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Contents/Contenu

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

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

A selenophoma leaf spot on cereals in the Maritimes[1]

G. Sampson[2] *and K. S. Clough*[3]

A leaf spot caused by *Selenophoma donacis* var. *stomaticola* was found on barley and wheat in several locations in Nova Scotia and Prince Edward Island in 1978.

Can. Plant Dis. Surv. 59:3, 51-52. 1979

Une tache feuille causée par *Selenophoma donacis* var. *stomaticola* a été trouvée sur les plantes d'orge et du blé dans plusiers locations de la Nouvelle Ecosse et L'Ile du Prince Edouard.

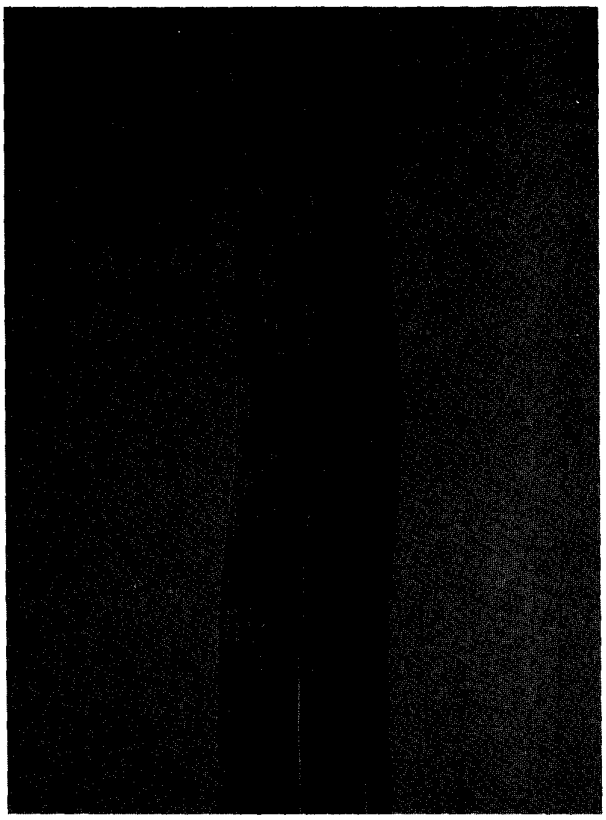

Fig. 1. Symptoms of selenophoma leaf spot on barley

Introduction

Leaf spots caused by species of *Selenophoma* have been described by Sprague (4) on a number of grass and cereal hosts in the United States. In Canada species of the fungus were reported on *Hordeum vulgare* L. in 1943 (1) and *H. jubatum* L. (2) in Alberta in 1956, but there are no previous published records of its occurrence in Eastern Canada. In this paper we report the occurrence of *Selenophoma donacis* var. *stomaticola* (Bäuml.) Sprague & Johnson on barley and wheat in Nova Scotia and Prince Edward Island. This is the first record of this disease in the Maritimes.

Observations

Symptoms of the disease on barley were small rectangular or squarish lesions with grey to straw colored centres and dark brown margins (Fig. 1.). Older lesions contained rows of black pycnidia. There was some coalescence of lesions from older infections and in some cases lesions were surrounded by a chlorotic halo or streaking between lesions. Typical lesions were also found on leaf sheaths and culms but not on awns. Pycnidia were not found on culm lesions. In moist conditions mucilaginous cirrhi were observed oozing from pycnidial ostioles. The cirrhi contained septate, sickle-shaped pycnidiospores 12-20 mμ in length. These features distinguish *S. donacis* var. *stomaticola* from *S. donacis* (Pass.) Sprague & Johnson which has larger aseptate spores of a similar shape (4).

The disease was prevalent in early sown fields but severities were generally slight except in fields with a dense canopy and in test plots with high nitrogen rates where leaf spots accounted for up to 25% of the leaf area according to the assessment keys of Cooke and Brokenshire (3).

In Nova Scotia the disease was found most frequently in Cumberland, Colchester, and Pictou counties. It was recorded also in Hants, Antigonish, and Kings Counties. In Prince Edward Island the disease was found in fields in Queens and Kings counties. In the majority of cases in both provinces the disease was on Loyola barley.

The only observations of the disease on wheat were from trials at Brookside, N. S., and the Charlottetown Research Station where it was noted on a number of different cultivars.

Leaf spots caused by *Selenophoma* spp. are described by various common names, notably 'speckle' (4) 'eye spot' (4), and 'halo spot' (3). These common names are

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inappropriate since they do not accurately describe symptoms and may be confused with other diseases, namely eyespot of wheat caused by *Cercosporella herpotrichoides* Fron and halo blight of oats caused by *Pseudomonas coronafaciens* (Ch. Elliot) Stev. Therefore we suggest that the use of these common names be discouraged and the disease be referred to as selenophoma leaf spot.

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Effect of fungicides on germination of Albugo candida oospores in vitro and on the foliar phase of the white rust disease[1]

P.R. Verma and G.A. Petrie

An oospore germination technique was used to study the effectiveness of 27 fungicides, including some systemic ones, in inhibiting germination at various stages. Among the chemicals tested, Mersil, PMA-10, and Panogen, each at a concentration of 500 ppm active ingredient, inhibited germination about 75%. Of the nonmercurial compounds, mancozeb and ethazole were the best giving about 60% inhibition. Several compounds were tested in the growth chamber for controlling the foliar phase of the disease. Application of either chlorothalonil or mancozeb, at 250 or 500 ppm, respectively, 6 hr before inoculation plus a week after inoculation controlled the disease effectively. However, sprayings of either fungicide 24 hr after inoculation plus a week later were not effective. Two foliar sprayings of chlorothalonil in June significantly reduced both foliar and systemic infections in the field. However, in view of the growth room studies on successful initiation of systemic infections, a third application at the time of flowering is also advised. More studies are required to determine when sprays should be applied for maximum disease control.

Can. Plant Dis. Surv. 59:3, 53-59, 1979.

Les oospores hivernant dans le sol ou portées sur les graines constituent l'inoculum primaire des infections de rouille blanche (bois de cerf) sur les cultures de colza de l'Ouest canadien. Nous avons utilisé une technique de germination d'oospores pour comparer l'efficacité de 27 fongicides, dont quelques endothérapiques, à divers stades de la germination. Parmi les produits étudiés, le Mersil, le PMA-10 et le Panogen, à des concentrations de 500 ppm de principes actifs, ont inhibé la germination dans la proportion d'environ 75 p. 100. Le mancozèbe et l'ethazole ont été les meilleurs des produits non mercuriels, donnant environ 60 p. 100 d'inhibition. Plusieurs composés ont été évalués en chambre de croissance sur leur efficacité à la phase foliaire de la maladie. Des applications de chlorothalonil à 250 ppm ou de mancozèbe à 500 ppm, exécutées 6 h avant et une semaine après l'inoculation se sont révélées efficaces. Toutefois, ces mêmes produits appliqués 24 h après inoculation et une semaine plus tard ont été sans effet. Au champ, deux pulvérisations foliaires de chlorothalonil en juin ont réduit le taux d'infection foliaire et systémique mais les essais en chambre de croissance sur le déclenchement des infections systémiques portent à conseiller un troisième traitement à la floraison. Il faudra poursuivre les recherches pour établir le calendrier de pulvérisation optimal.

Introduction

White rust [*Albugo candida* (Pers. ex Lev.) Ktze.] race 7 (P. H. Williams, pers. commun.) is the most important disease of Polish or turnip rape (*Brassica campestris* L.) in Western Canada. *B. napus* (Argentine rape) is immune to this race of the disease (17). In 1977, 48% of the total 1.34 million hectares of rapeseed in the three Prairie Provinces was seeded to *B. campestris* cultivars, the remainder to *B. napus* (1). In the absence of suitable control measures, losses caused by white rust in recent years have been quite significant. In Saskatchewan, the losses in 1970, 1971, and 1972 were estimated at 3, 6, and 9%, respectively (11). The estimated loss in northern and central Alberta in 1971 was 1.2% (2).

The disease is characterized by white to cream-colored pustules on the underside of leaves. However, the most conspicuous symptom is distortion and hypertrophy of infected inflorescences. These are often called "stagheads"; when mature they consist almost entirely of oospores. Oospores overwintered in soil or carried on seeds (12) most likely constitute the primary inoculum in the spring and early summer. Successful foliar infection is important for the production of secondary inoculum in the form of zoosporangia and perhaps in initiation of systemic infections (14) which lead to the formation of hypertrophied inflorescences. In the absence of cultivars of *B. campestris* resistant to white rust, fungicidal control measures could play an important role in reducing losses from this disease. However, to be truly effective a fungicide should control both primary and secondary inoculum.

Chemical control of white rust in rapeseed has received little attention. Perwaiz et al. (10) reported effective control and increased yield in *B. campestris* cultivar Sarson following foliar sprays of Polyram (zinc-activated polyethylene thiram disulphide). Among the fungicides reported by various workers to be effective against related species of *Albugo* are zineb (zinc ethylenebisdithiocarbamate), maneb (manganese ethylenebisdithiocarbamate), chlorothalonil (tetrachloroisophthalonitrile),

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Table 1. Percentage inhibition of germination of *Albugo candida* oospores by chemicals at a concentration of 500 ppm active ingredients

Product name*	Active ingredients % and formulation**	Source	Total % inhibition adjusted †
Bayleton	triadimefon[1-(4-chlorophenoxy)-3,3-dimethyl-1-(1H-1,2,4-triazole-1-y1)-2-butanone] 50%, WP	Chemagro	24.1
Benlate	benomyl [methyl-1-(butylcarbamoyl)-2-benzimidazole-carbamate] 50%, WP	Du Pont	24.5
Bravo	chlorothalonil (tetrachloroisophthalonitrile) 54%, Fwble.	Diamond-shamrock	21.2
Bromosan	thiophanate-methyl [dimethyl-4,4-o-phenylenebis-(3-thioallophanate)] 16.67% + thiram (tetramethylthiuram disulfide) 50%, WP	Cleary	46.2
Calixin	tridemorph (2,6-dimethyl-4-tridecylmorpholine) 75%, Soln	BASF	27.9
Chlorophenate	chlorophenate mixture 18%, WP	Cleary	56.7
Cyprex	dodine (N-dodecylguanidine acetate) 65%, WP	Cyanamid	24.9
Dexon-PCNB	p-dimethylaminobenzenediazo sodium sulfonate 35% + pentachloronitrobenzene 35%, 35%-35%, WP	Chemagro	21.0
Dowco-269	pyroxychlor [2-chloro-6-methoxy-4-(trichloromethyl) pyridine] 97%, Soln	DOW	46.5
DPX 3217	2-Cyano-N-(ethylaminocarbonyl)-2-(methoxyimino) acetamide 50%, WP	Du Pont	55.9
Duter	fentin hydroxide (triphenyltin hydroxide) 19%, WP	Ciba-Geigy	27.9
Kocide-101	copper hydroxide 83%, WP	Kennecott	13.2
Manzate-200	mancozeb (zinc and manganese ethylene-bisdithio-carbamate) 80%, WP	Du Pont	59.8
Mersil	mercury chloride ($HgCl_2$) 14% + mercurous chloride (Hg_2Cl_2) 28% + mercury equivalent 34%, WP	May and Baker	75.7
N.F. 48	thiophamine [2-(3-methoxycarbonyl-thioureido)-analine] 80%, WP	Nippon Soda	22.5
N.F. 65	thiophamine 40% + bis-(dimethylthiocarbomoyl disulfide) 40%, 80%, WP	Nippon Soda	25.5
Panogen	methylmercury dicyandiamide 0.9%, WP	Morton	74.5
PMA-10	phenyl mercuric acetate 10%, Soln	Later	75.7
Polyram	metiram [ammoniates of ethylene-bis-dithiocarbamate zinc 83.9% + ethylenebis-dithiocarbamic acid)] 16.9%, WP	Niagara	37.5
Sicarol	pyracarbolid (2-methyl-5,6-dihydro-4H-pyran-3-carboxanilide) 50%, WP	Hoechst	19.8
Tersan SP	chloroneb (1,4-dichloro-2,5-dimethoxybenzene) 65%, WP	Du Pont	22.0
Terraclor	quintozene (pentachloronitrobenzene) 75%, WP	Olin	20.4
Terrazole	ethazole [5-ethoxy-3-(trichloromethyl)-1,2,4-thiadiazole] 35%, P	Olin	59.8
Topsin M	thiophanate methyl [dimethyl 4,4-o-phenylenebis-(3-thioallophanate)] 70%, WP	Pennwalt	14.8
Vitavax	carboxin (5,6-dihydro-2-methyl-1,4-oxathiin-3-carboxanilide) 75%, WP	UniRoyal	28.8
R-28921	O,O-diethyl-2-[(3-methoxycarbonyl)thioureido] phenyl phosphoramidothioate 50%, WP	Stauffer	21.2
LFA 2043	iprodione	May and Baker	21.5
Control †			

* The use of trade names in this publication does not imply endorsement by Agriculture Canada of the products named or criticism of similar ones not mentioned.

** WP = wettable powder, P = powder, Soln = solution, Fwble - flowable.

† At least 400 spores counted per sample. Percentages of nongerminated oospores in the control (18) were subtracted from those in the treatments to obtain percentage inhibition due to fungicide.

dodine (N-dodecylguanidine acetate), and captan (N-[(trichloromethyl)thiol]-4-cyclohexene-1,2-dithiocarboximide) (3, 4, 7, 10). This paper presents results on the *in vitro* sensitivity of *A. candida* oospores to various fungicides and on the control of the foliar phase of white rust disease of *B. campestris* in the growth chamber and field.

Materials and methods

Screening for inhibition of oospore germination

Twenty-seven fungicides were tested for inhibition of oospore germination (Table 1). Concentrations of 500 ppm active ingredient (a.i.) were used for all fungicides. To obtain oospores for fungicide trials, dry hypertrophied

tissue collected from *B. campestris* plants infected with race 7 of *A. candida* in 1972 was finely ground with a mortar and pestle and screened through a 60-mesh sieve.

The method employed for testing the effects of chemicals on oospore germination was similar to that reported previously (16). Fifty ml sterile tap water solution or suspension of each test chemical was placed in a 125-ml erlenmeyer flask and a small amount of the oospore powder added. The mixtures of chemical, sterile tap water and oospores, or only sterile tap water and oospores for the control, were incubated at 18-20°C on a rotary shaker (200 rpm) for one week. The spore suspension was then poured into a Petri dish and kept stationary for a period of 24 hr at 13°C. Samples from each Petri dish were placed on slides in lactophenol aniline-blue. Counts of germinated oospores were made at magnification of 800X under oil. Percentages of non-germinated oospores in the control were subtracted from those in the treatments to determine the percentage inhibition due to the fungicide. Fig. 1 (A-D).

Growth chamber experiments

Some chemicals were also tested for controlling the foliar phase of the disease. Plants of *B. campestris* cultivar Torch were grown in modified Cornell soilless mix (15) and were maintained under 18 hr illumination (17,000 lux) at 21°C with a night temperature of 16°C. Two weeks after seeding, cotyledons and leaves of all experimental plants were drop-inoculated with a zoospore suspension obtained from germinating zoosporangia of *A. candida* race 7. Hemacytometer counts of zoospores in the suspensions ranged from 100,000 to 150,000 per ml. Control plants were drop-inoculated with sterile tap water. Following a dark period of 24 hr,

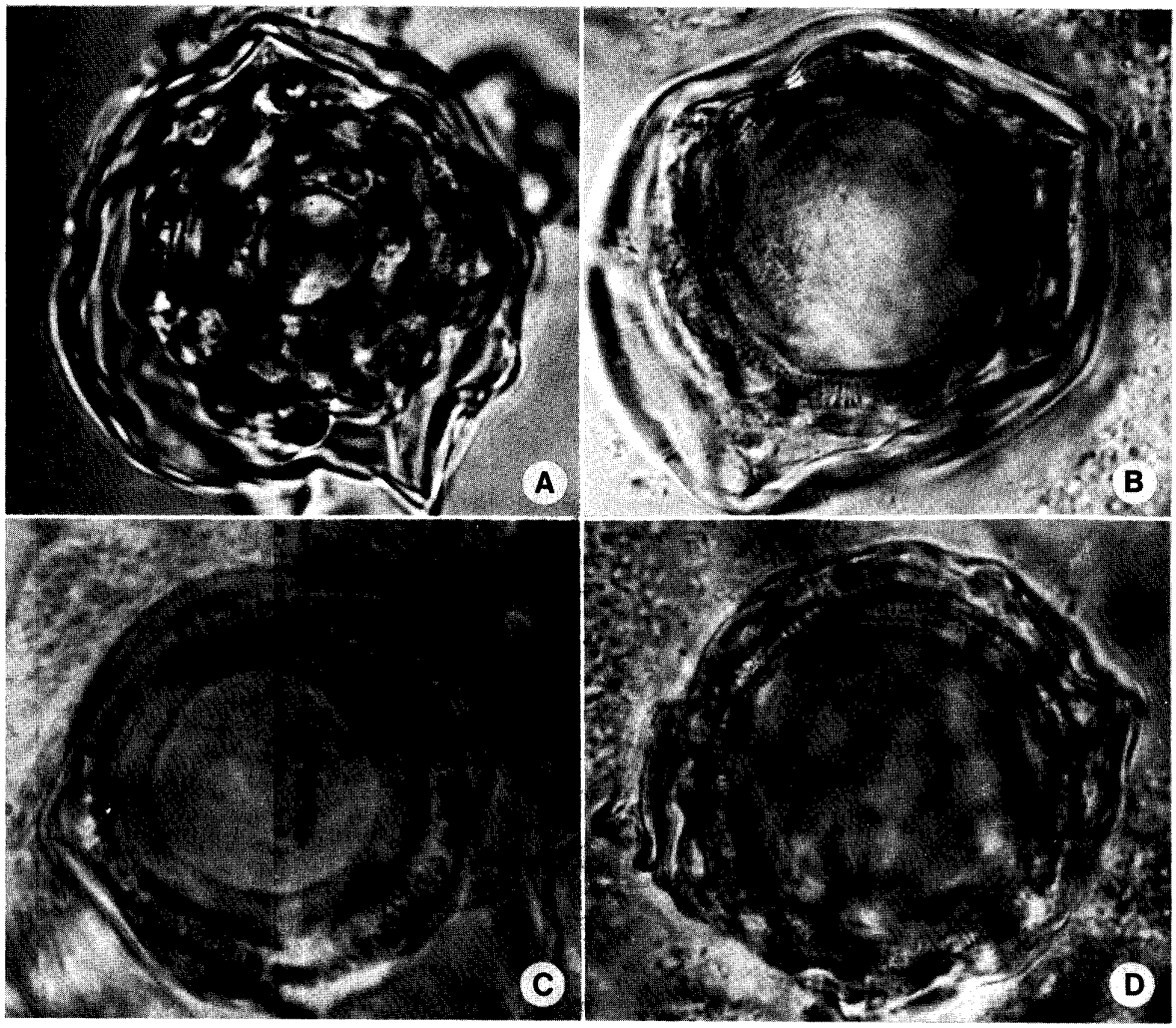

Figure 1 (A to D). Nongerminated oospores (A to C): (A) with both granular contents and central body, (B) with granular contents only and (C) both granular contents and central body almost disappeared. Germinated oospore, (D) both granular contents and central body absent.

plants were returned to an 18-hr day and maintained under a continuous water mist for a period of 3-4 days.

Preliminary screening of nine fungicides in the growth chamber showed that chlorothalonil and mancozeb were the only chemicals showing promise and therefore, subsequent experiments were conducted only with these two. The two concentrations used for chlorothalonil and mancozeb, respectively, were 100 and 250 and 250 and 500 ppm active ingredient. The plants were sprayed on both sides of leaves to run-off. Tween-20 was used at the rate of 1 ml per 100 ml of the fungicide solution.

There were five schedules for each concentration of fungicide as follows: Schedule 1: The first application was 96 hr before inoculation when the plants were 10 days old. Additional applications were made 24 hr before, and 96 and 168 hr after inoculation. Schedule 2: Applications were made 24 hr before, and 96 and 168 hr after inoculation. Schedule 3: Fungicides were sprayed 6 hr before and 168 hr after inoculation. Schedule 4: Applications were made 24 hr and 168 hr after inoculation: Schedule 5: Control sprayed with water. Two or three plants were grown in each 10-cm pot and there were five pots of each schedule of each fungicide.

Two weeks after inoculation the numbers of pustules on all infected leaves were counted. The experiment was replicated at three different times and the results presented are the mean of all three replicates.

Because the dependent variables are dichotomous (i.e. qualitative or categorical data) the data were analysed by the maximum likelihood procedure described by Fienberg (5) and Goodman (8) and used more recently by Gavora et al. (6). Since the data were in the form of a table of counts, a four-dimensional contingency table with the categories being replicate, fungicide treatments, time of application and infection, maximum likelihood estimates of the expected frequencies were carried out for a number of models. The appropriate $\log_e$ likelihood ratio statistic was calculated for each of these models. This statistic approximately follows the chi-square distribution which was used to test hypotheses on how well the various models described the data.

Field experiments

Results of growth chamber tests and a preliminary unreplicated field test in 1975 showed that chlorothalonil might be an effective protectant for the control of *A. candida* on rapeseed. Therefore, in 1976, a field study with four different spray schedules and a nonsprayed check was established to determine how chlorothalonil could be effectively utilized. Each plot consisted of eight 6.6-m rows spaced 32 cm apart. All treatments were replicated four times in a randomized block design with 2-m pathways between the ends of the plots. Certified seed of *B. campestris* cv. Torch was sown on May 19 at the rate of about 350 seeds per row. Carbofuran 5G was applied with the seed at the rate of 1 g per row for flea beetle (*Phyllotetra* spp.) control. Chlorothalonil (54% a.i.) was mixed with water and applied with a low-pressure hand sprayer. Spray volume was 1.3 kg a.i./550 litres/hectare. The four spray schedules were: No. 1 (June 9 and 17), No. 2 (June 9, 17, and July 9), No. 3 (June 9, 17, July 9, and 23), No. 4 (June 9, 17, 24, July 9, 16, and 23). Applications were always made on calm mornings or evenings.

Both on June 30 (growth stage 3.1) and July 15 (growth stage 4.2) fifty plants randomly pulled from each plot were rated for number of plants and leaves infected and number of pustules per infected leaf. When plants were approaching maturity on August 16 (growth stage 5.4), 100 plants were randomly pulled from each plot and rated as to presence and number of stagheads. All the remaining plants in a plot were harvested on September 8 to obtain yield data.

Results

Of the 27 chemicals tested, the three mercurial fungicides, Mersil, PMA-10, and Panogen, were the best inhibitors of oospore germination (Table 1). The total percentage inhibition with any of these fungicides was about 75. Among the nonmercurial compounds, mancozeb and ethazole were the most effective giving total inhibition of about 60%. The inhibition provided by Bromosan or Pyroxychlor was about 50%. All other compounds listed in Table 1 were not very effective at the concentration tested.

Preliminary screening of nine fungicides in the growth chamber showed that carbathiin, chlorophenate and benomyl were phytotoxic causing stunting and leaf-tip burning. Polyoxin AGB, Polyoxin B, Pyroxychlor and DPX 3217 were relatively ineffective in controlling the foliar phase of white rust. Chlorothalonil and mancozeb were the only chemicals showing promise and therefore, only results of these two are presented here.

Since all of the plants from the control and nearly all from spray schedule 4 were infected, the multidimensional contingency table analysis was done using only data from the first three spray schedules. Log_e likelihood ratio statistics are given in Table 2. The results in Tables 3 and 4 suggest that irrespective of time of application the differences in the degree of control between schedules 1, 2, and 3 were not significant; differences between schedule 4 and the control were not significant, but they were both significantly different from other spray schedules. However, the percent control obtained with two rates of application of both fungicides in schedules 1, 2, and 3 was significantly different (Table 2).

In schedules 1, 2, and 3 about 50% of the plants sprayed with chlorothalonil at 100 ppm showed white rust symptoms 14 days after inoculation, as compared to very little disease on those sprayed at 250 ppm (Table 3). However, regardless of concentration, the amount of

Table 2. Multidimensional contingency table analysis of numbers of clean and white rust-infected plants pooled over three schedules of fungicide sprays on turnip rape in the growth chamber

Source of variation	df	-2XLLR*
Replicate x fungicide x schedule	12	5.905
Fungicide x schedule	6	0.835
Replicate x schedule	4	0.756
Replicate x fungicide	6	1.915
Schedule	2	2.735
Fungicide	3	82.223**

* -2XLLR = the negative of two times the log likelihood ratio.

** Statistically significant difference, P = 0.01.

disease on plants sprayed 24 and 168 hr after inoculation was about the same as that in the control. The mean number of pustules per infected leaf on plants sprayed as per schedule 4 and in the control were 12 and 13, respectively (Table 3).

Mancozeb was not as effective as chlorothalonil in preventing white rust infection (Table 4). Even plants sprayed at 500 ppm in schedules 1, 2, and 3 developed some white rust symptoms. However, as for chlorothalonil, plants sprayed 24 hr after inoculation and then a week later, developed as much disease as that recorded in the control (Table 4).

In the field, chlorothalonil effectively reduced foliar and systemic infections when applied as a foliar spray (Table 5). Two sprays in June (June 9 and 17) significantly reduced disease severity and increased yield slightly. Results of June 30 sampling are not included in Table 5 because of the fact that only one out of 50 plants in the check had developed white rust symptoms; all sampled plants from spray treatments were free of disease. Data recorded on July 15 and August 16 show that percentages of infected plants, number of infected leaves per plant, number of pustules per leaf, and percentages of plants with stagheads were invariably higher in the check than those on plants from sprayed treatments (Table 5). The differences between the four spray treatments for the four variables were not significant in most cases. However, with the exception of mean number of infected leaves per plant, the unsprayed check was significantly different from other treatments in all cases. The total grain yield in the four spray treatments was about 10% higher than in the check. However, because of variability within treatments, the differences were not significant.

Discussion

Albugo candida oospores occur commonly on *Brassica* seed samples throughout the Prairies (12). According to this report the inoculum levels on seeds may be considerably higher than actually required for initiation of infection bearing in mind that on germination a single oospore releases 40-60 zoospores (13, 16). Recent reports have demonstrated oospore germination following a period of washing in water (13, 16) and infection of *Brassica* cotyledons by zoospores produced from germinating oospores (17). Furthermore, unpublished data from field experiments showed more foliar and systemic infections in plots where the seed was treated with oospore powder than in the controls. This evidence supports the view that seed-borne oospores constitute

Table 3. Efficacy* of Bravo applied at two concentrations in four spray schedules against *A. candida* on turnip rape in the growth chamber

Spray schedules			Concentration applied a.i.	Mean % plants infected	Mean no. of pustules/leaf
Number	Hours from inoculation Before	After			
1	96 + 24	96 + 168	100	44.1	7.3
			250	6.7	3.0
2	24	96 + 168	100	52.9	7.1
			250	11.1	2.6
3	6	168	100	50.0	7.7
			250	5.6	2.0
4	-	24 + 168	100	100.0	12.0
			250	97.4	12.2
Control	-	-	-	100.0	13.0

* Recorded 14 days after inoculation.

Table 4. Efficacy* of Manzate-200 applied at two concentrations in four spray schedules against *A. candida* on turnip rape in the growth chamber

Spray schedules					
	Hours from inoculation		Concentration applied	Mean % plants	Mean no. of
Number	Before	After	a.i.	infected	pustules/leaf
1	96 + 24	96 + 168	250	47.6	5.7
			500	10.5	1.9
2	24	96 + 168	250	56.8	6.3
			500	18.2	2.3
3	6	168	250	45.7	5.0
			500	11.8	5.6
4	–	24 + 168	250	100.0	10.7
			500	100.0	11.5
Control	–	–	–	100.0	13.0

* Recorded 14 days after inoculation.

Table 5. Efficacy of Bravo in four spray schedules against *A. candida* on turnip rape in the field, 1976

			July 15			Aug. 16	Sept. 8
Schedules	No. of sprays	Dates applied	% infected plants	Mean no. of infected leaves/ plant	Av. no. of pustules/ leaf	% plants with stagheads	Mean yield/ plot (g)
Check	–	–	76.0 a*	1.76 a	7.9 a	14.3 a	2485 a
1	2	June 9, 17	19.0 b	1.37 a	3.1 b	2.5 b	2776 a
2	3	June 9, 17 and July 9	21.5 b	1.33 a	3.1 b	2.3 b	2763 a
3	4	June 9, 17 and July 9, 23	17.5 b	1.51 a	3.6 b	1.3 b	2765 a
4	6	June 9, 17, 24 and July 9, 16, 23	3.5 c	1.43 a	2.0 b	1.8 b	2674 a

* Within column, figures suffixed by the same letters do not differ significantly at the 5% level as determined by Duncan's multiple range test.

primary inoculum for infection of *Brassica* species in western Canada. Thus seed treatment even by a protectant fungicide could be important in controlling white rust infections either by inhibiting oospore germination or by killing the zoospores on emergence. None of the fungicides tested in the present study was 100% effective. The mercury fungicides were found to be the best inhibitors of oospore germination, but provided only 75% inhibition. Therefore, the search for a completely effective fungicide, preferably a systemic, needs to be continued.

The growth chamber experiment showed that chlorothalonil or mancozeb at 250 and 500 ppm active ingredients, respectively, applied 6 hr before inoculation and then a week later, controlled the disease effectively without any apparent phytotoxic effects. In view of their mainly protectant action, failure to control white rust by either fungicide applied 24 hr and 168 hr after inoculation was not surprising, because establishment of *A. candida* infection of rapeseed cotyledons and perhaps on leaves would normally be completed within 24 hr of inoculation (17).

Two years' field experiments showed that chlorothalonil possesses sufficient protectant activity to control white rust in *B. campestris* cultivar Torch. These results are in agreement with those of Chambers et al. (3) where chlorothalonil was also found effective for control of white rust of spinach. Two sprays in June when the plants were about 3-4 weeks old reduced the disease significantly.

Rain fell on 17 of the 23 days between June 22 and July 14. The high humidity during this period probably resulted in a build-up and spread of inoculum. The data suggest that application of chlorothalonil on June 24 at the beginning of this period was perhaps at a time prior to release and spread of inoculum and was therefore effective in reducing infection. Should that be the case, it lends support to our growth chamber experiments where an application 24 hr before inoculation was quite effective. The data also suggest that an additional spray treatment of chlorothalonil in late July could result in a slightly lower incidence of floral infection.

The distortion and hypertrophy of infected inflorescences (staghead) is the most important factor from a yield-loss standpoint (9). Cotyledonary infections in the spring have been considered responsible for the formation of stagheads through systemic infections (14). However, growth chamber experiments have shown that large numbers of staghead can be initiated at a later stage of plant development by infecting floral buds (unpublished data). In view of these findings, it is possible that significant reduction in the number of stagheads on plants in sprayed treatments over the control was due to control of foliar and floral infections.

Failure to demonstrate significant yield responses to disease control in field tests was not surprising. However, if evaluated on a larger scale with high plant densities and disease intensity, such as is commonly observed in commercial fields, economic yield responses would probably result from effective disease control. More studies are required to determine when fungicides should be applied to ensure maximum disease control. The results do indicate that two applications in June and an application at the time of flowering are required to reduce the disease to a significant level. However, multiple application may not be economically feasible under commercial rapeseed production.

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Verticillium wilt, a potentially dangerous disease of alfalfa in Canada[1]

J.W. Sheppard

Verticillium wilt of alfalfa, caused by *Verticillium albo-atrum* has been identified from fields in British Columbia. This is the first report of a large acreage of the disease in Canada. All cultivars grown in Canada are likely susceptible to Verticillium wilt.

Can. Plant Dis. Surv. 59:3, 60, 1979.

La présence du Flétrissement verticillien de la luzerne, causé par *Verticillium albo-atrum* R & B, a été constatée dans des champs en Colombie-Britannique. C'est la première fois au Canada qu'on signale la maladie sur de grandes étendues. Tous les cultivars actuellement utilisés au Canada sont apparemment sensibles à la maladie.

Verticillium wilt, caused by *Verticillium* spp. has become one of the most important diseases of alfalfa in Great Britain and Europe. The disease was first reported in Germany in 1938 (Richter & Klinkowski, 1938). Other countries including USSR, Hungary, New Zealand and Canada have also reported the disease (Szoko 1966). *V. albo-atrum* R & B is the principal pathogen, but *V. dahliae* Kleb. has also been reported to cause similar symptoms (Isaac 1957). The disease may be introduced into previously unaffected areas with the seed from infected crops. However, unlike most seed-borne disease, Verticillium wilt is rarely found in or on the seed but in the inert matter, usually in pieces of pods and pedicels which have passed through the threshing and cleaning equipment with the seed.

In Canada the disease was first reported by Aubé & Sackston (1964) who found a number of infected plants in an alfalfa plot at Normandin, Quebec. The disease was also found about the same time in a breeder's plot at the Agricultural Research Station in Vancouver, B. C. (Dr. H. S. Pepin personal communication). The infected plots were ploughed down and the disease was not found the following season. In 1976 an outbreak of the disease occurred in the Columbia River Basin of western United States (Graham, Peaden & Evans 1977). The disease was so severe that only two harvests were taken before the stand was diminished. Most of the alfalfa seed imported into Canada originates in this area.

In British Columbia, near Okanagan Falls, approximately 600 acres of alfalfa have been found to be infected with the disease. The disease is believed to have entered this area on alfalfa hay or seed imported from neighbouring Washington State. (M. Soder, personal communication.)

A *Verticillium* sp. has also been isolated from the vascular tissues of the crowns of alfalfa plants submitted from the Kootenay Flats area near Creston, B. C. Complete identifications and pathogenicity tests on these isolates are now being conducted. Over 2,000 acres of alfalfa are involved in this region.

To isolate the causal organism, samples of plant material from B. C. alfalfa fields submitted to the Seed-Borne Disease Unit were surface disinfected with 2% sodium hypochlorite sectioned and plated on V-8 juice agar. *V. albo-atrum* was isolated from roots, stems and leaf tissue of infected alfalfa plants. The isolates obtained from this material were hyaline in nature and did not readily form dark, resting mycelium typical of *V. albo-atrum*. The hyaline nature of this isolate is similar to that observed on an isolate obtained from Ivor Isaac, Swansea, Wales through Dr. H. S. Pepin and observed by W. E. Sackston in isolates from alfalfa in Quebec. Isolates from the Okanagan Falls area have been shown to be pathogenic to DuPuits alfalfa.

This is the first report of a large area of established Verticillium wilt on alfalfa in Canada. The appearance of this disease demonstrates the need for greater control over the movements of diseased plant material from infected areas into non-infected regions. At the present time most commercially grown alfalfa cultivars are likely to be susceptible to the disease. Work is already in progress to incorporate some of the resistance of European cultivars into cultivars suitable for Canadian growing conditions.

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Growth of a Phytophthora sp. on carrot agar

D. Stelfox and M. Herbut[1]

The rate of growth of an unidentified species of *Phytophthora*, causing rubbery brown rot of stored carrots, was greatest on carrot agar medium prepared from frozen samples of carrots harvested at 14 weeks from seeding and from carrots frozen following 13 weeks storage at 1°C.

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Le taux de croissance d'une espèce non identifiée de *Phytophthora* provoquant une pourriture brune caoutchouteuse sur la carotte de conservation a atteint son intensité maximum sur gélose préparée à partir de carottes congelées récoltées à leur 14e semaine et de carottes congelées après 13 semaines de conservation à la température de 1°C.

Introduction

A rubbery brown rot disease of carrots (*Daucus carota* L. var. sativa D.C.) caused by *Phytophthora megasperma* Drechs. was first reported as occurring in the field in Tasmania (1,8) and later elsewhere in storage (6,7). In Alberta, a similar rubbery brown rot of carrots, caused by an unidentified species of *Phytophthora*, was responsible for serious losses in 1969-70 (3) and recurred there in 1975-76 (7). It appears to be caused by an undescribed species of *Phytophthora*. This paper reports the results of a study to determine whether carrot roots taken from the field at different intervals after seeding or stored for different periods of time would vary in supporting growth of the causal fungus.

Materials and methods

Two isolates of the Alberta carrot *Phytophthora* (7) (980-1 and 1157) obtained in 1970 were used on the test media. These media included 7 field samples of irrigated Imperator 11 carrot roots harvested weekly at the 12 to 18 wk growth stages, and 6 samples of unwashed carrot roots Filacell-stored at 1°C taken at 3.0, 3.5, 4.5, 6.5, 10.0 and 13.0 wk during storage. "Filacell" storage involves the combining of refrigeration and humidification by forcing air through a heat and moisture exchanger wound on a frame attached to inside storage room walls. All carrots were frozen as quickly as possible after sampling and remained so, in 1.5 mil closed unperforated polyethylene bags until used in media preparation.

The effect of sampling date on radial growth of mycelium of the 2 fungal isolates was studied using 5 mm agar plugs of inoculum grown on standard carrot agar and placed on the centre of the test agar in petri plates. Standard agar for all tests was prepared using a single sample of unwashed, mature carrot roots Filacell-stored at 1°C for 18 wk and grown on the same field as the test carrots. For each test carrot agar was prepared by blending 200 g frozen carrot tissue with 250 ml distilled water. The juice was strained through a triple layer of cheesecloth, and distilled water was added to make up 1 litre to which 15 g of Difco agar was then added. The medium was sterilized in 2 litre flasks for 20 min at 121°C and 15 lb pressure. Radial growth of the mycelium (mm) was recorded at intervals during a 20 day period using 10 replicates of each isolate per date of carrot sampling. Radial growth measurements of the 2 isolates were averaged for recording purposes.

Results and discussion

Rate of growth of mycelium was greater on all fresh carrot test media than on the standard carrot medium (Fig. 1A). Radial growth was greater by 60%, after 10 days incubation, for carrots sampled after the 14 wk growth than on the standard carrot medium. This period of carrot root development coincides with the "biochemical maturity" phase referred to by Phan and Hsu (4) when sugar content has reached a plateau. Media from carrot roots sampled before and after the 13 and 14 wk from seeding produced 10-20% less radial growth. In Alberta the disease has so far not been found in the field, nor in unwashed carrot roots at harvest time.

The growth pattern of *Phytophthora* on stored carrots media was similar to that on fresh carrot media. The decreased growth on media prepared with carrots that had been stored for 3 to 4.5 wk may be a reflection of the heightened respiration demands on reducing sugars in stored carrots immediately after harvest (2,5).

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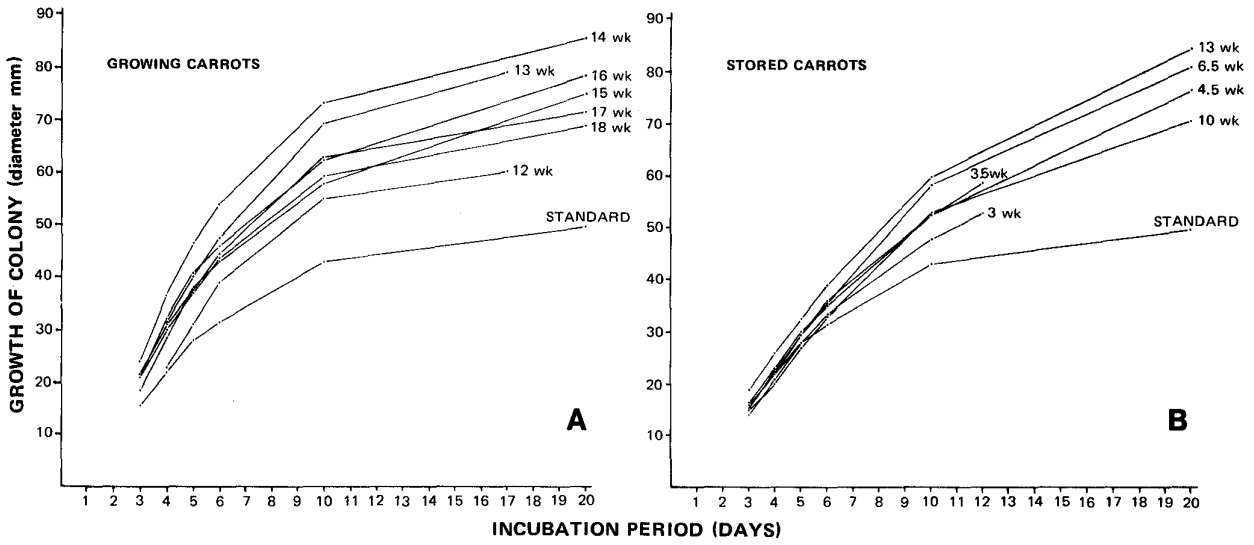

Figure 1. Radial growth of a *Phytophthora* sp. during 20 days incubation on media prepared from frozen samples of carrot roots, (A) taken at different intervals after seeding and, (B) at different intervals during storage.

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Potato late blight forecasting in Prince Edward Island in 1978

A. Bootsma[1]

Potato late blight reports were issued semi-weekly by means of the public news media in Prince Edward Island during the 1978 season as a trial service to potato growers in the province. Data on temperature, relative humidity and rainfall within potato fields at seven locations across the province were heavily relied upon in formulating spray recommendations for controlling the late blight fungus *Phytophthora infestans*. The time of first appearance of disease symptoms following periods of high humidity in late July was accurately anticipated and alerted growers to a potential epidemic situation. Growers were advised to relax their spraying schedule to 14 day intervals in the last half of August and early September when dry weather caused the disease to die out and further spread was prevented. Results from a mailed survey questionnaire indicated many growers were able to use the service to help them time spray applications and to reduce the number of sprays required.

Can. Plant Dis. Surv. 59:3, 63-66, 1979.

Au cours de la campagne de végétation de 1978, des bulletins d'information sur le mildiou ont été transmis, à titre d'essai, deux fois par semaine par les media à l'intention des planteurs de pomme de terre de l'Ile-du-Prince-Edouard. Les données concernant la température, l'humidité relative et la pluviométrie dans des champs répartis à sept endroits de la province ont servi de base à l'établissement de recommandations pour les pulvérisations contre l'organisme pathogène *Phytophthora infestans*. La date de l'apparition des symptômes après une période de forte humidité en fin de juillet a pu être prévue avec exactitude et on a pu alerter les producteurs des risques d'infestation d'envergure épidémique. Par la suite, les producteurs ont été en mesure de ramener leur calendrier de pulvérisation à intervalles de 14 jours dans la seconde moitié d'août et le début de septembre, le temps sec ayant alors entraîné la disparition virtuelle du pathogène et écarté tout nouveau danger de propagation. Les réponses obtenues d'une enquête postale conduite auprès des producteurs ont fait ressortir que ce service leur a permis de prévoir les dates de pulvérisation et aussi de réduire le nombre de traitement de protection.

Introduction

In Prince Edward Island, Canada, potato late blight caused by the fungus *Phytophthora infestans* (Mont.) de Bary, is a disease of economic significance with which growers must contend. In most years, field losses due to late blight can be substantial unless adequate fungicide treatments are employed (1, 2). A survey in 1972 indicated that many growers applied routine sprays irrespective of the presence of blight or prevalence of weather conditions conducive to the development of late blight (5). Studies elsewhere have shown that the efficiency of fungicides can be improved when blight sprays are applied according to forecasting methods based on weather conditions (3, 6). Thus, there is a need to have good weather-based potato late blight forecasts in Prince Edward Island to (1) provide early warnings of blight outbreaks, (2) assist growers in scheduling sprays for blight control and (3) reduce costs by eliminating unnecessary sprays. Blight warnings were issued in the province for many years by L.C. Callbeck, but were discontinued upon his retirement after the 1976 season.

In the 1978 growing season, the Prince Edward Island Department of Agriculture and Forestry and the Charlottetown Weather Office, Environment Canada issued potato blight reports jointly on a trial basis. The purposes of this paper are to (1) describe the forecasting system that was used, (2) report on the recommendations that were made based on this system and (3) give some indications of the response of growers to this service.

Materials and methods

The forecasting system used to predict blight occurrence and recommend spray intervals was patterned after methods developed by Hyre (4) and Wallin (7) as combined and modified later by Krause (6) and also by Hodgson (personal communication, W.A. Hodgson, 1978). Hyre's system used daily rainfall and temperature to predict the onset of blight. Wallin's system based forecasts of initial occurrence and subsequent spread on temperature and relative humidity criteria. Krause's Blitecast system, which was a combination of these two methods, recommended more sprays than necessary when tried under our local conditions and therefore some modifications in Krause's methods were required. These modifications are given in Table 1, which shows the relationship of Wallin's severity values and Hyre's rain-favourable days to a blight weather index (BWI) and a recommended spray schedule.

Air temperature, relative humidity and rainfall were continually monitored in representative potato fields at

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seven locations across the province during the 1978 season. Hygrothermographs and maximum and minimum thermometers were mounted in standard weather shelters situated between the potato rows at ground level. The data were collected each Monday and Thursday and Wallin severity values and Hyre rain-favourable days as described by Krause (6) were calculated. A BWI was then determined for each region using relationships shown in Table 1. The climatic data were also relayed by telephone to W.A. Hodgson, Fredericton Research Station, Agriculture Canada and fed into a computer-based experimental blight forecasting program as an independent check on the data analyses and spray recommendations.

Table 1. Blight Weather Index and general spray recommendations as determined by Wallin severity values and Hyre rain-favourable days.

Number of rain-favourable days during last seven days	Severity Values for the last seven days					
	<3	3	4	5	6	>6
≤4	V	V	L	M	M	H
>4	V	L	M	M	H	E

Blight Weather Index	General Spray Recommendations
E - Extreme	5 to 7-day spray
H - High	7-day spray
M - Moderate	10-day spray
L - Low	14-day spray
V - Very Low	No spray recommended

Potato late blight reports were prepared every Monday and Thursday afternoon from July 14th to September 15th, and communicated to growers via radio, newspaper and television by noon on the following day. The reports contained the following information: (a) a BWI for each region of the province, indicating the conduciveness of the weather conditions of the past 7-10 days to the development of late blight; (b) a statement of forecast weather conditions and the anticipated effect on the BWI; (c) reports on the location and severity of blight outbreaks in the province; (d) a recommended spray schedule (time interval between sprays) and suggested rates of application of fungicides. The statements of forecast conditions were prepared by staff of the Charlottetown Weather Office, Environment Canada. Reports of blight incidence in the field were routinely received from field inspectors with the Plant Quarantine Division of Agriculture Canada, Charlottetown. Growers were advised of the general spray recommendations in Table 1 at the beginning of the season, but in the blight reports the spray recommendations were sometimes adjusted. These adjustments were based on the Fredericton experimental blight forecasting program because this system also took into consideration the blight severity in the field, the forecast weather conditions and the time of year (personal communication, W.A. Hodgson, 1978). In the general spray recommendation, only antecedent weather conditions were taken into consideration.

Following is a typical example of the type of blight report issued in 1978:

POTATO BLIGHT REPORT

(to be issued on or before Tuesday, August 1 only)

The P.E.I. Department of Agriculture and Forestry and the Charlottetown Weather Office issued the following potato blight report on Monday, July 31:

The Blight Weather Index is low for all regions of the Province.

Except for a few showers late Tuesday and Wednesday, mainly cool and dry conditions should prevail for most of the period. No significant change is predicted in the blight index over the next few days.

Traces of blight have been reported in a number of fields in the central and southeast region of the province, although drier weather during the past week has helped to keep the disease in check. A 10 to 14 day advisory spray schedule is in effect for all areas.

(Next report will be issued on Thursday, August 3).

After the harvesting season, a one-page questionnaire was mailed to 112 growers, being approximately 10% of all potato producers in the province. Names were selected by choosing every tenth grower from an alphabetical listing of all seed and tablestock producers. The questions pertained to the following areas: (1) potato acreage; (2) cultivars grown; (3) incidence of blight; (4) spraying practices, i.e. timing, chemicals used, method of application; (5) frequence with which reports were received; (6) usefulness of the various statements in the blight reports; (7) effect on spraying practices; (8) communication media; (9) advertisement; (10) future requirements for blight forecasts.

Results

At the time of the initial blight report issued on July 14, growers were advised to apply the first blight spray even though the BWI was "low" and no blight outbreaks had yet been reported. The BWI increased to "high" in all regions during the latter part of July, and the first symptoms of blight were observed in various fields a few days after a warning of a threatened blight outbreak had been issued. August was an exceptionally dry month during which old infections were kept in check and no new outbreaks were reported. The BWI dropped to "very low" in all regions for a 24-day period beginning August 14, and growers were advised that a 14-day spray schedule would control the disease adequately at that time. Abnormally cool temperatures kept the BWI low during damp weather in the second week of September, and no new outbreaks of blight were reported. Over the entire season, the blight forecasting system recommended from 4 to 6 sprays for the control of late blight.

A brief evaluation of the forecast statements contained in eighteen blight reports indicated the following: Ten

forecasts predicted the BWI category for the next period accurately (the category being either extreme, high, moderate, low or very low as in Table 1); three forecasts predicted a BWI which was off by one category in at least some areas of the province; two forecasts were off by one category in all areas; one forecast was off by at least one category in all areas and up to two categories in some regions; two forecasts were off by two categories in all regions.

Some of the results of the questionnaires mailed to growers after the season are summarized in Table 2. The percentage of affirmative responses to each item on the questionnaire is indicated. All other respondents either replied in the negative, indicated they did not know or left the question blank. Of the 112 questionnaires sent out, only 26 were returned by growers (23%), and one of these was considered ineligible. Seventy-six percent of the respondents indicated that the reports helped them schedule fungicide sprays and a large majority said they were able to reduce the number of sprays applied. This reduction in sprays apparently did not affect disease incidence adversely, because all respondents reported no problems with late blight in 1978. Ninety-two percent indicated that the blight incidence reports were a useful component of the service. The recommended spray schedules drew the least favourable response and only 52% indicated that these were useful. Almost 50% of the respondents normally use a flexible spray schedule while the remainder usually adhere to a rigid 7-day or 10-day program. Over 90% of the respondents indicated that they thought the service should continue in future years.

Table 2. Results of survey questionnaire as indicated by percentage of affirmative responses. (23% of 112 selected growers responded).

Item	Affirmative responses	
	Percentage	Number of growers
Reports helped to schedule sprays	76%	19
Reports helped to reduce number of sprays	60%	15
Growers who used 4-6 sprays	60%	15
Growers who used >6 sprays	20%	5
Growers normally using flexible spray program	48%	12
Growers normally on rigid 7 or 10 day program	52%	13
Useful items of blight reports:		
(i) blight incidence reports	92%	23
(ii) blight weather forecasts	84%	21
(iii) BWI	80%	20
(iv) recommended spray schedule	52%	13
Blight forecasting service adequately advertised	56%	14
Blight reports should continue in following year	92%	23

Discussion

The 1978 season was very suitable for testing the ability of the blight forecasting system to reduce the number of sprays required, because weather conditions were not very conducive to the development of late blight epidemics. Due to dry weather, researchers at the Charlottetown Research Station experienced difficulty in establishing late blight symptoms in unsprayed plots that were inoculated with spores of *P. infestans* (personal communication, H.W. Platt, 1978). Therefore we estimate that two or three properly timed sprays would have given adequate blight control in most cases. Many growers sprayed more often as an insurance against risk of disease and were reluctant to extend their spray schedule beyond 10-14 day intervals even though conditions were not conducive to the development of late blight.

In our opinion, the following facts indicate that the blight forecasting system used in 1978 was successful: (1) the time of appearance of initial blight symptoms was accurately anticipated; (2) no increase in blight was reported during periods when growers were advised to relax their spray schedule; (3) in general, growers responded favourably to the service; (4) many growers were able to reduce the number of blight sprays and still maintain good disease control. One year's results, however, cannot be considered as a thorough test of the system. Since we intend to continue blight forecasting as an on-going service to growers in the province, there will likely be opportunity for further evaluation in the future.

The results of the questionnaire probably represent a somewhat biased view of the opinions of potato producers in the province, since only 23% of the growers that were surveyed gave a response. For example, a greater percentage of growers who made use of the service may have responded to the questionnaire than of growers who did not know of the service or did not make use of it. In our opinion, however, the results represent the views of at least 23% of all producers since growers were selected at random from a list of names.

The blight forecasting service is potentially more useful to growers using a flexible schedule than to those on a rigid 7 or 10-day program. We believe, however, that growers on a rigid schedule will be prepared eventually to build some flexibility into their spraying operations once they can be convinced that the blight forecasting system is reliable. Growers' confidence in the blight forecasts can only be increased if the system can demonstrate repeated successes in future years. Additional advertisement and explanation of the service may also increase the level of acceptance by growers, since only 56% of the respondents to the questionnaire indicated that the service was advertised adequately prior to the season.

One of the present concerns of some growers is that the service will encourage fewer sprays and thereby reduce protective coverage in the province and increase the risk of blight epidemics. This concern is understandable because in past years it has been necessary to encourage growers to spray more often for blight control. The forecasting system, however, encourages a "cautious" reduction in the frequency of blight spraying only when

there is little threat of a blight outbreak and thus helps growers save costs from needless sprays. At present costs of about $5 to $6 per acre ($12 to $15 per ha) per spray, $280,000 to $336,000 could have been saved in 1978 in P.E.I. for each spray that was not required on an estimated 56,000 acres (22,660 ha) potatoes grown in the province. In wet years when conditions are very conducive to blight epidemics, no savings on spraying costs would be made since the number of blight sprays would not be reduced. It is expected that under those conditions the service will help growers - especially those who do not spray enough - in maintaining a regular spray program, and thereby reduce crop losses due to late blight disease.

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Leaf rust of wheat in Canada in 1978[1]

D.J. Samborski

Leaf rust was first found in Manitoba on June 21. It was widespread in Manitoba and eastern Saskatchewan by mid-July but subsequent development was slow and leaf rust caused little damage to wheat in 1978. Identification of races from leaf rust survey samples was carried out with 19 backcross lines with single genes for resistance as differential varieties. Lines with resistance genes *Lr 11, Lr 16, Lr 19, Lr 21* and T^4 x PI 58548 were resistant to all isolates of leaf rust. Twenty-eight virulence combinations on fourteen genes for resistance were identified in 1978.

Can. Plant Dis. Surv. 59:3, 67-68, 1979.

Arrivée au Manitoba vers le 21 juin, la rouille de la feuille était, à la mi-juillet, largement répandue dans cette province et dans l'est de la Saskatchewan. Par après, sa progression a été lente et, somme toute, la maladie n'a infligé que peu de dégâts aux cultures de blé. L'enquête épidémiologique a été réalisée sur 19 lignées de rétrocroisement utilisées comme variétés réactifs, chacune possédant un gène unique de résistance. Les lignées possédant les gènes *Lr 11, Lr 16, Lr 19, Lr 21* et T^4 x PI 58548 se sont montrées résistantes à tous les isolats de rouille. Vingt-huit combinaisons de virulence envers 14 gènes de résistance ont été observées.

Disease development and crop losses in western Canada

Leaf rust (*Puccinia recondita* Rob. ex. Desm.) was first found on wheat (*Triticum aestivum* L.) in Manitoba on June 21. It was widespread in Manitoba and eastern Saskatchewan by mid-July but subsequent development was slow and leaf rust caused little damage in 1978. The bread wheat varieties Neepawa, Napayo and Manitou were moderately susceptible while Sinton was resistant and Glenlea highly resistant to leaf rust. All commercial durum varieties grown in Canada were resistant to leaf rust in 1978. The durum wheat varieties grown in Canada have always been resistant to leaf rust and virulence in the leaf rust population has never been observed on these varieties.

It was not possible to obtain reliable estimates of leaf rust prevalence and intensity on varieties in the rust nurseries. However, it was often possible to obtain small samples of leaf rust for race identification.

Physiologic specialization

Field collections of leaf rust were established on Little Club wheat in the greenhouse and one single-pustule isolate was taken from each collection for race identification. Urediospores from the remaining pustules were collected and bulked with collections from each geographic area to give composites that were used to inoculate a group of highly resistant varieties of wheat.

A total of 245 cultures were established in 1978 from the single-pustule isolates. These single pustule isolates were used to inoculate 19 backcross lines of wheat with single genes for resistance that served as differential varieties. Genes *Lr 11, Lr 16, Lr 19, Lr 21* and T^4 x PI 58548 were resistant to all isolates of leaf rust and only two isolates, both from Ontario, were virulent on *Lr 9* (Table 1). In 1978, as in previous years (1), virulence on *Lr 3, Lr 10* and *Lr 14a* predominated in the leaf rust population. Virulence on *Lr 1* and on the alleles at the *Lr 2* locus, was at a very low level for many years but increased in the early 1970's and has remained fairly stable for several years. Leaf rust cultures from Manitoba and Saskatchewan tend to be virulent on the adult plant gene, *Lr 13*, derived from Frontana, while cultures from Ontario and Quebec tend to be virulent on the adult plant gene *Lr 12*, derived from Exchange. A total of 43 cultures were isolated from collections in Ontario and 36 of these were obtained from winter wheat.

Table 1. Virulence of isolates of *Puccinia recondita* on backcross lines containing single genes for resistance to leaf rust in Canada in 1978.

Resistance genes	No. of virulent isolates from: B.C.	Alta.	Sask.	Man.	Ont.	Que.	N.S.	Total no. of virulence isolates	% virulent isolates
Lr 1	4	5	9	13	37	2	0	70	28.6
Lr 2a	0	1	8	12	0	0	0	21	8.6
Lr 2b	0	1	8	12	0	2	0	23	9.4
Lr 2c	6	15	9	13	42	10	5	100	40.8
Lr 8	2	7	0	0	41	10	4	64	26.1
Lr 3	0	7	61	100	29	2	8	207	84.5
Lr 3ka	0	0	2	2	28	2	2	36	14.7
Lr 9	0	0	0	0	2	0	0	2	0.8
Lr 10	6	17	45	79	39	7	4	197	80.4
Lr 11	0	0	0	0	0	0	0	0	0.0
Lr 14a	0	5	61	100	33	10	4	213	86.9
Lr 16	0	0	0	0	0	0	0	0	0.0
Lr 17	0	4	5	5	0	0	0	14	5.7
Lr 18	6	10	5	4	42	9	6	82	33.5
Lr 19	0	0	0	0	0	0	0	0	0.0
Lr 21	0	0	0	0	0	0	0	0	0.0
Lr 24	0	0	16	14	0	0	0	30	12.2
Lr T	0	0	2	2	14	2	0	20	8.2
T^4 x PI 58548	0	0	0	0	0	0	0	0	0.0

[1] *Contribution No. 892, Agriculture Canada, Research Station, 195 Dafoe Road, Winnipeg, Manitoba, R3T 2M9.*

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Twenty-eight virulence combinations on fourteen genes for resistance were identified in 1978 (Table 2). Most of the isolates from the Canadian prairies combine virulence on *Lr 3, Lr 10* and *Lr 14a*. Most cultures from Ontario were virulent on *Lr 18* and many combine virulence on *Lr 3ka* and *Lr T*.

Composite collections of leaf rust were used to inoculate a number of highly resistant varieties of wheat. A number of single pustule isolates that developed on these varieties were studied but no new combination of virulence was detected.

Table 2. Virulence combinations of *Puccinia recondita* isolates on backcross lines containing single genes for resistance to leaf rust in Canada in 1978.

Avirulence/virulence formula	No. of isolates from:							Total no. of isolates
	B.C.	Alta.	Sask.	Man.	Ont.	Que.	N.S.	
1,2a,2b,2c,B,3ka,9,10,17,18,24,T/3,14a	0	0	2	4	0	0	0	6
1,2a,1b,1c,B,3ka,9,17,18,24,T/3,10,14a	0	2	39	62	1	0	0	104
1,2a,2b,2c,B,3ka,9,10,17,18,T/3,14a,24	0	0	13	11	0	0	2	26
1,2a,2b,2c,B,3ka,9,17,24,T/3,10,14a,18	0	0	1	1	0	0	0	2
1,2a,2b,2c,B,9,10,17,18,24,T/3,3ka,14a	0	0	0	0	0	0	1	1
1,2a,2b,2c,B,9,10,17,18,24/3,3ka,14a,T	0	0	1	0	0	0	0	1
2a,2b,2c,B,3ka,9,17,18,24,T/1,3,10,14a	0	0	0	5	0	0	0	5
2a,2b,2c,B,3ka,9,10,18,24,T/1,3,14a,17	0	0	1	3	0	0	0	4
2a,2b,2c,B,3ka,9,10,17,18,T/1,3,14a,24	0	0	1	0	0	0	0	1
2a,2b,2c,B,3ka,9,17,18,T/1,3,10,14a,24	0	0	1	1	0	0	0	2
1,2a,2b,3,3ka,9,10,14a,17,24,T/2c,B,18	0	0	0	0	4	3	0	7
1,2a,2b,3,3ka,9,14a,17,18,24,T/2c,B,10	0	0	0	0	0	1	0	1
1,2a,2b,3,3ka,9,14a,17,24,T/2c,B,10,18	2	5	0	0	0	1	0	8
1,2a,2b,B,3ka,9,14a,18,24,T/2c,3,10,17	0	4	0	0	0	0	0	4
1,2a,2b,3ka,9,14a,17,24,T/2c,B,3,10,18	0	0	0	0	0	0	4	4
1,2a,2b,B,9,10,17,18,24,T/2c,3,3ka,14a	0	0	0	0	0	0	1	1
2a,2b,B,3,3ka,9,14a,17,24,T/1,2c,10,18	1	3	0	0	1	0	0	5
2a,2b,3,3ka,9,17,24,T/1,2c,B,10,14a,18	0	2	0	0	9	0	0	11
1,B,3ka,9,17,18,24,T/2a,2b,2c,3,10,14a	0	1	3	8	0	0	0	12
2a,2b,B,9,18,24/1,2c,3,3ka,10,14a,17,T	0	0	1	1	0	0	0	2
1,B,9,17,18,24/2a,2b,2c,3,3ka,10,14a,T	0	0	0	1	0	0	0	1
1,2a,2b,14a,17,24,T/2c,B,3,3ka,9,10,18	0	0	0	0	1	0	0	1
2a,9,14a,17,24/1,2b,2c,B,3,3ka,10,18,T	0	0	0	0	0	1	0	1
2a,2b,14a,17,24,T/1,2c,B,3,3ka,9,10,18	0	0	0	0	1	0	0	1
2a,2b,9,14a,17,24,T/1,2c,B,3,3ka,10,18	0	0	0	0	12	0	0	12
2a,2b,9,14a,17,24/1,2c,B,3,3ka,10,18,T	0	0	0	0	14	0	0	14
B,3ka,9,10,17,24,T/1,2a,2b,2c,3,14a,18	0	0	2	2	0	0	0	4
B,3ka,9,10,24,T/1,2a,2b,2c,3,14a,17,18	0	0	3	1	0	0	0	4

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The occurrence of the lambda race of bean anthracnose in Ontario[1]

V.R. Wallen

Seven isolates of *Colletotrichum lindemuthianum* collected in 1977 during a survey of pedigreed field beans for anthracnose have been determined as belonging to the lambda race. This is the first report of this race in Canada.

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Sept isolats de *Colletotrichum lindemuthianum* prélevés en 1977 au cours d'une enquête sur la fréquence d'anthracnose chez les haricots secs de catégorie généalogique ont été rattachés à la race lambda. Il s'agit de la première mention de cette race au Canada.

In 1976, during routine inspections for purity and freedom from disease of white bean Select plots, a pod with anthracnose-like symptoms was located in one of the Sanilac plots near Staffa, Ontario. As the principal cultivars of white beans, Sanilac, Seafarer and Kentwood were resistant to the prevalent races of anthracnose in Ontario at that time, it was suspected that a new race of the organism *Colletotrichum lindemuthianum* (Sacc. and Magn.) Bri and Cav. was present in the bean growing areas. A second inspection revealed that two additional fields were infected with the organism. Subsequently, using the differential bean cultivars, Widusa, Kaboon, Cornell 49-242 and Dark Red Kidney for the identity of races of *C. lindemuthianum* it was determined that the fungus isolated from the Select plot belonged to the delta group (2).

With the knowledge that this new race was present in Canada and the immediate danger to the bean crop, as the three principal bean cultivars, Sanilac, Seafarer and Kentwood are susceptible, a large comprehensive field survey was carried out in 1977 by a combined team of Plant Products and Plant Quarantine Division personnel, Food Production and Marketing Branch and Research Branch personnel, Agriculture Canada. All pedigreed fields in Ontario were inspected in this survey, conducted during the last week of August and the first week of September. Over 60 isolates were obtained from infected bean leaves and pods from infected fields located in this survey and subsequently race determinations were made. The results of this survey will be reported later.

In preliminary tests for race determination, it became apparent that although most of the isolates tested were of the delta race, seven isolates did not fit into the delta category because of their ability to infect the differential cultivar, Kaboon. The differentiation between races "delta" and "lambda" is dependent on the reaction to the cultivar Kaboon which is resistant to delta and slightly susceptible to lambda, according to Hubbeling (1) who isolated a deviating mutant alpha race and named it lambda.

The occurrence of the lambda race in Ontario does not warrant additional concern to the bean industry as the delta and lambda races are closely related and incorporating delta resistance will also include lambda resistance. Studies for anthracnose resistance are now being carried out at a number of establishments in Ontario.

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[1] *Contribution No. 569 Ottawa Research Station, Agriculture Canada, Ottawa, Ontario K1A 0C6*

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Stem rust of oats in Canada in 1978[1]

J.W. Martens

Stem rust (*Puccinia graminis* f. sp. *avenae*) was first observed on oats (*Avena sativa*) in Manitoba in mid-July. Light infections occurred throughout Manitoba and eastern Saskatchewan by the third week in August but crop losses were confined to late-seeded fields in eastern and central Manitoba. A new system of race nomenclature for North America, including an expanded set of differential lines has been adopted for use in Canada. Physiologic races NA27 (9,13,15,16,a/1,2,3,4,8) and NA16 (2,4,9,13,15,16,a/1,3,8) continued to predominate in western Canada. Race NA25 (8,13,16,a/1,2,3,4,9,15) was the most common in eastern Canada. A late fall survey of southern Alberta indicated the widespread presence of a distinct rust population dominated by race NA5 (1,2,4,8,9,13,16,a/3,15). None of the 206 field isolates studied were virulent on lines with resistance conferred by genes Pg-13, Pg-16 or the Pg-a complex.

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La rouille de la tige (*Puccinia graminis* f. sp. *avenae*) en 1978 a fait sa première apparition au Manitoba vers la mi-juillet et, dans la troisième semaine d'août, de légers foyers d'infection s'étaient déclarés un peu partout dans la province et dans l'est de la Saskatchewan, encore que les pertes de récolte se limitaient aux semis tardifs de l'est et du centre du Manitoba. On a adopté cette année une nouvelle nomenclature des rouilles pour l'Amérique du Nord et le groupe des variétés différentielles (réactifs) pour le Canada a été élargi. Les races physiologiques NA27 (9,13, 15, 16, a/1, 2,3,4,8) et NA16 (2,4,9,13,15, 16, a/1,3,8) ont conservé leur prépondérance dans l'Ouest, tandis que NA25 (8,13,16.a/1,2,3,4, 9,15) était la plus fréquente dans l'Est. Une enquête effectuée en fin d'automne dans le sud de l'Alberta a révélé la présence généralisée d'une population de rouilles caractéristique dominée par NA5 (1,2,4,8,9,13,16,a/3,15). Aucun des 206 isolats de terrain examinés n'a manifesté de virulence envers les lignées pourvues des gènes de résistance Pg-13, Pg-16 ou du complexe Pg-a.

Prevalence and crop losses in western Canada

Stem rust of oats (*Avena sativa* L.) caused by *Puccinia graminis* Pers. f. sp. *avenae* Eriks. and E. Henn. was first observed in southern Manitoba in mid-July in 1978. Light infections occurred throughout Manitoba and eastern Saskatchewan by the third week in August but crop losses were confined to late-seeded fields in eastern and central Manitoba where infections of up to 80% were observed at the end of August. A survey in late September indicated that oat stem rust was common across southern Alberta at least as far west as Lethbridge in 1978.

The commonly grown cultivars Harmon, Kelsey, Random, Rodney and Terra are susceptible to stem rust, but Hudson, which comprised 25.1% and 5.3% of the hectarage in Manitoba and Saskatchewan, respectively, continued to be moderately resistant to all the races of stem rust occurring in western Canada.

Uniform rust nurseries

Rust nurseries comprising the oat cultivars Fraser (Pg-2, -4), Hudson (Pg-2-4-9), Rodney (Pg-4), RL 903 (Pg-8), RL 996 (Pg-a), RL 1005 (Pg-15), RL 1008, RL 2924, RL 2925, RL 2926, and W 76121 were grown at 28 locations across Canada. Trace to light infections were observed on nurseries grown at Guelph, Vineland and Kapuskasing, Ont.; and Durban and Morden, Man.; Indian Head, Sask.; Lethbridge, Alta.; and Creston, B.C. Heavy infections occurred on the nursery grown at Brandon, Man. No rust infections were observed on nurseries grown at Charlottetown, P.E.I.; Kentville and Truro, N.S.; Fredericton, N.B.; La Pocatiere, Macdonald College, Normandin and Quebec, Que.; Appleton, New Liskeard, Ottawa, Sudbury and Thunder Bay, Ont.; Melfort and Scott, Sask.; Beaverlodge, Edmonton and Lacombe, Alta.; and Agassiz, B.C.

Physiologic specialization

Rust isolates obtained from wild oats (*A. fatua* L.), commercial oats and rust nurseries grown across Canada were established on the susceptible cultivar Victory and avirulence/virulence combinations were determined by the infection types produced on seedlings of the differential lines shown in Table 1. This expanded group of differential lines form the basis of a new system of race nomenclature now in use in North America (3). The lines not previously used as differentials are CI 9351, RL 997 (Pg-15) with resistance derived from *A. sterilis* L. collected near Uskudar, Turkey, CI 9352, RL 822 (Pg-16) a 44 chromosome disomic addition line with resistance from *A. barbata* (J.E. Pott ex Link) line No. D203, and the genetically undefined (Pg-12 and additional factor(s)) line designated Pg-a with resistance derived from CI 9139. Except for the Pg-a line, all the differentials are backcross derived lines in the Rodney 0 (CI 9317, RL 805) oat background. Lines carrying the Pg-14 resistance gene (1) were tested with approximately 125 isolates, including race NA1 virulent only on the Pg-15 line, but no avirulent reactions were observed.

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Table 1. Avirulence/virulence combinations of *Puccinia graminis avenae* field isolates on back-cross lines with single-gene resistance to stem rust in Canada in 1978.

North American No.	Avirulence/virulence formula	No. of isolates from N.S., Ont. & Que.	Man.	Sask.	Alta.	Total isolates	Percentage of total isolates
A.	Combined isolates from all hosts						
NA1	1,2,3,4,8,9,13,16,a/15			1		1	0.5
NA5	1,2,4,8,9,13,16,a/3,15				19	19	9.0
NA10	1,4,8,9,13,16,a/2,3,15	2			1	3	1.4
NA15	2,4,8,9,13,15,16,a/1,3			2		2	0.9
NA16	2,4,9,13,15,16,a/1,3,8	1	13	14	1	29	13.5
NA20	3,8,13,16,a/1,2,4,9,15		1	2		3	1.4
NA24	8,9,13,16,a/1,2,3,4,15			3		3	1.4
NA25	8,13,16,a/1,2,3,4,9,15	6				6	2.8
NA27	9,13,15,16,a/1,2,3,4,8	2	92	45	9	148	69.1
Total		11	106	67	30	214	
B.	Isolates from cultivars with known stem rust resistance genes						
NA10		2				2	2.4
NA15				1		1	1.2
NA16		1	1	2		4	4.8
NA20				1		1	1.2
NA24				1		1	1.2
NA25		6				6	7.2
NA27		2	43	19	4	68	82.0
Total		11	44	24	4	83	
C.	Isolates from wild oats and cultivars with no known stem rust resistance genes						
NA1				1		1	0.8
NA5					19	19	14.5
NA10					1	1	0.8
NA15				1		1	0.8
NA16			12	12	1	24	18.3
NA20			1	1		2	1.5
NA24				2		2	1.5
NA27			49	25	5	81	61.8
Total			62	43	26	131	

Races NA27 and NA16 continued to predominate in western Canada (2) and comprised about 69% and 14% of all field isolates, respectively (Table 1). The isolates obtained from Alberta in late September consisted primarily of race NA5 which is similar to a race commonly found in the winter oat area of the southern United States, especially Texas (4). This race was reported only from the southern United States and Mexico in 1977 (4) and it almost certainly did not come from the Great Plains region. The occurrence of the relatively avirulent races NA1 and NA15 in Saskatchewan is also noteworthy. In eastern Canada the traditional race NA25 continued to predominate (2) and the rare race NA10 was isolated for only the second time since 1964. The separation of isolates by origin (Table 1, B + C) illustrates the bias in population sampling caused by cultivars with genes for resistance.

None of the field isolates from eastern or western Canada were virulent on lines with genes Pg-13, -16 or the a-complex resistance (Table 2). The next most resistant were lines with Pg-9 and -15 vs. western isolates and

Pg-8 vs. eastern isolates. Virulence on lines with genes Pg-1 through Pg-4 continued at high levels with slight declines from the previous year for all except Pg-3 attributable largely to the relatively avirulent NA5 isolates from Alberta.

In a continuing effort to detect new virulence combinations in the rust population natural-infection trap nurseries consisting of breeding lines and various other genotypes were planted at Glenlea and Portage la Prairie, Manitoba. The 124 isolates obtained from these nurseries (Table 3) included more races than the 106 field isolates (6 vs. 3) from Manitoba. However, none of the races identified were new or constitute a threat to the resistance being used in the breeding program.

Table 2. Frequency of virulence (% of isolates) in the oat stem rust population in eastern and western Canada on oat lines with single resistance genes in 1978.

Source of isolates	Genes for resistance										Total no. isolates	Mean virulence capability*
	Pg-1	Pg-2	Pg-3	Pg-4	Pg-8	Pg-9	Pg-13	Pg-15	Pg-16	Pg-a		
East	82.0	90.9	100	72.7	27.3	54.5	0.0	72.7	0.0	0.0	11	5.0
West	89.6	75.4	98.0	75.0	85.7	1.5	0.0	14.8	0.0	0.0	203	4.4

* Mean virulence capability = No. of isolates virulent on Pg-1 + . . . Pg-a/total no. of isolates.

Table 3. Avirulence/virulence combinations isolated from *P. graminis avenae* trap nurseries comprising backcross lines with single-gene resistance planted at Glenlea and Portage la Prairie, Manitoba in 1978.

North American No.	Avirulence/virulence formula	No of isolates	Percent of isolates
NA1	1,2,3,4,8,9,13,16,a/15	2	1.6
NA5	1,2,4,8,9,13,16,a/3,15	3	2.4
NA6	1,2,4,8,13,16,a/3,9,15	4	3.2
NA7	1,2,4,8,16,a/3,9,13,15	4	3.2
NA16	2,4,9,13,15,16,1/1,3,8	24	19.4
NA27	9,13,15,16,a/1,2,3,4,8	87	70.2
Total		124	

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Titles should be concise and informative providing, with the Abstract, the key words most useful for indexing and information retrieval.

Abstracts of no more than 200 words, in both English and French, if possible, should accompany each article.

Figures should be planned to fit, after reduction, one column (maximum 84 × 241 mm) or two columns (maximum 175 × 241 mm), and should be trimmed or marked with crop marks to show only essential features. Figures grouped in a plate should be butt-mounted with no space between them. A duplicate set of unmounted photographs and line drawings is required. Figures should be identified by number, author's name, and abbreviated legend.

Tables should be numbered using arabic numerals and have a concise title; they should not contain vertical rules; footnotes should be identified by reference marks (* † § # ¶ ** ††) particularly when referring to numbers.

Literature cited should be listed alphabetically in the form appearing in current issues; either the number system or the name-and-year system may be used. For the abbreviated form of titles of periodicals, refer to the most recent issue of *Biosis List of Serials* published by Biosciences Information Service of Biological Abstracts or to the *NCPTWA Word Abbreviation List*, American National Standards Institute.

Recommandations aux auteurs

Les articles et les communiqués sont publiés en anglais ou en français. Les manuscrits (l'original et une copie) et toute la correspondance qui s'y rapporte doivent être envoyés au Rédacteur intérimaire M. H.S. Krehm Service des programmes de recherche, Direction de la recherches, ministère de l'Agriculture du Canada, Ottawa (Ontario) K1A 0C6.

Les manuscrits doivent être concis et faire preuve de suite dans le style, l'orthographe et l'emploi des abréviations. Ils doivent être dactylographiés à double interligne, de préférence sur des feuilles à lignes numérotées. Toutes les pages doivent être numérotées y compris celles portant le résumé, les tableaux et les légendes. Pour plus de renseignements sur le format des feuilles et le style, prière de consulter nos dernières publications et le *CBE Style Manual* (3e ed. 1972) de l'American Institute of Biological Sciences, Washington (DC). Dans la mesure du possible, les données numériques doivent être exprimées en unités métriques, (SI) ou être suivies de leur équivalent métrique. L'emploi de crochets est autorisé pour l'identification du nom scientifique d'un micro-organisme pathogène après le nom commun de la maladie dont il est l'agent causal.

Les titres doivent être courts et révélateurs en contenant, avec le résumé, les mots clés les plus utiles pour le classement et l'extraction de l'information.

Chaque article doit être accompagné d'un *résumé* d'au plus 200 mots en anglais et en français, si possible.

Les figures doivent pouvoir, après réduction, remplir une colonne (maximum 84 × 241 mm) ou deux colonnes (maximum 175 × 241 mm) et devraient être taillées ou montrer les parties essentielles à garder. Les figures groupées sur une même planche doivent être montées côte à côte, sans intervalle. L'article doit être accompagné d'un double des photographies non montées et des graphiques. Les figures doivent être numérotées, porter le nom de l'auteur et une légende abrégée.

Les tableaux doivent être numérotés en chiffres arabes et avoir un titre concis. Ils ne devraient pas avoir de lignes verticales. Les renvois doivent être identifiés par un signe typographique particulier (* † § # ¶ ** ††) surtout lorsqu'il s'agit de nombres.

Les références bibliographiques devraient être citées par ordre alphabétique comme dans les livraisons courantes. On peut utiliser le système de numération ou le système nom-et-année. Pour l'abrégé du titre des périodiques, on suivra l'édition la plus récente de *Biosis List of Serials* publiée par les Biosciences Information Services de Biological Abstracts ou la *NCPTWA Word Abbreviation List* et l'American National Standards Institute, Standards Committee Z39.