellaneous losses and wastage	0.31	492	0		
TOTAL	3.48	5,488	2,583	3.14	19,285

* Estimates of disease losses in North Carolina are based on data published by F. A. Todd (10).

While pole rot is the major disease problem in Ontario, losses due the disease are limited or negligible in North Carolina. This might be attributed to different factors: a) In N.C. the tobacco growing season is longer than in Ont., therefore harvesting mature leaves is much more common in N.C. Mature leaves need a shorter yellowing period and the yellowing process provides optimal conditions for development of the disease. b) Kilns in Ont. are generally more air-tight than those in N.C. and hence operate at a higher relative humidity during curing which favors pole rot.

Acknowledgments

The technical assistance of Mr. D. A. Brown is gratefully acknowledged. Thanks are also due to Mr. N. L. Jerry, Agricultural Research Institute, London, Ontario, for preparing the photographs and to Miss Mary E. Elliott and Dr. S. J. Hughes, Biosystematics Research Institute, Ottawa, for identifying *S. sclerotiorum* and *M. verrucaria*, respectively. The assistance of Mr. N. W. Sheidow, Tobacco Specialist, Soils and Crops Branch, Ontario Ministry of Agriculture and Food, in arriving at the disease loss estimates is also gratefully acknowledged. The authors are also indebted to Dr. H. F. Dias and Dr. W. R. Allen, Research Station, Vineland, Ontario, for identifying TVNV on diseased plants.

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Oat yield losses from septoria leaf blotch at four locations in eastern Canada[1]

R. V. Clark[2], C. O. Gourley[3], H. W. Johnston[4], L. J. Piening[5], G. Pelletier[6], J. Santerre[6], and H. Genereux[6]

In a 3-year field plot experiment, natural infection of oats, *Avena sativa*, by *Leptosphaeria avenaria* f. sp. *avenaria* was most severe at Charlottetown, P.E.I., followed by La Pocatière, Que., Kentville, N. S., and Ottawa, Ont. At Charlottetown in 1970 a 50% increase in seed yield was obtained when plants were protected regularly with foliar applications of maneb, and the average increase for the 3 years, 1970-72 was 15%; at La Pocatière the largest increase in yield of maneb treated plants amounted to 13% with an average increase of 7% for 3 years. At Kentville and Ottawa septoria infection was light and fungicide sprays had little effect on yields over the 3 years. Although increases in yield were substantial at Charlottetown and La Pocatière, no consistent signficant improvement was found at either location over the 3-year period. This probably was due to changes in the environment from year to year, affecting disease prevalence and severity, cultivar response, and disease control. Spraying regularly with maneb increased kernel weight and percent protein and decreased percent hull of the seed at Charlottetown, indicating additional losses due to this disease.

Can. Plant Dis. Surv. 55: 36–43. 1975.

Dans une expérience de 3 ans en parcelles, l'infection naturelle de l'avoine (*Avena sativa*) par *Leptosphaeria avenaria* f. sp. *avenaria* a été la plus virulente à Charlottetown (île-du-Prince-Edouard), suivie dans l'ordre par La Pocatière (Québec), Kentville (Nouvelle-Ecosse) et Ottawa (Ont.). A Charlottetown en 1970, on a obtenu une hausse du rendement en grain de 50% lorsque les plants ont été régulièrement protégés au moyen d'applications foliaires de manèbe, et la hausse moyenne des 3 années (1970 à 1972) a été de 15%; à La Pocatière, la plus forte hausse de rendement des plants traités au manèbe a atteint 13%, et la hausse moyenne des 3 ans a été de 7%. A Kentville et à Ottawa, l'infection par la septoriose a été faible et les pluvérisations de fongicides ont eu peu d'effet sur les rendements au cours des 3 années. Même si les augmentations de rendement ont été substantielles à Charlottetown et à La Pocatière, on n'a constaté aucune hausse constante significative à aucun des deux endroits durant la période de 3 ans. Ce phénomène est probablement attribuable à des modifications du milieu d'année en année, qui ont influé sur la fréquence et la gravité de la maladie, la réaction des cultivars et la lutte contre les maladies. A Charlottetown, les pulvérisations régulières au manèbe ont accru le poids des grains et leur teneur en protéines, et diminué le pourcentage de balle, ce qui prouve par conséquent que les pertes attribuables a cette maladie ont été considérables.

Septoria leaf blotch incited by *Leptosphaeria avenaria* Weber f. sp. *avenaria* (imperfect state *Septoria avenae* Frank f. sp. *avenae*) is a prevalent and serious disease of oats (*Avena sativa* L.) in eastern Canada. The causal fungus attacks leaves, stems, and seed; infection is initiated in the early summer, primarily by ascopores that develop on overwintered straw and stubble. As the disease progresses, pycnidia develop in infected leaves and sheaths and pycnidiospores provide the inoculum for the secondary spread of the disease. By maturity most of the aboveground parts of host plants are diseased and in some instances considerable stem break and lodging occur (1).

In earlier studies at Ottawa (2) it was found that yield increases of up to 20% could be obtained by applying fungicides such as maneb to the oat foliage a number of times during the summer. A number of new oat cultivars have been introduced since then and as the septoria disease is prevalent throughout eastern Canada it is important to establish the yearly progress of the disease and to determine crop losses at several locations. This paper reports the results of a 3-year cooperative study initiated in 1970 with tests located at Ottawa, Ont.; La Pocatière, Que.; Kentville, N.S.; and Charlottetown, P.E.I. In 1971 and 1972 the test was carried out also at Lacombe, Alta., a location usually free from the septoria disease.

Materials and methods

Uniform methods of field plot layout and maintenance, disease assessment, and yield determination were employed. A randomized block design of four replicates and three or four fungicide regimes and at least three cultivars (Dorval, Garry, and Russell) were used. Oat seed of good size and condition was obtained at each location and planted with a mechanical plot seeder at the rate of 76 kg/ha (2 bu/ac) as close as possible to the recommended seeding date. Row lengths of 3 m (10 ft) with 10 rows per plot or 3.6 m (12 ft) with 8 rows per

[1] *Contribution nos. 428, 1567, 312, and 58 respectively from Agriculture Canada Research Stations at Ottawa, Kentville, Charlottetown, and Ste-Foy.*

[2-6] *Research Station, Agriculture Canada, [2]Ottawa, Ont., [3]Kentville, N.S., [4]Charlottetown, P.E.I., [5]Lacombe, Alta., [6]Ste-Foy and La Pocatière, Que.*

A	10	11	15	16	18	27	27	29	30	31	32	37	50	53	55	65	73	74	91
B	10	9	13	13	11	25	21	27	30	27	30	37	44	50	53	62	71	70	88

Figure 1. Disease assessment key for the septoria leaf blotch of oats. The percentage involved on each leaf was determined by A) the scatter point method and B) the drum scanner technique.

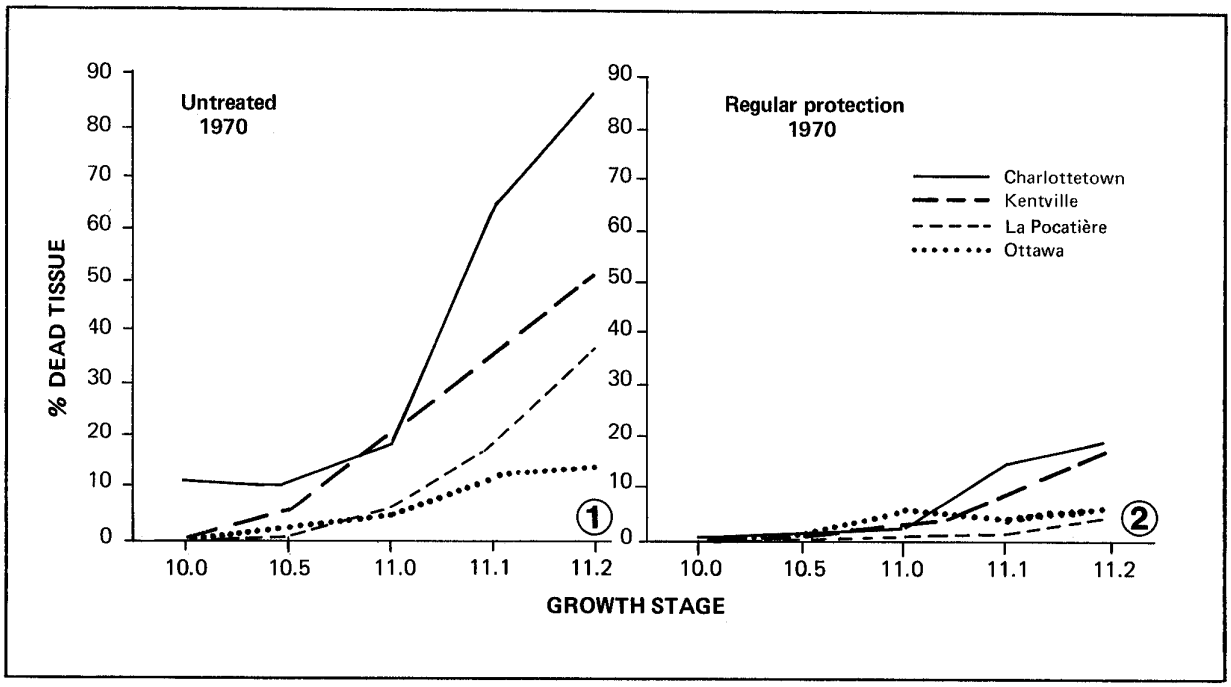

Figure 2. Oat septoria progress curves for Charlottetown, Kentville, La Pocatière, and Ottawa for the years 1970-72. 1-2) Curves for the four locations for 1970 on the untreated and regular spray applications, with disease severity based on 2 — 4 leaves per plant.

plot were used depending on location. At maturity 18.2 m (60 ft) of row per plot were harvested for yield determinations leaving the two outside rows and ends as border material. Four buffer rows of barley were planted between each oat plot to allow for spray drift and to reduce disease spread and interplot interference. Recommended fertilizer applications for each area and weed control (MCPA) practices were followed at all locations. When necessary, plots were sprayed for aphid control with endosulfan.

Manzate D (80% maneb, Du Pont of Canada, Toronto) at concentrations of 3.3 kg/ha the first year and 6.7 kg/ha the second and third year was applied to the oat foliage starting at the late tillering stage. Sprays were applied with knapsack type sprayers until runoff and care was taken to avoid drift and to obtain maximum coverage. If a heavy rain washed the fungicide off a few hours after the original application, then a second spray was applied. The following regimes were employed applying sprays every 10 days: 1) untreated, no protection; 2) regular protection, with applications from late tillering until maturity; 3) early protection, with applications from late tillering until midheading stage; 4) late protection, with applications from midheading stage until maturity.

Septoria leaf blotch severity was assessed by estimating the percentage of leaf area affected, using an infection key prepared by the senior author (Fig. 1). The leaf area diagrams were based on a range of leaf sizes and infection percentages of naturally infected oat leaves. The percent infection on the individual leaves in the key was established by both a scatter point method and an IBM drum scanner technique (4). With the scatter point method the amount of surface area representing disease was determined by overlaying leaves in the key with scatter point paper (Bruning Areagraph Chart No. 4850), and the number of dots in both the diseased and healthy areas were counted and then used to calculate the percentage of healthy and diseased areas involved. This procedure was repeated a number of times and the results were averaged.

Beginning at early heading stage, disease assessments were made on 10 main tillers selected at random from the rows within each plot. The tillers were removed carefully so that those remaining on each plant were left to mature. Early in the growing season, when septoria symptoms were scarce, only one or two replicates were assessed and tillers where chosen from the border rows. Disease was recorded in 1970 as the percent damage per plant based on 2-4 leaves and in the following 2 years as the percent damage per leaf using the 2 top leaves. Other diseases present were also noted. At times it was difficult to differentiate the cause of specific necrotic leaf areas because of the presence of a number

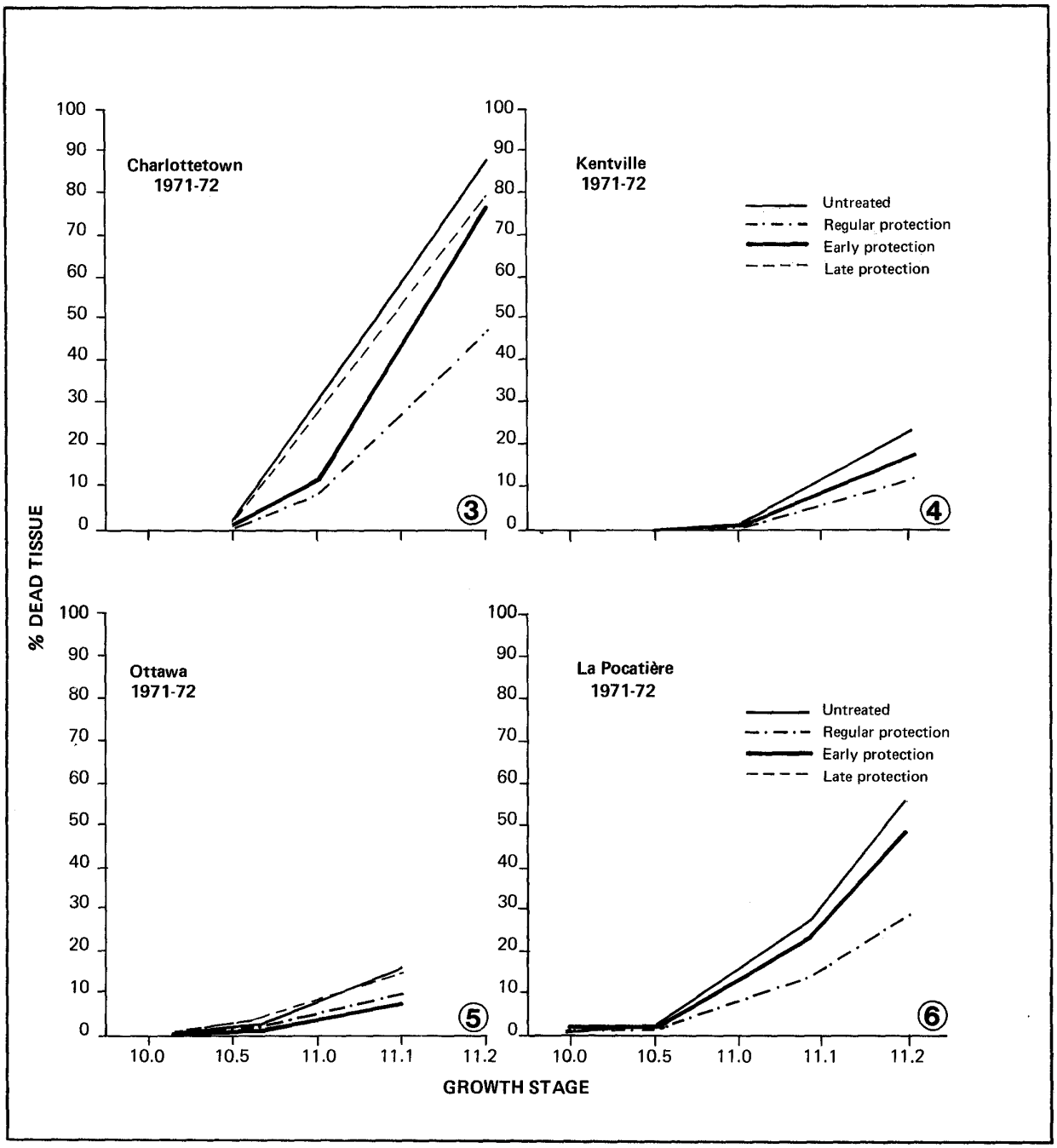

Figure 2. (continued). 3-6) Curves for the same treatments for 1971-72 at the four locations, with disease severity based on the flag and second leaves.

of diseases. However, since by far the majority of the dead tissue resulted from infection by septoria, assessments were done on the basis of the total chlorotic and necrotic areas present. In the last assessment each year (mealy ripe stage) the amount of septoria black stem infection was recorded. Each time a disease assessment was made the average growth stage of each cultivar was recorded according to the Feekes scale (6). Grain yields

and 1000-kernel weights were obtained at all locations, and percent hull, bushel weight, and percent protein at Charlottetown. The protein content of the seed was measured by determining grain N content using an automated kjeldahl digest method and then multiplying by a factor of 6.25 (3, 5). The various data were subjected to individual and, in some cases, combined analyses of variance.

Results

Disease data

Septoria leaf blotch was the principal disease each year at the four locations in eastern Canada. Other diseases developed in lesser amounts; these included barley yellow dwarf, drechslera leaf blotch [*Drechslera avenacea* (Curt. ex Cke.) Shoem.], and crown rust [*Puccinia coronata* Cda. f. sp. *avenae* Erikss. & Henn.]. Barley yellow dwarf occurred sporadically at all four locations most years, usually only on plants at the edge of the plots. The use of endosulfan to control aphids once barley yellow dwarf symptoms were noted did not always stop the development of the disease as it was prevalent at both Charlottetown and La Pocatière in 1971. Drechslera leaf blotch occurred in trace amounts at the four locations, but because symptoms are very similar to those of septoria the two diseases were difficult to separate. Crown rust occurred regularly at Ottawa, mostly in trace amounts, and rarely at the other locations.

The scatter point technique of determining leaf surface area on the key generally overestimated the amount of the infected area on most leaves when compared with the electronic drum scanner method (Fig. 1). The overestimate amounted to 3 or 4% on most leaves but did go as high as 7%. The greatest differences between the two techniques occurred on leaves with numerous small lesions and these no doubt could be more accurately measured by the scanner. However, both techniques are probably within the accuracy limits of visual estimates. This key is superior to others (4) in that it contains various sized leaves showing a range of typical septoria lesions.

In 1970, disease ratings were done on a per plant basis (Fig. 2, 1-2) and, by maturity, septoria was most severe at Charlottetown and lightest at Ottawa with intermediate levels at the other locations. At Charlottetown that year regular applications of maneb every 10 days reduced average leaf area affected per plant to 20% from 90% in the untreated plots. In 1971 and 1972 assessments were based on the average leaf area affected on the top (flag) and second leaves. In both years the severity of septoria was lower at Kentville. Maneb applications were less effective in controlling septoria at Charlottetown and La Pocatière, resulting in smaller differences at maturity between the untreated and regular application curves (Fig. 2, 3-6). These variations may have resulted from the change in the way disease assessments were made or from the influence of seasonal changes in local environments and disease syndromes.

Table 1. Septoria development on stems of oats treated with maneb sprays for 2 years at Charlottetown and Kentville (1971-72) and 1 year at La Pocatière (1971) and Ottawa (1972)

Location	Fungicide application*			
	Untreated	Regular	Early	Late
Charlottetown	8.4 †	2.0	2.5	5.8
Kentville	39.6	21.6	22.8	
La Pocatière	51.3	6.1	11.4	
Ottawa	1.8	1.5	1.5	1.5

* Maneb application regimes: regular, every 10 days from late tillering to maturity; early, every 10 days from late tillering to mid-heading; late, every 10 days from mid-heading to maturity.

† Average infection per stem in centimeters.

An effort was made to utilize the septoria assessment data recorded for the various growth stages and treatment regimes for 1971 and 1972 to extrapolate yield losses for a particular disease severity. Unfortunately the data were not suitable for processing so this could not be done. However, the progress curves (Fig. 2, 3-6) show that septoria develops very little until the flowering stage (10.5) but from then on increases uniformly until the crop is ripe. The regular application of maneb every 10 days reduced septoria severity by approximately 50% at all locations. At maturity early and late applications of maneb showed little effect in reducing the disease.

Infection of oat stems in the latter part of the growing season is often an important feature of the septoria disease. In these studies, black stem development varied among locations (Table 1) and from year to year. Black stem severity and leaf blotch severity did not necessarily follow the same order, especially at Charlottetown. The regular and early spray applications of maneb reduced the amount of black stem but did not eliminate it.

Yield data

Seed yields at the five locations varied considerably from year to year (Table 2). Significant increases in yield were obtained with plants receiving regular maneb applications compared with plants receiving no treatment in 2 of 3 years at Charlottetown and La Pocatière; however, there was no yield response from maneb at Kentville and Ottawa. At Lacombe in 1971 a significant difference in yield occurred as the regular maneb applications gave an increased yield over the controls while the early applica-

Table 2. Individual and combined seed yields (g) of oats treated with maneb sprays at five locations for 3 years

Location	Fungicide application†	1970 Yield (g)	1970 % of untreated	1971 Yield (g)	1971 % of untreated	1972 Yield (g)	1972 % of untreated	1970-72 Yield (g)	1970-72 % of untreated
Charlottetown	Untreated	889		1108		1441		1146	
	Regular	1273**	149	1216**	110	1480	103	1323	115
	Early	1105**	124	1253**	113	1525*	106	1294	113
	Late			1258**	113	1455	101		
Kentville	Untreated	1560		1365		1606		1510	
	Regular	1585	102	1393	102	1662	103	1547	102
	Early	1578	101	1367	100	1618	101	1521	101
	Late					1585	98		
La Pocatière	Untreated	1244		1242		1365		1284	
	Regular	1326**	107	1233	99	1550**	113	1370	107
	Early	1303**	105	1228	98	1479	108	1337	104
	Late					1550**	113		
Ottawa	Untreated	1100		1208		858		1055	
	Regular	1095	99	1271	105	830	97	1065	101
	Early	1030	94	1233	102	827	96	1030	98
	Late			1306	108	862	100		
Lacombe	Untreated			727		1130		929	
	Regular			755**	104	1150	102	953	102
	Early			702	96	1133	100	917	99
	Late					1140	101		

* Significant at P = 0.05.

** Significant at P = 0.01.

† See text for schedule.

tions resulted in a reduced yield. Injury from hail storms occurred that year and this may have had a differential effect. A combined analysis of yearly data for each location indicated that yield differences were significant for years but not for maneb applications. Treatment × variety interactions were not significant but a number of the interactions with years were significant, especially at Charlottetown. At Charlottetown and La Pocatière, on occasion, early and late applications of maneb increased yields considerably.

Yields of individual cultivars varied considerably among locations and years. Significant differences in cultivar yields were obtained with 8 of 14 location-years when individually analyzed but no significance was found when the yearly data were combined for each location. The three cultivars differed in their response to the maneb applications, with the yield of Dorval being increased by an overall average of only 2% while Garry and Russell were increased by an average of 7%. Maneb applications did not reduce percent leaf area infection on Dorval but possibly resulted in slightly less black stem on this cultivar. Thus Dorval benefited less than the other cultivars from spraying with maneb, indicating that this cultivar has considerable tolerance to septoria leaf blotch.

Table 3. Thousand kernel weights (g) of seed of three oat cultivars treated at three locations with maneb sprays

Fungicide application	Charlottetown	Kentville	Ottawa	Mean
Untreated	31.0	35.2	29.8	32.0
Regular	32.7	36.3	30.1	33.0
Early	32.1	35.4	29.7	32.4
Late	32.1		29.4	
	N.S.	N.S.	N.S.	

N.S. = No significance.

Table 4. Hull and protein content (%) of seed of four oat cultivars treated at Charlottetown with maneb sprays

Fungicide application	Cultivar								Mean	
	Dorval		Garry		Russell		Cabot			
	Hull	Protein	Hull	Protein	Hull	Protein	Hull	Protein	Hull	Protein
Untreated	25.6	12.1	30.9	14.0	26.2	12.7	27.8	12.2	27.6	12.7
Regular	24.6	12.4	25.9	13.5	23.2	13.5	24.4	13.4	24.5**	13.2
Early	25.0	12.8	26.8	13.9	23.8	13.6	24.9	13.0	25.1**	13.3
Mean	25.1	12.4	27.9	13.8	24.4	13.3	25.7	12.9	25.8	13.1

** Significant at P = 0.01.

Significant increases in kernel weight from applications of maneb occurred each year at Charlottetown but not at the other locations (Table 3). However, treatment differences were not significant in the combined analysis of kernel weights for Charlottetown as cultivar, year, and location differences were sizeable.

Percent hull and percent protein were determined at Charlottetown (Table 4). Percent hull was significantly decreased by applications of maneb; the mean percent protein was slightly increased.

Discussion

Most of the variability in the yearly agronomic data obtained at each location in this study probably was due to changes in environmental conditions over the 3 years which in turn influenced the prevalence and severity of diseases. A 50% increase in yield from regular applications of maneb was obtained in 1970 at Charlottetown, with a 15% average increase over the 3 years. This increase was obtained with partial control of the disease, and the best results occurred in 1970. It is obvious from these tests that septoria leaf blotch can be a very devastating disease at Charlottetown and to a lesser extent at La Pocatière. However, due to the variability in weather conditions and their effect on plant development, disease prevalence, and fungicide performance, a significant consistent effect was not found. Also some improvement in yield may have resulted from the application of manganese to the plants by use of the maneb fungicide (7). At Lacombe where little or no septoria occurred there was a small but consistent increase in yield from the regular applications of maneb. Manganese deficient soils are common in the Lacombe area so that applications of manganese to the oat foliage could result in increased yields.

No consistent yield increases from applications of maneb were obtained at Kentville and Ottawa. This is a change from previous studies done at Ottawa (2). However, field observations over the last few years in eastern Ontario by the senior author indicate that septoria is not as prevalent or severe at it was 15 years ago.

Data on a number of environmental factors at the four eastern research stations for the months of June, July, and August 1970-72, recorded in the Canadian Weather Review, and Daily Agrometeorological Data, Environment Canada, may explain the differences in septoria development and yield response obtained at Kentville and Ottawa as compared with Charlottetown and La Pocatière. Average monthly maximum temperatures were high at Kentville and Ottawa, 23.7°C and 24.4°C, respectively, and low at Charlottetown and La Pocatière, 21.8°C and 21.9°C. Average mean daily temperatures showed the same relationship for the four locations but the comparison was not as good because mean low temperatures differed considerably. High maximum temperatures would shorten the length of time required for the oat crop to reach maturity which is the case at Kentville and Ottawa. The considerably longer period of maturity at La Pocatière and Charlottetown would favor septoria development, and the disease progress curves show that the major development takes place after the flowering stage. The overall importance of septoria in eastern Canada may be greater than these tests indicate since only partial control was achieved with regular applications of maneb.

Acknowledgments

The authors thank C. S. Shih, Statistical Research Service, Agriculture Canada, for help with statistical procedures.

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Correction

The title of the article by J. Drew Smith and R.P. Knowles, volume 54 number 4, page 108, should read "Alternaria flower-stalk rot in Bromus inermis"

Tolerance of Botrytis cinerea and rose powdery mildew to benomyl

W. R. Jarvis and K. Slingsby[1]

An initially effective spray schedule of benomyl applied regularly to roses failed to control gray mold [*Botrytis cinerea*] in the third season and powdery mildew [*Sphaerotheca ?pannosa*] in the second season. In agar plate tests, conidia from benomyl-treated tomatoes proved to be tolerant to benomyl and also to several other fungicides.

Can. Plant Dis. Surv. 55: 44. 1975.

Efficaces au début, des pulvérisations régulières de bénomyl effectuées sur des rosiers n'ont pu combattre le blanc (*Sphaerotheca?pannosa*) durant la deuxième saison de croissance, ni la moisissure grise (*Botrytis cinerea*) durant la troisième saison. Dans des essais sur plaque de gélose, les conidies prélévées sur des rosiers traités au bénomyl et sur des tomates également traitées se sont révélées tolérantes à ce produit et également à plusieurs autres fongicides.

Botrytis cinerea

Tolerance of *Botrytis cinerea* Pers. ex Fr. to the fungicide benomyl was first recorded by Bollen and Scholten in the Netherlands (1) and has since been recorded in Britain (3,4) and the U.S.A. (5). This note records its occurrence in Canada.

At Kingsville, Ontario, it was noted in the late summer of 1974 that moribund rose flowers were unusually badly affected by gray mold despite regular sprays of Benlate (50% benomyl) through the preceding three seasons. Conidia of *Botrytis cinerea* from affected flowers were streaked onto potato dextrose agar containing 100, 500, and 1000 ppm benomyl, added as Benlate to the agar at 40°C immediately before pouring. The conidia germinated without delay and vigorous colonies developed within 2-3 days at room temperature at all benomyl concentrations. Sporulation occurred within 3 days and sclerotia formed within 4 days.

Conidia taken from colonies of the original isolate were put into small incisions in ripe tomato fruit; a vigorous and typical gray mold rot resulted in 3 days. Conidia taken from gray mold lesions on tomato stems and fruit in commercial glasshouses known to have received Benlate sprays also proved to be benomyl-tolerant when used as inocula on benomyl agar.

Conidia taken from the same benomyl agar plates were also used to inoculate PDA containing up to 1000 ppm a.i. benomyl, dichloran, chlorothalonil, copper (as COCS), anilazene, captan, Dikar (72% mancozeb + 4.4% dinocap), each incorporated at 40°C. In each case, with the exception of dichloran and Dikar, colonies, though sometimes delayed and restricted in diameter, developed and sporulated. Thus, benomyl-tolerant conidia also showed tolerance to a range of commercially-alternative fungicides.

Rose powdery mildew

This note also records the failure of a regular spray schedule of Benlate (50% benomyl) to control rose powdery mildew *Sphaerotheca ?pannosa* Wallr. Lev. At Kingsville, Ontario, a spray schedule of 0.5 - 0.75 lb benomyl/100 gal (0.5 - 0.75 g/liter) applied at intervals of approximately 10 days throughout the summer controlled powdery mildew until 1972. However in the summers of 1973 and 1974 it was uncontrolled. In common with some other powdery mildews (2), rose powdery mildew thus appears to have developed tolerance to benomyl.

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[1] *Research Station, Agriculture Canada, Harrow, Ontario NOR 1GO*