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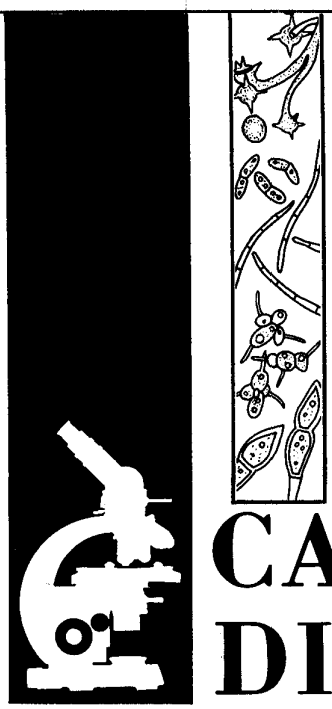

CANADIAN PLANT DISEASE SURVEY

EDITOR W.L. SEAMAN

RESEARCH BRANCH CANADA DEPARTMENT OF AGRICULTURE

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CONTENTS

"The Canadian Plant Disease Survey is a periodical of information and record on the occurrence and severity of plant diseases in Canada. It will also accept other original information such as the development of methods of investigation and control, including the evaluation of new materials. Review papers and compilations of practical value to phytopathologists will be included from time to time. It will not accept results of original research suitable for publication in more formal scientific journals".

EVALUATION OF TERRACLOR AND TERRACLOR SUPER-X FOR THE CONTROL OF RHIZOCTONIA ON POTATO IN BRITISH COLUMBIA[1]

N.S. Wright[2]

Abstract

Broadcast applications of Terraclor or Terraclor Super-X containing a minimum of 20 lb quintozene/acre, when applied to the soil prior to planting and incorporated by disking or rototilling, controlled Rhizoctonia solani on 'Netted Gem' potatoes grown in a clay soil. However in muck soil rates as high as 90 lb/acre did not control the disease. Rates of up to 90 lb/acre did not affect yield adversely. Control of stem cankers gave increased marketable yield in 1966, when soil moisture was deficient for about 3 weeks in mid-season. In 1965 and 1967, when soil moisture was supplemented by irrigation or when no shortage occurred, control of stem cankers failed to influence yield. Quintozene residues in tubers were found only in the peels. Tubers from plots that received 90 lb quintozene/acre contained a maximum residue of 0.512 ppm in the peel or a calculated residue of 0.101 ppm in whole tubers.

Introduction

Terraclor[3] and Terraclor Super-X[3] are products which contain quintozene, the common name for pentachloronitrobenzene. Terraclor Super-X also contains Terrazole[3], a trade name for 5-ethoxy-3-trichloromethyl 1, 2-4-thiadiazole. Quintozene is known to suppress Rhizoctonia solani Kühn (Thanatephorus cucumeris (Frank) Donk) by making the soil solution toxic (4). However, in the Columbia River Basin in Washington, where potatoes are grown under irrigation, quintozene failed to consistently reduce rhizoctonia stem canker and tuber black scurf or to increase the yield of marketable tubers (1, 2, 3).

The tests reported here were conducted on alluvial clay and on muck soils in the Fraser River delta of British Columbia. In the low-lying soils of this area, moisture is normally adequate until mid-season or later and often, due to subirrigation or summer rain, there is no need to apply water. Experiments were conducted during the growing seasons of 1965, 1966, and 1967.

Materials and methods

The experiments were located on well-managed farms on which there was a history of moderate to severe Rhizoctonia infection on potato (Solanum tuberosum L.). The variety 'Netted Gem' was used each year and 'Warba' was included in the 1967 test.

In 1965 soil moisture was not measured, but irrigation water was applied as required in the opinion of experienced farm operators. In 1966 and 1967, the soil moisture in the 'Netted Gem' plots was determined by a bouyoucos bridge with conductivity blocks placed at the 6-, 12-, and 18-inch levels. No supplementary water was added in either year.

Terraclor and Terraclor Super-X were used as emulsifiable concentrates each year. In addition both products were used as wettable powders in 1965 and as granules in 1967. Rates applied were in lb/acre actual quintozene.

In 1965 both clay and muck soils were given broadcast treatments at rates of up to 90 lb/acre. In 1966 rates up to 60 lb/acre were applied as broadcast treatments to clay soil. In 1967 similar clay soils were treated at rates of up to 60 lb/acre as broadcast and up to 20 lb/acre as row treatments.

Broadcast treatments were incorporated by double disking or rototilling within 4 hours of application. Planting was completed within a week after treatment. Row treatments were applied in a 12-inch band on the bottom and sides of open furrows just before planting. The experiments were set up in a randomized block design containing four replications. The standard plot for broadcast treatments contained eight rows 34 inches apart and 25 feet long. Row treatments were applied to two rows 34 inches apart and 25 feet long.

All stems in 50 feet of row in each broadcast-treated plot and all stems in 10 feet of row in each row-treated plot were dug 30-40 days after planting. Each stem was rated as follows: 0 = no cankers, 1 = few superficial cankers, 2 = many superficial and 2 deep cankers, 3 = 3 or more deep cankers, 4 = stem completely girdled. A canker index was

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[1] Contribution No. 148, Research Station, Canada Department of Agriculture, Vancouver, British Columbia.

[2] Plant Pathologist.

[3] Trade names of Olin Mathieson Chemical Corporation, Little Rock, Arkansas.

calculated for each plot by multiplying the number of stems in each class by the class value, adding the products and dividing the sum by the number of stems examined. In 1967 a second canker index was calculated on another sample taken from each treatment of 'Netted Gem' 77 days after planting.

At harvest, after grading and weighing, a random sample of approximately 80 tubers from each plot was stored in a dry room for 2 weeks. The tubers were then washed and examined for sclerotia. Each sample was assigned a sclerotial index calculated (as described) from tuber ratings, based on surface covered by sclerotia, as follows: 0 = no sclerotia, 1 = 0.5% or less, 2 = 1%, 3 = 3%, 4 = 5%, 5 = 7% or more.

In 1965 tubers grown in clay soil were analyzed for residues of quintozene by the Agricultural Experiment Station, Washington State University, Pullman; in 1966 analyses were made by the Agricultural Pesticide Laboratory, British Columbia Department of Agriculture, Vancouver. Tubers that had been in storage for about 4 months were scrubbed with a brush under running water before extractions were made from the peels and from peeled tubers. Quintozene residues were identified by gas chromatography.

Results

Soil moisture

In 1965 sufficient irrigation water was applied to both the clay and muck soils to provide excellent growing conditions. In 1966 the moisture content in the top 12 inches of soil was lowest from mid-July until August 10. Some temporary wilting of plants occurred. During this period the Bouyoucos bridge indicated resistance of 10-15 X 10^3 ohms at the 6-inch level, 7-10 X 10^3 ohms at the 12-inch level, and 3-5 X 10^3 ohms at the 18-inch level. Before and after this dry period the same blocks indicated resistance of 4-8 X 10^3 ohms at the 6- and 12-inch levels and 3-4 X 10^3 ohms at the 18-inch level. In 1967 resistance at all levels was 6 X 10^3 ohms or lower throughout the season and there was no evidence that moisture was deficient at any time.

The control of stem cankers and tuber-borne sclerotia and the effect on yield of Terraclor and Terraclor Super-X were independent of formulation. Consequently, the results of multiple tests with either product in the same experiment were consolidated.

Control of stem cankers

Both Terraclor and Terraclor Super-X reduced the numbers of rhizoctonia stem cankers on potato plants grown in clay soil (Figure 1). The minimum effective rate was approximately 20 lb quintozene/acre in broadcast applications. Results from the row treatments were inconsistent. In most experiments the fungicidal effectiveness of Terraclor and Terraclor Super-X were similar, but the 1967 data indicate somewhat better control by Terraclor Super-X than by Terraclor.

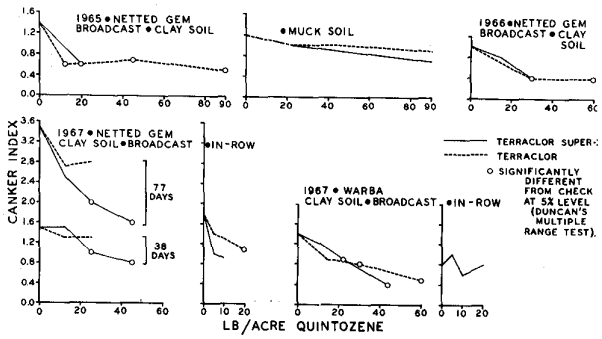

Figure 1. Effect of Terraclor and Terraclor Super-X on rhizoctonia stem canker of 'Netted Gem' and 'Warba' potatoes grown in muck or clay soils in 1965, 1966, and 1967. A canker index of 0 indicates absence of cankers and 4 indicates complete girdling of the stem. Except where indicated, plants were examined 30–40 days after planting.

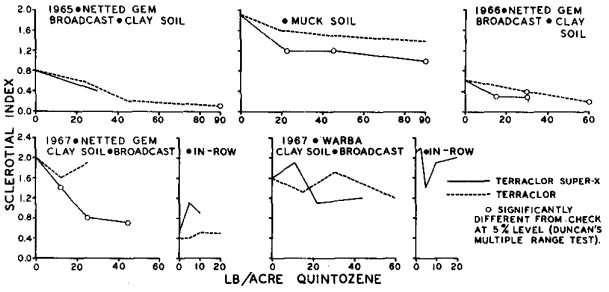

Figure 2. Effect of Terraclor and Terraclor Super-X on the formation of tuber-borne sclerotia of *Rhizoctonia solani* on tubers of 'Netted Gem' and 'Warba' potatoes. A sclerotial index of 0 indicates no sclerotia and 5 indicates 7% or more of the tuber surface covered by sclerotia.

Control of sclerotia

Terraclor and Terraclor Super-X applied as broadcast treatments to either clay or muck soil reduced the incidence of tuber-borne sclerotia on 'Netted Gem' potatoes (Fig. 2). In 1966 both products controlled sclerotia on clay soil when broadcast at rates of 15 to 30 lb quintozene/acre. In 1965 on muck soil and in 1967 on clay soil, broadcast treatment with Terraclor Super-X gave good control in 'Netted Gem', but Terraclor did not. Neither product reduced sclerotia on the early variety 'Warba' and neither gave control on 'Netted Gem' or 'Warba' when applied as a row treatment.

Yield

Neither Terraclor nor Terraclor Super-X at as much as 90 lb quintozene/acre reduced marketable or total yield. In 1965, when 'Netted Gem' potatoes were grown on treated clay or muck soils that were irrigated to maintain good growing conditions, there was no increase in yield (Table 1), even though both fungicides, when applied to the clay soil (Figure 1), controlled rhizoctonia stem canker. However, in 1966, when water was not applied to relieve a drought in late July, an increase in marketable yield followed the use of Terraclor and of Terraclor Super-X (Table 2). This increase was due to the prevention of second growth, which caused tubers in the control plots to become knobby.

Table 1. Yield of 'Netted Gem' potatoes from irrigated plots on clay and muck soils treated with broadcast applications of Terraclor or Terraclor Super-X in 1965

Soil	Fungicide	Quintozene (lb/acre)	Mean* yield (cwt/acre) Marketable	Total
Clay	Terraclor	22.5	308	342
	Terraclor	45	378	438
	Terraclor	90	312	360
	Terraclor Super-X	30	336	372
	Control		332	372
Muck	Terraclor	22.5	271	328
	Terraclor	45	247	316
	Terraclor	90	272	321
	Terraclor Super-X	22.5	264	332
	Terraclor Super-X	45	258	314
	Terraclor Super-X	90	258	326
	Control		272	344

*Means are not significantly different at the 5% level (Duncan's Multiple Range Test).

Table 2. Yield of 'Netted Gem' potatoes from non-irrigated plots on clay soil treated with broadcast applications of Terraclor or Terraclor Super-X in 1966

Fungicide	Quintozene (lb/acre)	Mean* yield (cwt/acre) Marketable	Total
Terraclor	30	366 a	438
Terraclor	60	384 a	440
Terraclor Super-X	15	342 ab	430
Terraclor Super-X	30	366 a	438
Control		308 b	418

*Means followed by the same letter or no letter are not significantly different at the 5% level (Duncan's Multiple Range Test).

In 1967, soil moisture in the 'Netted Gem' plots was adequate throughout the growing season, and, although both products controlled stem cankers (Figure 1), yield was not affected (Table 3). In plots of 'Warba' in a location where soil moisture was not measured but where low yields (Table 3) indicated adverse growing conditions, broadcast applications of both Terraclor and Terraclor Super-X controlled stem cankers (Figure 1). Small increases in yield of 'Warba' followed the application of both fungicides at rates providing more than 40 lb quintozene/acre (Table 3).

Table 3. Yield of potatoes from non-irrigated plots on clay soil treated with broadcast or row applications of Terraclor or Terraclor Super-X in 1976

Potato variety	Application method	Fungicide	Quintozene (lb/acre)	Mean* yield (cwt/acre) Marketable	Total
Warba	Row	Terraclor Super-X	2.5	118	142
		Terraclor Super-X	5	112	140
		Terraclor Super-X	10	128	150
		Terraclor Super-X	20	124	148
		Control		106	132
	Broadcast	Terraclor	15	106 a	134 a
		Terraclor	30	136 ab	168 bc
		Terraclor	60	154 b	184 b
		Terraclor Super-X	11	124 a	154 ac
		Terraclor Super-X	22	124 a	150 ac
		Terraclor Super-X	44	130 ab	172 b
		Control		110 a	157 ac
Netted Gem	Row	Terraclor	5	384	444
		Terraclor	10	386	448
		Terraclor	20	392	442
		Terraclor Super-X	2.5	392	446
		Terraclor Super-X	5	378	430
		Terraclor Super-X	10	363	418
		Control		388	456
	Broadcast	Terraclor	12.5	462	537
		Terraclor	25	414	514
		Terraclor Super-X	12.5	405	458
		Terraclor Super-X	25	427	499
		Terraclor Super-X	45	423	491
		Control		407	481

*In each group, means followed by the same letter or no letter are not significantly different at the 5% level (Duncan's Multiple Range Test).

Residue analyses

Analyses for quintozene (Table 4) showed that the amount of residue increased as the applied rate/acre increased. Virtually the entire residue, which varied considerably in the 2 years, occurred in the peels. Tubers from plots that received twice the amount required for stem canker control in 1965 contained 0.257 ppm quintozene in the skin and 0.054 ppm in the whole tuber. In 1966, tubers from similar plots contained 0.015 ppm in the skin.

Table 4. Residues of quintozene in potato tubers from plots on clay soil treated for Rhizoctonia control by broadcast applications

Year	Quintozene applied to soil (lb/acre)	Quintozene residue* (ppm) Peel	Peeled potato	Whole potato**
1965	0	0.007	0.005	0.005
	22.5	0.079	0.005	0.019
	45	0.257	0.005	0.054
	90	0.512	0.005	0.101
1966	0	Trace	0.0	
	15	0.004	0.0	
	30	0.007	0.0	
	60	0.015	0.0	

* Average of duplicate samples.

** Calculated from the values obtained for the peel and peeled portions of the samples.

Discussion

This evaluation of Terraclor and Terraclor Super-X shows that quintozene suppresses growth of R. solani and thereby reduced the incidence of stem cankers and tuber-borne sclerotia. The fungicides were more effective on clay than on muck soils, and broadcast applications were superior to row treatments. Quintozene residues were confined almost totally to the peel of the tubers. The actual amount of residue, although small, varied considerably in 2 years. If an official tolerance is established, more work is needed before a safe application rate can be estimated.

The results show that the benefits that accrue from chemical control of R. solani stem cankers on 'Netted Gem' potato are obtainable in British Columbia by the provision of adequate soil moisture throughout the growing season. Further, since tuber-borne sclerotia do not constitute a serious grade defect in this area, it is unnecessary at this time to recommend chemical soil treatment for the control of this fungus.

Acknowledgments

I am grateful to Mr. E.C. Hughes, Assistant in Field Crops, British Columbia Department of Agriculture, for help with soil moisture determinations; to Olin Mathieson Chemical Corporation for supplying the fungicides; to Washington State University for residue analyses in 1965; and to the British Columbia Department of Agriculture for residue analyses in 1966.

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COOPERATIVE SEED TREATMENT TRIALS - 1967[1]

H.A.H. Wallace[2]

Abstract

Sixty seed treatment chemicals were tested for their efficacy in controlling bunt of wheat (Tilletia foetida), covered smut of oats (Ustilago kolleri), covered smut of barley (U. hordei), and seed rots of flax and wheat caused by a complex of soil- and seed-borne microorganisms. The best treatments for control of the three smuts were Ceresan M, Panogen 15B, UniRoyal G 696-75, Merck FV-XI-122A, and Chemagro 14-67 and 15-67. Generally, the emergence of flax and wheat was not increased by seed treatment.

Introduction

In 1967 sixty seed treatment chemicals were tested for their efficacy in controlling common blunt of wheat (Tilletia foetida (Wallr.) Liro), covered smut of oats (Ustilago kolleri Wille), covered smut of barley (U. hordei (Pers.) Lagerh.), and seed rots of flax and wheat caused by a complex of soil- and seed-borne microorganisms.

Materials and methods

Clean seed of 'Red Bobs' wheat (Triticum aestivum L.), naturally smutted seed of 'Vanguard' oat (Avena sativa L.), and naturally smutted seed of 'Plush' barley (Hordeum vulgare L.) were used in field tests. To insure heavy infection, 1 g of the appropriate smut spores was added to each 200 g of seed. 'Marine' flax (Linum usitatissimum L.) and a sample of 'Manitou' wheat of low viability were used for emergence tests to measure phytotoxic action of the chemicals.

The source, product name, and chemical name of the seed treatment materials are given in Tables 1 and 2. Ceresan M, Panogen 15B, and Pandrinox in the Cooperative Test, and Panogen PX and Polyram in the Drillbox Test were included as standards. For both the Cooperative and Drillbox Tests, each chemical was applied to 200 g of seed at the dosages shown in Tables 3 and 4 by shaking the seed and chemical in a glass jar until the seed was uniformly covered. Seed for the Cooperative Test was removed from the jar after 2 days and samples of 200 seeds in paper envelopes were stored in polyethylene bags at 15 C for several weeks prior to seeding. For the Drillbox Test, seed was treated as described and sown within 2 hours.

Both tests were carried out at Brandon, Morden, and Winnipeg. Each experimental plot consisted of a row 12 ft long containing 200 seeds; all rows were planted 9 inches apart and were arranged in a randomized block design. Emergence of flax and 'Manitou' wheat was determined 4 to 6 weeks after seeding, and the percentages of smutty heads, based on counts of 200 heads per row, were recorded after the crop had headed. The results are given as means of 12 replicates, four from each planting site, and the data were subjected to an analysis of variance.

Results and discussion

Bunt infections from the untreated seed in the Cooperative Test were 35%, 20%, and 4% at Brandon, Morden, and Winnipeg, respectively. Although the same seed lot was used in both tests and seeding was done on the same day, the percentage bunt infection in the untreated plots in the Drillbox test was only about half that of the untreated plots in the Cooperative test. However the incidence of smut from untreated oats and barley was similar in the two tests, averaging 8% and 7% in the Cooperative test and 7% and 4% in the Drillbox test. Generally emergence of flax and 'Manitou' wheat was only slightly higher from treated than from untreated seed.

The best treatments for smut control were Ceresan M, Panogen 15B, UniRoyal G696-75 (1 oz/bu), Merck FV-XI-122A (Table 3), Vitavax (Tables 3 and 4), and Chemagro 14-67 and 15-67 (Table 4). Chemagro 4497 + Dexon, and Terracoat gave acceptable control of all three smuts only at the highest dosages used (Table 3). Chemagro 4497 alone, and Merck FV-XI-126A, FV-XI-131A and FV-XI-146A did not control smut. Terraclor (6 oz/bu) and UniRoyal F849-75ST appeared to be phytotoxic to wheat seed, but not to flax.

Acknowledgments

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

[1] Contribution No. 307, Research Station, Canada Department of Agriculture, Winnipeg, Manitoba.

[2] Plant Pathologist.

Table 1. Source, product name, and chemical name of seed treatment materials used in the Cooperative Test

Treatment no.	Source*	Product name	Chemical name
1		Untreated check	
2	Dupont	Ceresan M	7.7% ethyl mercury-p-toluene sulfonanilide
3	Morton	Panogen 15B	3.7 oz/gal methyl mercuric dicyandiamide
4-13	Morton	"EP-"	Identities not available
14	Morton	Pandrinox A	1.32 oz/gal methyl mercuric dicyandiamide plus 2.5 lb/gal aldrin
15-20	Chemagro	4497	bis (1, 2, 2-trichlorethyl) sulfoxide
18-20	Chemagro	Dexon	p (dimethylamino) benzenediazo sodium sulfonate
21-24	UniRoyal	Vitavax	2, 3-dihydro-5-carboxanilido-6-methyl-1, 4-oxathiin
25-26	UniRoyal	G696	2, 4-dimethyl-5-carboxanilido thiazole
27-28	Niagara	Niadual	Identity not available
29	Niagara	Polyram	zinc activated polyethylene thiuram disulfide (applied as slurry)
30-32	Hoechst	2844	Identity not available
33	Niagara	Cufram Z	Identity not available
34-42	Merck	"FV-"	Identity not available
43-45	Olin	Terraclor	quintozene
46-48	Olin	Terraclor Super X	quintozene (2%) + 5-ethoxy-3-trichloromethyl-1, 2, 4 thiadiazole (0.5%)
49-51	Olin	Terracoat	quintozene (2%) + 5-ethoxy-3-trichloromethyl-1, 2, 4 thiadiazole (1.0%)
52	UniRoyal	F849-75ST	2-amino-4-methyl-5-carboxanilido thiazole
53		Untreated check	

* E. I. Dupont de Nemours & Co. Inc., Wilmington, Delaware; Morton Chemical Company, Woodstock, Illinois; Chemagro Corporation, Kansas City, Missouri; United States Rubber Co., Naugatuk, Connecticut; Niagara Brand Chemicals, Burlington, Ont.; American Hoechst Corp., North Hollywood, California; Merck Chemical Division, Hawthorne, New Jersey; Olin-Mathieson Chemical Corp., Agricultural Division, Little Rock, Arkansas.

Table 2. Source, product name, and chemical name of seed treatment materials used in the Drillbox Test

Treatment no.	Source*	Product name	Chemical name
1		Untreated check	
2-11	Green Cross	"SWF-"	Identities not available
12	UniRoyal	Vitavax 10%	2, 3-dihydro-5-carboxanilido-6-methyl-1, 4-oxathiin
13-22	Chipman	"-67"	Identities not available
23-25	Morton	"EP-"	Identities not available
26	Morton	Panogen PX	0.9% methyl mercuric dicyandiamide
27-29	Niagara	Polyram Seed Protectant	53.5% zinc activated polyethylene thiuram disulfide
30	Co-op	Seed Treatment	Identity not available
31	Co-op	Dual Purpose Treatment	Identity not available
32	Niagara	Polyram Dual Purpose	Polyram + 16.7% aldrin
33-34	Chipman	"-67"	Identities not available
35		Untreated check	

* Green Cross Products, Montreal, P. Q.; United States Rubber Co., Naugatuk, Connecticut; Chipman Chemical Limited, Hamilton, Ontario; Morton Chemical Company, Woodstock, Illinois; Niagara Brand Chemicals, Burlington, Ontario; Interprovincial Co-operatives Limited, Winnipeg, Manitoba.

Table 3. Results of cooperative seed treatment trials

Treatment no.	Product name and Formulation*		Dosage (oz/bu)		Smutted heads**(%)			Emergence(%)	
			Cereals	Flax	Bunt	Oat smut	Barley smut	Flax	Wheat
1	Untreated check				17.77	7.13	6.80	75.2	21.4
2	Ceresan M	WP	0.50	1.00	0.13	0.13	0.17	83.7	24.4
3	Panogen 15B	Sn	0.75	1.50	0.00	0.00	0.29	81.9	25.2
4	EP-277	WP	1.00	1.00	0.63	0.80	2.23	77.8	22.4
5	EP-277	WP	2.00	2.00	0.04	0.87	2.31	82.8	27.3
6	EP-277	WP	3.00	3.00	0.50	0.47	1.21	82.2	21.3
7	EP-277 (40%)	Sn	1.00	1.00	1.30	2.04	2.17	78.3	23.2
8	EP-277 (40%)	Sn	2.00	2.00	1.10	0.63	2.33	76.5	27.8
9	EP-277 (40%)	Sn	3.00	3.00	0.17	1.27	1.90	76.0	25.0
10	EP-368	D	1.50	1.50	0.00	0.73	0.88	78.6	25.1
11	EP-368	D	3.00	3.00	0.00	0.51	0.79	78.0	27.1
12	EP-369	D	1.50	1.50	0.33	0.95	1.04	73.3	21.7
13	EP-369	D	3.00	3.00	0.13	0.73	1.14	76.3	24.4

Table 3 (continued)

Treatment no.	Product name and Formulation*		Dosage (oz/bu) Cereals	Dosage (oz/bu) Flax	Smutted heads**(%) Bunt	Smutted heads**(%) Oat smut	Smutted heads**(%) Barley smut	Emergence(%) Flax	Emergence(%) Wheat
14	Pandrinox	Sn	2.50	2.50	0.17	1.01	0.13	77.1	25.5
15	Chemagro 4497 (50%)	WP	0.30	0.60	8.33	3.23	4.38	59.6	19.9
16	Chemagro 4497 (50%)	WP	0.60	1.20	7.25	1.92	2.19	62.9	20.7
17	Chemagro 4497 (50%)	WP	1.20	2.40	2.38	0.21	1.18	59.2	20.7
18	Chemagro 4497 +	WP	0.30	0.60	0.17	3.00	3.67	71.2	19.1
	Dexon (70%)	WP	0.20	0.40					
19	Chemagro 4497 +	WP	0.60	1.20	0.33	0.68	1.27	68.4	20.8
	Dexon (70%)	WP	0.42	0.84					
20	Chemagro 4497 +	WP	1.20	2.40	0.04	0.08	0.33	65.5	22.8
	Dexon (70%)	WP	0.84	1.68					
21	Vitavax 75	W	2.00	2.00	0.08	0.04	0.08	74.4	19.3
22	Vitavax 75	W	4.00	4.00	0.13	0.00	0.25	72.9	17.6
23	Vitavax Conc.	L	1.25	1.25	0.00	0.04	0.13	71.9	17.2
24	Vitavax Conc.	L	2.50	2.50	0.00	0.00	0.00	74.6	19.7
25	G696-75	WP	0.50	1.00	1.04	0.00	0.21	64.2	16.4
26	G696-75	WP	1.00	2.00	0.08	0.13	0.00	68.7	16.5
27	Niadual MP	L	2.00	4.00	2.03	1.18	0.75	76.3	26.0
28	Niadual Conc.	L	0.75	1.50	0.84	0.93	0.50	74.1	23.9
29	Polyram - 80	WP	2.00	4.00	0.17	0.44	0.24	76.5	20.2
30	Hoechst 2844	D	1.50	3.00	1.67	1.97	5.04	65.4	18.6
31	Hoechst 2844	D	2.00	4.00	1.20	1.78	2.66	67.0	18.4
32	Hoechst 2844	D	2.50	5.00	0.88	0.96	1.48	64.5	18.5
33	Cufram Z 80	WP	2.00	4.00	0.00	0.67	0.25	74.7	18.7
34	FV-XI-122A	D	3.00	5.00	0.00	0.13	0.08	81.6	19.5
35	FV-XI-127A	D	4.00	7.00	0.00	2.66	1.53	62.2	15.1
36	FV-XI-124A	D	3.00	6.00	0.13	0.67	0.25	80.0	21.7
37	FV-XI-123A	D	2.00	4.00	0.17	0.90	1.54	67.3	13.7
38	FV-XI-128A	D	3.00	6.00	0.00	0.67	0.13	78.7	22.3
39	FV-XI-126A	D	4.00	8.00	3.80	1.26	0.83	74.8	16.3
40	FV-129A	D	4.00	8.00	0.00	3.42	4.32	66.8	10.7
41	FV-XI-131A	L	4.00	8.00	10.19	5.55	8.57	64.1	12.6
42	FV-XI-146A	L	4.00	8.00	2.71	3.73	6.96	61.9	13.4
43	Terraclor	L	2.00	2.00	0.13	4.70	2.58	65.6	12.5
44	Terraclor	L	4.00	4.00	0.00	2.47	0.50	66.5	14.4
45	Terraclor	L	6.00	8.00	0.00	1.12	0.38	61.2	9.7
46	Terraclor Super X	L	2.00	2.00	0.00	5.23	4.20	69.6	18.0
47	Terraclor Super X	L	4.00	4.00	0.00	2.12	0.47	64.6	15.9
48	Terraclor Super X	L	6.00	8.00	0.04	0.93	0.63	65.3	15.9
49	Terracoat	L	2.00	2.00	0.04	4.16	2.83	67.5	16.5
50	Terracoat	L	4.00	4.00	0.00	2.23	1.04	66.4	16.2
51	Terracoat	L	6.00	6.00	0.00	0.45	0.38	64.3	17.0
52	F849-75ST	WP	2.50	2.50	0.54	0.13	0.08	66.0	9.0
53	Untreated check				21.61	8.08	7.08	73.9	19.9
LSD (5%)					9.25	1.85	1.75	8.4	5.0

* Formulation code: D = dust; L = liquid; Sn = solution; WP = wettable powder

** Mean of 200 heads grown in field plots at Brandon, Morden, and Winnipeg.

Table 4. Results of drillbox seed treatment trials

Treatment no.	Product name and Formulation	Dosage (oz/bu)		Smutted heads (%)*			Emergence (%)	
		Cereals	Flax	Bunt	Oat smut	Barley smut	Flax	Wheat
1	Untreated check			10.00	6.70	4.37	68.2	10.8
2	SWF 510	2.0	4.0	0.00	0.50	0.04	73.3	14.5
3	SWF 520	2.0	4.0	0.13	0.79	0.13	73.5	15.8
4	SWF 530	2.0	4.0	0.00	0.17	0.17	79.5	13.5
5	SWF 540	2.0	4.0	0.00	0.79	1.43	82.9	16.5
6	SWF 550	2.0	4.0	0.00	0.50	0.75	73.1	17.4
7	SWF 560	2.0	4.0	0.00	0.46	0.08	71.3	16.2
8	SWF 570	2.0	4.0	0.00	0.17	0.04	72.4	15.2
9	SWF 580	2.0	4.0	0.04	0.54	0.08	75.9	16.3
10	SWF 610	2.0	4.0	0.08	0.87	1.03	75.3	13.2
11	SWF 3944 x (3-2-4)	2.0	4.0	0.00	1.00	0.58	74.2	16.9
12	Vitavax 10%	8.0	8.0	0.33	0.00	0.00	67.4	9.0
13	10-67	1.5	3.0	0.00	0.79	0.21	74.6	12.7
14	10-67	2.0	4.0	0.08	0.54	0.04	71.7	12.4
15	11-67	2.0	4.0	0.00	0.38	0.13	75.3	14.5
16	14-67	4.0	8.0	0.04	0.00	0.00	72.0	12.9
17	15-67	4.0	8.0	0.04	0.00	0.00	67.9	12.0
18	17-67	2.0	4.0	0.82	0.54	0.88	74.8	16.5
19	18-67	3.0	6.0	0.00	0.50	0.04	69.1	11.7
20	19-67	2.0	4.0	0.04	1.63	0.00	75.0	13.0
21	26-67	2.0	4.0	0.08	1.08	0.04	71.1	15.0
22	27-67	2.0	4.0	0.00	0.67	0.13	74.1	12.5
23	EP-277 WP	2.0	4.0	0.33	0.49	0.13	72.8	15.0
24	EP-368	2.0	4.0	0.00	1.05	1.02	67.9	12.3
25	EP-369	2.0	4.0	0.04	1.13	0.92	70.3	12.5
26	Panogen PX	2.0	4.0	0.08	0.33	1.21	73.9	13.1
27	Polyram	1.0	2.0	0.00	1.52	0.21	69.6	13.6
28	Polyram	2.0	4.0	0.00	0.83	0.08	75.8	15.1
29	Polyram	3.0	6.0	0.00	0.40	0.21	76.4	12.3
30	S. P.	2.0	4.0	0.17	0.29	0.04	76.1	15.0
31	D. P.	2.0	4.0	0.54	1.13	1.30	66.1	15.4
32	Polyram DP	3.0	6.0	0.00	0.83	0.17	74.1	14.2
33	12-67	2.0	4.0	0.04	1.37	1.63	75.0	18.2
34	13-67	2.0	4.0	0.00	2.21	3.25	79.5	15.8
35	Untreated check			9.36	7.30	4.59	67.6	10.6
LSD (5%)				3.00	1.87	1.47	10.7	5.1

* Means of 200 heads grown in field plots at Brandon, Morden, and Winnipeg.

CLOVER VIRUSES IN EASTERN CANADA IN 1967[1]

Michael J. Pratt[2]

Abstract

A limited survey of clover fields in Ontario, Quebec and the Maritime provinces in June, 1967, showed the presence of eight identifiable viruses, some widespread and others localized. Pea streak virus was the most commonly found virus in red clover (Trifolium pratense) stands, followed by red clover vein mosaic, bean yellow mosaic and pea mosaic viruses. Clover phyllody virus was the important virus of red, white (T. repens) and alsike (T. hybridum) clovers in Prince Edward Island, but its incidence decreased in fields westward to central Quebec. Clover yellow vein virus, which was recently described in England, was found occasionally in clovers in Quebec, New Brunswick and Prince Edward Island. Alfalfa mosaic and white clover mosaic viruses were sporadically present in most of the areas surveyed. Although none of the viruses could be considered a prime limiting factor in yield and maintenance of clover, losses were evident in some areas and the infected clovers provide a source of infection for annual legumes.

Introduction

Recent surveys of forage legume diseases in Quebec (1) and Prince Edward Island (7) have indicated the presence of virus diseases, but with the exception of clover phyllody the viruses were not identified. In Wisconsin six virus diseases were found in red clover (3). In decreasing order of prevalence these were: red clover vein mosaic, pea mosaic, bean yellow mosaic, Wisconsin pea streak, alsike clover mosaic and alfalfa mosaic viruses.

The present survey was undertaken in order to identify the main viruses infecting clover in Eastern Ontario, Quebec and the Maritime provinces.

Materials and methods

Red clover (Trifolium pratense L.) was the main species examined, followed by white clover (T. repens L.), alsike clover (T. hybridum L.), and sweetclover (Melilotus spp.).

Fields were surveyed during early June in areas where clover is an important crop. The incidence of virus diseases in and around the fields was estimated from symptoms, and sample plants were taken to identify the viruses present. The viruses were identified by their host range and symptoms produced on a series of inoculated test plants, by electron microscopic examination of virus particles, and by serology. The test plants used were Chenopodium amaranticolor Coste & Reyn., Gomphrena globosa L., Nicotiana tabacum L. 'Haranova', Pisum sativum L. 'Lincoln', Phaseolus vulgaris L. 'Black Turtle', and Vicia faba L. Some inoculations were made to Nicotiana clevelandii Gray, Phaseolus vulgaris L. 'Top Crop', Pisum sativum L. 'Little Marvel' and Trifolium incarnatum L. Virus particles were obtained from cut leaves by the dip method. Serological identifications were made by the precipitin test on clarified sap. The author is grateful to Dr. R. E. Ford, Iowa State University, for antisera against pea streak virus (PSV) and red clover vein mosaic virus (RCVMV) and to Dr. M. Hollings, Glasshouse Crops Research Institute, Rustington, England for antiserum against clover yellow vein virus (CYVV). Antisera against other viruses were produced in this laboratory.

Results and discussion

Regional differences in the distribution of clover viruses are evident (Tables 1-5). Pea streak virus (PSV) is widespread in red clover in the Ottawa Valley in Ontario and along the St. John Valley in New Brunswick, but is less common in Quebec and southern Ontario and was not found in Prince Edward Island. Moderate stunting of clover plants infected with PSV was evident in southern New Brunswick but in other areas the growth was not noticeably affected. This virus can reduce the yields of peas (6), and infected clover serves as a source of inoculum.

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Table 1. Clover viruses found in Ontario

Location	Culture	Estimated age (yr)	Clover* host	Viruses**	Index of occurrence ***
Ottawa	hay	2	red	PSV, BYMV	2
	roadside		red	PSV	nq
South March	hay	2	red	PSV, PMV	3
Arnprior	roadside		red	PSV, BYMV	nq
Renfrew	hay	2	red	PSV	2
Pembroke	hay	1	red	PSV	1
Havelock	hay	5	red	BYMV, PSV	3
Brampton	hay	1	red, sweet-clover	BYMV	1
Brampton	hay	3	red	PSV	2
Peterborough	hay	1	red	BYMV	1
Peterborough	hay	2	red	BYMV	2
Hamilton	hay	4	white	PSV, RCVMV	2
Hamilton	hay	2	red, white	PSV	1
Haldimand Co.	hay	1	red	PMV	1
Haldimand Co.	roadside		red	BYMV, PSV	nq
Niagara Falls	lawn		white	WCMV	nq

The following footnotes are applicable to Tables 1 to 5:

* Red = Trifolium pratense, white = T. repens, alsike = T. hybridum, sweet = Melilotus spp.

** AMV = alfalfa mosaic virus, BYMV = bean yellow mosaic virus, CPV = clover phyllody virus, CYVV = clover yellow vein virus, PMV = pea mosaic virus, PSV = pea streak virus, RCVMV = red clover vein mosaic virus, WCMV = white clover mosaic virus.

*** The frequency of plants with virus symptoms is indicated as follows: 1 = less than 1%, 2 = 1-5%, 3 = 5-25%, 4 = more than 25%, nq = not quantitative.

Table 2. Clover viruses found in Quebec

Location	Culture	Estimated age (yr)	Clover host	Viruses	Index of occurrence
Macdonald College	hay	2	red	PSV	2
St. Hyacinthe	roadside		white	CYVV	nq
Victoriaville	hay	3	white, red alsike	RCVMV	2
	roadside		white	CPV	nq
Larochelle	hay	1	white, red alsike	0	
Gentilly	hay	4	red	BYMV, CYVV, RCVMV	2
Lotbinière	pasture	5+	white	AMV, WCMV	4
	hay	2	white	WCMV	1
St. Antoine	pasture	5	white	CYVV	2
Montmagny	hay	1	red	0	
			white	CPV	1
Montmagny	hay	3	red, white	AMV, RCVMV	2
				CPV	2
St. Augustin	hay	3	red, white	AMV	1
(Laval farm)	hay	1	red, alsike	CPV, CYVV	1
La Pocatière	hay	3	red	PSV	2
(CDA farm)			white	CYVV	1
			red, white	RCVMV	2
			white	CPV	1

Clover phyllody virus was widespread in Prince Edward Island, where it could be seen to be a limiting factor in stand maintenance in some fields. In northern Nova Scotia and in southern New Brunswick it was less of an economic factor but was present in most of the fields surveyed. The virus was uncommon in the parts of Quebec surveyed although it is known to be common in the Lac St. Jean area. It was not found in Ontario.

Common white clover with an unusual chlorotic blotching of the leaves was collected near St. Hyacinthe, Quebec, and from the vicinity of the CDA Research Station, Fredericton, New Brunswick. Inoculation of the test plants gave host reactions which were similar to those described for clover yellow vein virus (CYVV) in England (2, 4). Virus particles from leaves infected with these isolates were flexuous rods about 750 mμ long, which corresponds to length determined for CYVV by Gibbs et al. (2). Antiserum against CYVV obtained from Dr. M. Hollings reacted positively with the Canadian isolates. Typical bean yellow mosaic virus (BYMV) and pea mosaic virus (PMV) isolates obtained in the

Table 3. Clover viruses found in New Brunswick

Location	Culture	Estimated age (yr)	Clover host	Viruses	Index of occurrence
Moncton	hay	5+	red, alsike	PSV	2
			red	RCVMV, CPV	2
Petitcodiac	hay	1	red, alsike	PSV	1
				CPV	3
Sussex	hay	1	red	CPV	1
Cambridge	hay	5+	red	RCVMV	1
			red, white	PSV	2
Fredericton (CDA station)	hay	1	red	PSV	2
	roadside		alsike, white	CPV	3
				CYVV	3
Hartland	hay	4	red	CPV	2
				PSV	1
Perth	hay	3	alsike, red	PSV	3
			red, white	CPV	2
Centreville	hay	3	red, white	PSV	4
				CPV	3
Centreville	hay	1	red	CPV	1

survey have some similar host reactions to CYVV and a similar particle length, but they did not react with the CYVV antiserum. It is possible that CYVV has been collected in North America before, but has been called BYMV or PMV. A virus isolated from beans in Idaho resembled CYVV in infecting white clover and in producing chlorotic blotch local lesions on tobacco (5). It was called a strain of BYMV but it did not cross-protect from other strains of the virus.

BYMV, PMV and RCVMV were found in red clover in many of the areas surveyed. RCVMV was also found occasionally in white clover. Yield reductions due to infection by these viruses were minor, but aphid transmission to peas and beans could be economically important. Alfalfa mosaic virus was sparsely distributed, occurring mainly in white clover in old stands or in the vicinity of alfalfa fields. White clover mosaic virus, which does not

Table 4. Clover viruses found in Nova Scotia

Location	Culture	Estimated age (yr)	Clover host	Viruses	Index of occurrence
Westville	hay	2	red, white	RCVMV, CPV	1
Truro	lawn		white	WCMV	nq
	roadside		white	WCMV, CPV	nq
Truro	pasture	5	white	unident.	nq
	hay	3	red	0	
Glenholme	hay	5	red, white	CPV	2
Glenholme	hay	1	red	CPV	1
Glenholme	hay	1	red	CPV	1
Wentworth Centre	hay	1	red	PMV, PSV	1
Wentworth C.	hay	2	red	CPV	2
Oxford	hay	1	red	CPV	1
Springhill	pasture	5	alsike	unident.	1
			red	PSV	1
Amherst	hay	5	red	0	
Amherst	hay	1	red	PMV	1

appear to have an insect vector but which is easily transmitted mechanically, was found mainly in white clover in lawns, pastures and on roadsides.

Acknowledgments

The author is indebted to Dr. C. C. Chi, Ottawa; Dr. C. Aubé, CDA, Laval University; Dr. R. H. E. Bradley, Fredericton, N. B., and Dr. C. B. Willis, Charlottetown, P. E. I., for their assistance in the survey. The technical assistance of Mrs. A. C. Buckley is gratefully acknowledged. Mrs. M. J. Veto is to be thanked for the examination of the leaf dips in the electron microscope.

Table 5. Clover viruses found in Prince Edward Island

Location	Culture	Estimated age (yr)	Clover host	Viruses	Index of occurrence
Charlottetown (CDA station)	hay	1	red, white	AMV	2
	pasture	5+	white	CYVV	nq
Green Gables	lawn		white	WCMV	nq
Cavendish Beach	roadside		white	RCVMV	nq
Cavendish	hay	2	red	CPV	4
				RCVMV	1
Summerside	hay	1	red	CPV	3
Central Bedeque	hay	1	red, alsike	CPV	1
Bonshaw	hay	1	red	CPV	1
Upton (CDA farm)	hay	2	red, alsike	CPV	3
			white	AMV	2
			red	unident.	1
Vernon	hay	3	red	CPV	4
Flat River	hay	1	red	CPV	2

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SUSCEPTIBILITY OF STRAWBERRY VARIETIES TO RED STELE DISEASE[1]

C.O.Gourley[2] and D.L.Craig[3]

Abstract

The susceptibility of 23 strawberry varieties and one selection to red stele disease caused by Phytophthora fragariae was determined under field conditions. No variety or selection was found to be immune to the disease. All plants of 'Redcoat' and 'Sparkle', two of the most commonly grown commercial varieties, were killed by this disease. 'Guardsman' and 'Sunrise' exhibited more tolerance to red stele than any of the other varieties.

Introduction

In Nova Scotia the occurrence of red stele, caused by the fungus Phytophthora fragariae Hickman, has been sporadic in strawberry plantings. The disease was first noted in 1945 and the first general infection occurred in 1948. Red stele epidemics appear to be correlated with climatic conditions since there have been intervals of up to 4 years between reports of this disease in commercial plantings. In 1961, the authors found that several races of P. fragariae were present in Nova Scotia soils (unpublished results).

The most characteristic symptom of the disease is the red color of the core or stele of strawberry roots. Anderson (1) reported that no other disease or condition has been found which gives this red core symptom. Red stele is most evident from the start of growth in the spring until a week or two after harvest. Infected roots may appear healthy, except that they have a grayish cast and a rat-tail appearance, with few lateral rootlets. Some roots may have brown tips where the tissue has started to die. Often the first evidence of the disease is wilting of plants, especially in the lower areas of a planting, about the time the fruit begins to ripen. An examination of the roots of the wilting plants invariably confirms the presence of the red stele organism. After harvest most of the diseased roots are decayed, and generally there is no evidence of the disease on roots that remain alive.

In 1968, red stele was particularly severe in strawberry plantings at the Research Station, Kentville. The 1967 season was characterized by a cool, wet spring and a summer with higher than normal rainfall. These conditions apparently provided an ideal environment for the development and spread of P. fragariae throughout the plantings. Summer soil temperatures at Kentville are generally within the 18-22C optimum for growth of P. fragariae.

Materials and methods

Observations on varietal susceptibility were taken from strawberry plants in two fields, each of approximately 2 acres. Both fields were thoroughly infested with P. fragariae, infected plants having been found throughout each of them. Twelve plant plots of each variety, replicated 2 or 3 times, were set out in 1967 and allowed to form a matted row. These were rates for plant stand in May, and at harvest in July, 1968. In May, the roots of 10 plants dug at random from each plot of each variety were examined for red stele. A plant was considered to be infected if red stele was found in one or more roots.

Results and discussion

The varieties 'Guardsman', 'Midway', 'Red Gauntlet' 'Sparkle', 'Talisman', and 'Templar' have been reported to be resistant to one or more races of P. fragariae (2, 3). Here no strawberry variety was immune to red stele (Table 1). 'Redcoat' and 'Sparkle', two of the most commonly grown commercial varieties, showed no resistance to infection by P. fragariae and all plants died prior to harvest. The variety 'Midway' exhibited no resistance as all plants succumbed to red stele. More plants of 'Talisman' and 'Templar' were infected with red stele than those of 'Red Gauntlet'. 'Guardsman'aand 'Sunrise' exhibited more tolerance to this disease than any other variety. The 'Guardsman' plots did not excape infection in any replicate because adjacent plots of 'Gorella', 'Redcoat', 'Talisman' and 'Vesper' were infected or killed. Similarly, 'Sunrise' was bounded by plots of diseased 'Fulton', 'Garnet' and 'Revada'.

The breeding of resistant varieties, which has been complicated by the occurrence of races of P. fragariae, offers the only practical control of this disease (4). In areas where sporadic epidemics of red stele occur, commercial plantings should be of varieties which have a high degree of tolerance to red stele disease.

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Table 1. Susceptibility of strawberries to red stele, 1968

Variety	Origin	Plant stand* May 15	Plant stand* July 8	Percentage of plants with infected roots, May 15
Acadia	CDA	+++	+++	100
Elista	Holland	++	++++	100
Fresno	California	++	+++	100
Fulton	New York	++	++++	100
Garnet	New York	+++	++++	100
Gorella	Holland	++	++++	100
Guardsman	CDA	+	+	83
Juspa	Holland	+	++++	100
Midway	USDA	+++	++++	100
Raritan	New Jersey	+++	++++	100
Redcoat	CDA	++	++++	100
Red Gauntlet	Scotland	+	+++	87
Revada	Holland	+++	++++	100
Senga Sengana	Germany	++	+++	93
Solana	California	++	++++	100
Sparkle	New Jersey	++	++++	97
Sunrise	USDA	+	+	40
Talisman	Scotland	++	++	97
Templar	Scotland	++	++	100
Tioga	California	++	+++	100
Veestar	Ontario	+++	++++	100
Vesper	New Jersey	+++	++++	90
Vibrant	Ontario	+	++++	100
Alberta 57-108	CDA	+	++	100

* + = 0-$\frac{1}{4}$ of the plants dead; ++ = $\frac{1}{4}$-$\frac{1}{2}$; +++ = $\frac{1}{2}$-$\frac{3}{4}$, and ++++ = more than $\frac{3}{4}$ of the plants dead.

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FUNGAL AND BACTERIAL DISEASES OF CRUCIFERS AND CUCURBITS[1] IN WESTERN ONTARIO IN 1967

A.A.Reyes, G.H.Comly, L.F.Mainprize, D.A.Pallet, C.A.Warner, and W.A.Willows[2]

Surveys of the diseases of vegetable crops in southern, eastern and central Ontario in 1968 were published by Reyes et al. (1, 2). A similar survey was carried out in Western Ontario, but this report deals only with the diseases of crucifiers and cucurbits in this region.

Table 1. Diseases of crucifers and cucurbits in western Ontario in 1967

Crop	Disease and cause	Prevalence* and county
Crucifers		
Cabbage	Black rot (Xanthomonas campestris)	Sl. 1/7** fields (Halton)
	Clubroot (Plasmodiophora brassicae)	Mod. 1/7 fields (Halton)
	Wirestem (Rhizoctonia solani)	Tr. 1/1 field (Grey) sl. 1/1 field (Peel)
	Yellows (Fusarium oxysporum f. conglutinans)	Sl.-sev. 3/7 fields (Halton), tr. 1/1 field (Peel)
Cauliflower	Damping-off (Pythium spp., Rhizoctonia solani, Fusarium spp.)	Tr. 1/5 fields (Halton)
	Drop (Sclerotinia sclerotiorum)	Sl. 1/5 fields (Halton)
	Yellows (Fusarium oxysporum f. conglutinans)	Sl. 1/5 fields (Halton)
Cucurbits		
Cucumber	Angular leaf spot (Pseudomonas lachrymans)	Mod. 1/3 fields (Huron), sev. 1/1 field (Simcoe)
	Bacterial wilt (Erwinia tracheiphila)	Tr. 2/3 fields (Huron), Sev. 1/1 field (Simcoe)
	Wilt (Fusarium spp.)	Sl. 1/2 fields (Halton)
Muskmelon	Leaf blight (Alternaria cucumerina)	Sl. 1/1 field (Halton)

* Tr. (trace) = 1-10% of plants affected in the field; sl. (slight) = 10-30%; mod (moderate) = 30=60%; sev. (severe) = 60=100%.

** Number of fields in which the disease was found/number of fields inspected.

The counties surveyed were Grey, Halton, Huron, Peel, and Simcoe. The diseases were diagnosed and rated as in the two earlier reports (1, 2). Bacteria were identified on the basis of their growth on agar media and by the symptoms they caused on the host plants.

Cabbage had the highest number of diseases and muskmelon the lowest (Table 1). Most of the diseases were caused by fungi. With the exception of cucumber wilt caused by Fusarium spp., all the diseases encountered were reported in the other surveys (1, 2).

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IDENTIFICATION OF RACES OF PSEUDOMONAS PHASEOLICOLA FROM QUEBEC BEAN FIELDS[1]

V.R. Wallen[2]

Abstract

Races 1 and 2 of Pseudomonas phaseolicola were isolated from green beans (Phaseolus vulgaris) grown near Ste. Martine, Quebec in 1966. The races were identified on the basis of their pathogenicity on 'Red Mexican UI No. 3'. Twenty-six of the pathogenic isolates tested were of race 2, and four were of race 1.

Until recently bean seed produced in the semi-arid western United States, particularly in Idaho, has been free from the halo blight organism Pseudomonas phaseolicola (Burkh.) Dows. Similarly, halo blight has occurred rarely in California, where the annual rainfall is low and splash dispersal is at a minimum. However, in 1961, 1962, and 1963, the quality of seed produced in Idaho was impaired because of infection by P. phaseolicola. The incidence of the disease also increased in seed crops grown in 1965 and 1966 in California, where overhead sprinkler irrigation caused considerable splash dispersal. Furrow-irrigated fields planted with seed from the same source showed a very low incidence of disease (2). With the advent of an epiphytotic of halo blight in areas formerly regarded as excellent for the production of disease-free seed, studies relating to the identity of the organism in the seed were initiated. The presence of two physiologic races was determined (9), and serological reactions have been studied (3, 4).

Most of the bean seed used to produce canning, freezing, and field bean crops in Canada is grown in Idaho and California. Field surveys have revealed that the bacterial blight pathogens (Xanthomonas phaseoli and Xanthomonas phaseoli var. fuscans are frequently present in the field bean crop in Ontario (7, 10). Halo blight, however, has been found only occasionally, (8). In 1966, an epiphytotic of halo blight was present in the Ste. Martine area of Quebec where extensive acreages of beans are grown for canning. The seed used to produce this crop was grown in Idaho. Because two races of halo blight have been described in the United States (9) and Europe (1), experiments were set up to identify the races occurring in Quebec.

Materials and methods

Isolations were made from blighted leaves collected from green bean (Phaseolus vulgaris L.) fields in the Ste. Martine area of Quebec in 1966. The leaves were cut into 5 mm sections, which were surface sterilized for 2 minutes in 2% sodium hypochlorite solution, plated on nutrient agar in 90 mm disposable petri dishes, and incubated at 27C. Forty-seven Pseudomonas-like cultures were obtained in this manner and were grown on slants of yeast-dextrose-carbonate agar. Cultures of races 1 and 2 were obtained from Dr. J. Natti, New York Agricultural Experimental Station, Geneva, and were used for comparative purposes in all tests.

For the identification of races 1 and 2, several methods were examined and the following two were selected:

'Red Mexican UI No. 3' and 'Kinghorn Wax' plants were grown from seed in pots of soil in a growth chamber maintained at 20C and 94% relative humidity, and providing 1250 ft-c of fluorescent and incandescent light for 16 hr/day. Two-week-old plants were inoculated by atomizing an aqueous bacterial suspension onto the underside of the unifoliate leaves. After 2-3 weeks, the plants were examined for symptoms of halo blight.

In the second method, pods at the edible stage were surface sterilized for 2 min in a solution of sodium hypochlorite. Three pods of each variety were inoculated with each isolate by touching the tip of a sterilized dissecting needle onto a 24-hr-old agar slant culture of the organism, and then pricking the pod at a number of locations (Fig. 1). The inoculated pods were placed on moist filter paper in uncovered 150 ml petri dishes and maintained in a growth chamber under environmental conditions

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similar to those used in the first method. Pods were examined for symptoms of halo blight after two weeks.

Results and discussion

In preliminary tests with the spray inoculation method, considerable difficulty was encountered in distinguishing races 1 and 2 on the basis of the resistance and susceptibility of the variety 'Red Mexican UI No. 3'. However, after familiarization with the technique and repeated inoculations, the various isolates could be designated as belonging to races 1 or 2.

The pod inoculation tests were easier to interpret. Differences in the size of lesions were attributed to differences in the virulence of isolates belonging to the same race. Susceptible and resistant reactions were easily distinguishable on 'Red Mexican UI No. 3', because of the large diffuse-type of lesion produced by race 2 (Fig. 1c).

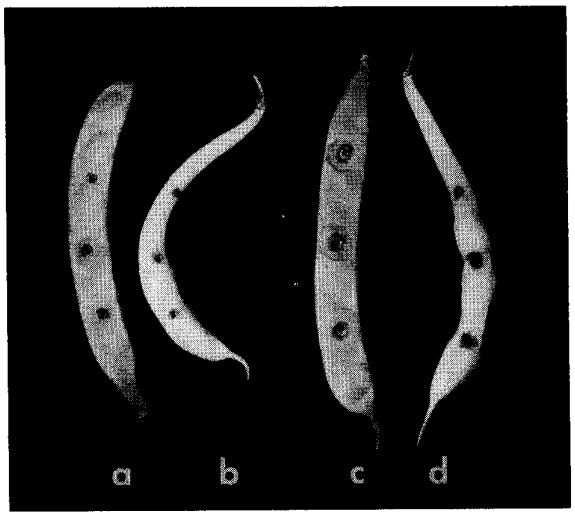

Figure 1. Differentiation of races 1 and 2 of *Pseudomonas phaseolicola* by pod inoculation. Race 1 reaction: (a) 'Red Mexican UI No. 3', resistant; (b) 'Kinghorn Wax', susceptible. Race 2 reaction: (c) Red Mexican UI No. 3', susceptible; (d) 'Kinghorn Wax', susceptible.

Of the 47 isolates tested, 26 were of race 2, four of race 1, and 19 isolates failed to produce symptoms of either 'Kinghorn Wax' or 'Red Mexican UI No. 3'. The prevalence of race 2 is in agreement with the findings of Guthrie and Fenwick (5). who showed that of 20 isolates of Idaho origin 17 belonged to race 2. Epton and Deverall (1) showed that of 7 isolates of P. phaseolicola from Europe and Africa, 4 were classified as race 1, and 3 as race 2. Patel and Walker (6) demonstrated that most isolates of foreign origin were of race 1, whereas all isolates from Wisconsin were of race 2.

Because the seed planted at Ste. Martine was grown in Idaho, where race 2 is believed to have originated (5), it is not surprising that the majority of the isolates from Quebec were of race 2. This study illustrates the ease by which races of pathogenic organisms can be distributed from country to country by seed and establishes the presence of both races 1 and 2 of Pseudomonas phaseolicola in Canada.

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CROWN RUST OF OATS IN CANADA IN 1968[1]

George Fleischmann[2]

Disease development and crop losses in Western Canada

Oat crown rust caused by Puccinia coronata Cda. f. sp. avenae Eriks. was first found in the vicinity of Morden, Manitoba, on July 22nd. This disease increased in intensity in the Red River Valley and westward in Manitoba during the remainder of the summer. The occurrence of crown rust was general on oats as far west as Yorkton, Saskatchewan. Crown rust development in Western Canada in 1968 was the heaviest in recent years due to favourable moisture conditions and the prolonged cool growing season.

Yield reductions from oat crown rust were negligible in experimental plots if disease development did not precede heading (1). In farm fields in 1968 damage was appreciable, although disease development did not occur until after heading. This late attack caused losses because of the unusually cool season that delayed maturity of the crop while encouraging rust development. Thus losses of 20 to 27 bushels per acre due to crown rust were observed in experimental plots despite the fact that the disease did not reach serious proportions on the crop till after heading.

Disease ratings in the nurseries

Ratings of crown rust intensity on 10 oat varieties grown at nurseries in Manitoba, Ontario, and Quebec are presented in Table 1. Omitted from this table are nurseries in which no crown rust was found on any of the 10 oat varieties, as well as nurseries from which rust intensity could not be estimated because of the mildewed or shrivelled condition of the leaves.

The intensity of crown rust infection from the Manitoba nurseries reflects conditions prevailing during the first part of August. Crown rust severity subsequently increased to 60-100% on most commonly grown varieties. The readings on material from nurseries in Ontario and Quebec were also taken fairly early in the season. Considerable infection was already noticeable, however, on oats grown in the vicinity of dense buckthorn infestations, i.e. the Kemptville, Williamstown, Appleton, and Ottawa nurseries.

Table 1. Percentage infection of crown rust on 10 oat varieties at 14 locations in Canada

Locality	Bond	Trispernia	Landhafer	Ceirch du Bach	Saia	Rodney ABDH	C. I. 3034	Rodney	Garry	C. I. 4023
Brandon, Man.	20	tr*	5	tr	tr	10	10	20	20	5
Morden, Man.	30	tr	10	tr	tr	20	10	30	30	20
Glenlea, Man.	30	tr	5	0	0	30	5	30	30	30
Verner, Ont.	20	0	0	0	2	5	10	10	10	20
Williamstown, Ont	40	0	0	0	0	10	10	20	30	30
Kemptville, Ont.	30	0	tr	2	5	10	30	20	30	30
Fort William, Ont.	30	tr	5	tr	5	20	10	30	30	30
Ottawa, Ont.	40	0	5	tr	5	10	10	30	20	30
Appleton, Ont.	40	0	0	0	0	30	5	40	40	40
Morewood, Ont.	40	0	tr	0	0	30	5	40	40	30
La Pocatière, Que.	30	0	0	0	0	10	0	20	20	10
Macdonald College, Que.	30	0	tr	0	2	20	20	30	30	30
Lennoxville, Que.	10	0	0	0	0	10	0	10	10	10
L'Assomption, Que.	20	0	0	0	0	30	20	30	30	20

* tr = trace infection, less than 1%

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The 'Rodney ABDH' backcross line containing additional stem rust resistance genes, once again appeared to afford some degree of crown rust resistance. This was reflected by the lower intensity of crown rust on it than on ordinary 'Rodney' at nearly all of the locations where rust occurred.

Nurseries from eastern Saskatchewan were read prior to the development of crown rust in that area.

Distribution of physiologic races

The frequency of occurrence and distribution of 29 physiologic races of crown rust identified from 170 Canadian isolates is presented in Table 2. Despite the occurrence of a considerable number of physiologic races in the west, two of these, 295 and 326, comprised 60% of the isolates identified. These two races predominated in the western crown rust population last year, but to a lesser extent. These races as well as most of the others isolated attacked the differential varieties 'Landhafer' and 'Santa Fe'.

A greater spectrum of physiologic races was identified from isolates made in Eastern Canada. The 'classical' Victoria-virulent races 203, 210, and 216 comprised 60% of the population. In contrast to Western Canada, there was a decrease in the prevalence of races attacking 'Landhafer' and 'Santa Fe' in the east. These races represented only 8% of the eastern crown rust population this year.

Table 2. Distribution of physiologic races of crown rust in Canada in 1968

Physiologic race	West		East		W & E totals	
	Number of isolates	% of all isolates	Number of isolates	% of all isolates	Number of isolates	% of all isolates
202	0	0	1	1.1	1	0.6
203	8	10.4	31	33.4	39	23.4
210	1	1.3	7	7.6	8	4.8
211	0	0	1	1.1	1	0.6
213	0	0	1	1.1	1	0.6
216	2	2.6	17	18.3	19	11.4
226	1	1.3	5	5.4	6	3.6
228	0	0	2	2.2	2	1.2
241	1	1.3	4	4.3	5	3.0
259	1	1.3	3	3.2	4	2.4
264	3	3.9	0	0	3	1.8
274	0	0	1	1.1	1	0.6
275	0	0	1	1.1	1	0.6
276	1	1.3	0	0	1	0.6
283	0	0	1	1.1	1	0.6
290	1	1.3	0	0	1	0.6
295	21	27.3	3	3.2	24	14.4
297	1	1.3	0	0	1	0.6
299	0	0	1	1.1	1	0.6
325	3	3.9	2	2.2	5	3.0
326	25	32.5	3	3.2	28	16.8
332	0	0	2	2.2	2	1.2
333	1	1.3	0	1.1	1	0.6
341	0	0	6	6.5	6	3.6
367	0	0	1	1.1	1	0.6
415	3	3.9	0	0	3	1.8
427	1	1.3	0	0	1	0.6
446	2	2.6	0	0	2	1.2
New race	1	1.3	0	0	1	0.6
Total races	18		20		29	
Total isolates	77		93		170	
Race:isolate ratio	1:4.3		1:4.6			

Table 3. Percentage of Canadian crown rust isolates virulent on differential host varieties in 1966, 1967, and 1968

Location and year	Anthony	Victoria	Appler	Bond	Landhafer	Santa Fe	Ukraine	Trispernia	Bondvic	Saia
Western Canada										
1968	90	48	90	95	82	81	95	10	10	3
1967	72	59	72	89	68	68	80	24	31	13
1966	66	58	62	82	24	23	83	2	2	4
Eastern Canada										
1968	79	40	83	87	8	9	96	2	2	7
1967	47	54	50	86	10	11	95	2	1	13
1966	51	45	30	77	9	9	85	0	0	9

One race with a previously undescribed combination of virulence on the differential varieties was discovered in Canada during the 1968 survey. The resistance formula of this race is: 1, 2, 3, 10.

Virulence on the differential varieties

The virulence of Canadian crown rust isolates on the sources of resistance represented by the differential varieties is presented in Table 3. The situation in Eastern Canada was much the same as in previous years with virulence on 'Anthony' and 'Appler' increasing once again.

In Western Canada virulence on the varieties 'Landhafer' and 'Santa Fe' increased from 24% in 1966 to 68% in 1967 and again increased in 1968 to 82%. The contrast between the virulence of the western crown rust population versus the avirulence of the eastern population (8% in 1968) is striking.

Acknowledgments

I am grateful for assistance given by the cooperators in the care of the rust nurseries and in the collection of crown rust specimens in Eastern Canada. Mr. W.L. Timlick performed the technical operations requisite to the identification of the physiologic races.

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STEM RUST OF OATS IN CANADA IN 1968[1]

J.W. Martens and G.J. Green[2]

Disease development and crop losses in Western Canada

Stem rust of oats caused by Puccinia graminis Pers. f. sp. avenae Eriks. & E. Henn. did not appear in Western Canada in 1968 until most of the oat crop was approaching maturity. Small amounts were first reported on August 27, and light infections developed in late fields in south-eastern Manitoba. Overall losses were negligble.

Uniform rust nurseries

Oat stem rust was scarce in the rust nurseries grown at 33 locations in Canada (Table 1). Rust was observed in only seven of the nurseries, and infections of over 10% were recorded only at Brandon and Winnipeg, Manitoba, and Appleton, Ontario.

Identification and distribution of physiologic races

Physiologic races were identified by the methods used in previous years (1). The virulence formulas, their numbers, and equivalent physiologic race numbers appear in Table 2 with the distribution of the races identified. In Western Canada the race distribution was unchanged from 1967. Race C10 continued to predominate and small amounts of races C3 and C5 were found. In eastern Canada, race C10 occurred in small amounts. In 1967, this race was common in Eastern Canada indicating that barberry eradication had restricted the prevalence of races originating on barberry and permitted race C10 from the south to become relatively more important. The smaller proportion of race C10 in the east in 1968 does not necessarily indicate that this process has changed. It is more likely that the scarcity of oat stem rust in the great plains region of North America in 1968 restricted the spread of race C10. The predominant races in Eastern Canada in 1968 are the same as those that predominated from 1958 to 1966 and were presumed to originate on barberry.

Table 1. Percentage infection by Puccinia graminis f. sp. avenae on 10 oat varieties at seven uniform rust nurseries* in Canada in 1968

Locality	Bond	Trispernia	Landhafer	Ceirch du Bach	Saia	Rodney ABDH	C. I. 3034	Rodney	Garry	C. I. 4023
Brandon, Man.	30	tr**	0	1	0	0	0	2	tr	tr
Winnipeg, Man.	30	30	20	30	tr	tr	tr	20	5	1
Glenlea, Man.	10	10	5	5	tr	tr	tr	2	tr	tr
Appleton, Ont.	60	5	5	10	0	25	1	25	30	5
Morewood, Ont.	0	tr	0	0	0	0	0	0	0	0
Macdonald College, Que.	10	0	0	5	0	5	tr	10	10	0
Lennoxville, Que.	0	0	0	0	0	tr	0	0	0	0

* No rust was observed in 26 other nurseries located at: Agassiz and Creston, B.C.; Beaverlodge, Lacombe and Lethbridge, Alta.; Indian Head, Scott and Melfort, Sask.; Morden, Man.; Verner, Williamstown, Douglas, Alfred, Kapuskasing, Guelph, Kemptville, Fort William, St. Catherines and Ottawa, Ont.; La Pocatière, L'Assomption and Normandin, Que.; Kentville and Truro, N.S.; Fredericton, N.B.; and Charlottetown, P.E.I.

** tr = trace infection.

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Table 2. Distribution by provinces of physiologic races of Puccinia graminis f. sp. avenae isolates in Canada in 1968

Race		Virulence formula (effective/ineffective host genes)		Number of isolates from:				Total isolates	Percentage of total isolates
Formula no.	Former designation	Pg gene designation	Alphabetical gene designation	Sask.	Man.	Ont.	Que.		
C3	7A-12A	2, 8/1, 3, 4, 9	AF/BDEH	1	5	0	0	6	3.8
C5	6F	4, 9/1, 2, 3, 8	BH/ADEF	3	3	0	0	6	3.8
C6	8A-10A	1, 8/2, 3, 4, 9	DF/ABEH	0	0	7	0	7	4.4
C8	4A	3, 8/1, 2. 4, 9	EF/ABDH	0	0	21	1	22	13.9
C9	6A-13A	8/1, 2, 3, 4, 9	F/ABDEH	0	1	37	4	42	26.6
C10	6AF	9/1, 2, 3, 4, 8	H/ABDEF	9	41	20	0	70	44.3
C11	8A	1, 8/2, 3, 4	DF/ABE	0	0	2	0	2	1.3
C17	11A	1, 3, 8/2, 4, 9	DEF/ABH	0	0	3	0	3	1.9
Total				13	50	90	5	158	100.0

All the races found in 1968, except C3 and C5, threaten the oat varieties grown in Canada. The oat crop could be seriously damaged whenever conditions favor stem rust development.

Acknowledgments

The assistance of cooperators who cared for rust nurseries and submitted rust collections from various parts of Canada is gratefully acknowledged. Mr. Peter K. Anema performed the technical operations necessary for the identification of physiologic races.

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STEM RUST OF WHEAT, BARLEY, AND RYE IN CANADA IN 1968[1]

G.J.Green[2]

Prevalence and importance in Western Canada

Stem rust (Puccinia graminis Pers. f. sp. tritici Eriks. and E. Henn.) was scarce on wheat and barley in Western Canada in 1968. It was first reported on July 23, when traces could be found on susceptible wheat varieties in experimental plots in southern Manitoba. Its development for the remainder of the growing season was slow, presumably because of the cool, wet weather that prevailed until late autumn. Precipitation in Manitoba from April 1 to September 9 averaged 17.83 inches (45.29 cm) and the mean temperature was 51.1F (10.6C) with normals of 12.11 inches (30.76 cm) and 56.7F (13.7C), respectively. Stem rust could not be readily found on susceptible wild barley (Hordeum jubatum L.) until early October.

Rye stem rust (P. graminis Pers. f. sp. secalis Eriks. and E. Henn.) was more prevalent than usual. 'Rosen' rye inoculated in the greenhouse with rust collected on wild and cultivated barley was frequently infected.

Stem rust of wheat, barley, and rye in the rust nurseries

Stem rust infections in the nurseries in 1968 were much lighter than usual. There was no rust at 17 of the 32 nursery locations and mere traces occurred at eight of the locations (Table 1). Infections of more than 5% occurred only at the four Manitoba locations and Appleton, Ont.

Table 1. Percentage infection of stem rust of wheat (Puccinia graminis f. sp. tritici) on 14 wheat varieties in uniform rust nurseries at 15 locations* in Canada in 1968

Locality	Common wheat											Durum wheat		
	Lee	Thatcher	Selkirk	Red Bobs	Manitou	Marquis	Kenya Farmer	McMurachy	Frontana	Exchange	Noreste 66	Mindum	Ramsey	Stewart 63
Indian Head, Sask.	0	0	0	tr	0	tr	0	0	0	0	0	0	0	0
Brandon, Man.	tr	0	0	20	0	5	0	0	0	0	0	tr	0	0
Morden, Man.	0	0	0	tr	0	0	0	0	0	0	0	25	0	0
Winnipeg, Man.	10	10	1	50	tr	20	1	1	2	1	2	5	tr	tr
Glenlea, Man.	1	tr	tr	50	tr	50	tr	tr	1	1	tr	30	tr	tr
Fort William, Ont.	tr	0	0	0	0	0	0	0	0	0	0	0	0	0
Guelph, Ont.	0	0	0	tr	0	tr	0	0	0	0	0	0	0	0
Vineland, Ont.	0	0	0	tr	0	tr	0	0	0	tr	0	5	0	0
Appleton, Ont.	tr	tr	0	tr	0	tr	0	0	tr	tr	0	15	1	0
Williamstown, Ont.	0	0	0	tr	0	0	0	0	0	0	0	0	0	0
Alfred, Ont.	0	0	0	5	0	0	0	tr	0	0	0	0	0	0
Morewood, Ont.	0	tr	0	tr	0	0	0	0	0	0	0	0	0	0
Macdonald College, Que.	0	0	0	tr	0	tr	0	0	0	0	0	0	0	0
L'Assomption, Que.	0	0	0	tr	0	0	0	0	0	0	0	0	0	0
Normandin, Que.	0	0	0	0	0	tr	0	0	0	0	0	0	0	0

*No rust was observed in nurseries at 17 other locations: Agassiz and Creston, B.C.; Beaverlodge, Lacombe and Lethbridge, Alta.; Scott and Melfort, Sask.; Verner, Douglas, Kapuskasing and Ottawa, Ont.; La Pocatière and Lennoxville, Que.; Kentville and Truro, N.S.; Fredericton, N.B.; and Charlottetown, P.E.I.

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The reactions of wheat varieties in the nurseries were the same as in earlier years. The heaviest infections were on the susceptible varieties 'Red Bobs', 'Marquis', and 'Mindum'. There were light infections on the moderately susceptible varieties 'Lee' and 'Thatcher' at Winnipeg. The other varieties, which are resistant, were lightly infected at a few locations.

Stem rust was observed on barley at only four locations, but it occurred on rye at 13 locations (Table 2). Infections on rye were generally more severe than those on wheat.

Table 2. Percentage infection of stem rust (Puccinia graminis) on three varieties of barley and one variety of rye in uniform rust nurseries at 13 locations* in Canada in 1968

Locality	Barley			Rye
	Montcalm	Parkland	C.I. 10644	Prolific
Agassiz, B.C.	0	0	0	5
Creston, B.C.	tr	tr	0	1
Glenlea, Man.	0	0	0	10
Williamstown, Ont.	0	tr	tr	25
Alfred, Ont.	tr	15	1	25
Guelph, Ont.	0	0	0	20
Ottawa, Ont.	0	0	0	15
Appleton, Ont.	20	5	5	70
Morewood, Ont.	0	0	0	25
La Pocatière, Que.	0	0	0	20
Macdonald College, Que.	0	0	0	15
Lennoxville, Que.	0	0	0	10
Kentville, N.S.	0	0	0	tr

*No rust was observed in nurseries at 18 other locations: Beaverlodge, Lacombe and Lethbridge, Alta.; Indian Head, Scott and Melfort, Sask.; Morden and Winnipeg, Man.; Verner, Douglas, Kapuskasing, Fort William, and Vineland, Ont.; L'Assomption and Normandin, Que.; Truro, N.S.; Fredericton, N.B.; and Charlottetown, P.E.I.

Distribution of physiologic races

In 1968, 202 isolates of wheat stem rust were identified as 10 virulence formulas or 9 physiologic races (Table 3). The scarcity of wheat stem rust in Canada limited the number of isolates identified. Many collections were made in Manitoba from wild barley, but one-third of them were rye stem rust (Table 4). Most collections were made from susceptible wheat varieties or from wild barley.

The methods used to identify races were the same as those used in previous years (1). Virulence formulas (1) show the virulence of the isolates on identified resistance genes. Physiologic races were identified on the varieties 'Marquis', 'Reliance', 'Arnautka', 'Mindum', 'Einkorn', and 'Vernal' of the standard differential hosts. In this report the formula number is followed by the race number in brackets.

The 1968 race distribution was similar to that of 1967 (Table 3). Race C18 (15B-1L Can.) continued to predominate and race C20 (11) was second in order of prevalence. Race C18 (15B-1L Can.) does not threaten the resistant varieties 'Manitou' and 'Selkirk' that predominate in the rust area of Western Canada. Race C20 (11) is virulent on seedlings but is not aggressive on adult plants of 'Selkirk'. Race C17 (56) continued a decline in prevalence that began in 1964 and, in 1968, was found only four times. Races C22 (32) and C25 (38) were the only other significant races identified. They are moderately virulent on seedlings of 'Manitou', but they are not aggressive on adult plants. Race C25 (38) was first found in Eastern Canada in 1964 and reappeared in small amounts in 1965 and 1966. It was not found in 1967, and its reappearance in trace amounts in 1968 was not anticipated. Trace amounts of race C22 (32) have been present in Canada for the last five years at least.

Two new virulence combinations were found. A culture obtained in 1967 was found to be a new race after the 1967 results had been reported (1). It is a strain resembling the currently prevalent race C18 (15B-1L Can.) but it is virulent on Ma^6 - Sr8. The formula (C33) is: 6, 9a, 9b/1, 5, 7, 8, 10, 11. The new race C34 (32) was found in Quebec in 1968. The formula is: 1, 6, 7, 9a, 9b, 11/5, 8, 10, 13, 14.

Resistance gene Sr1, first used in 1967, continued to be a useful differential. Genes Sr13, Sr14, Sr15 and Sr16 were used for the first time in 1968. More data is required before their usefulness can be fully evaluated. Sr13 and Sr14 appear promising. Sr15 may be useful in Canada, but Sr16 is of doubtful value, because it is ineffective against most races, and because it confers an indefinite reaction.

Composite collections of urediospores were used to inoculate a group of highly resistant varieties. No new virulence combinations were found. The varieties 'Mida-McMurachy-Exchange II-47-26', 'Frontana-K58-Newthatch II-50-17', 'Chris', 'Pitic 62', 'ND 264', 'Wis. 261', 'St 464', and 'C.I. 8155' were resistant or moderately resistant to all composite collections. A selection from a cross between 'Manitou' and a wheat-rye translocation stock

Table 3. Distribution by provinces of physiologic races of Puccinia graminis f. sp. tritici collected on wheat, barley, and grasses in 1968

Virulence formula number	Physiologic race number	Number of isolates from: Que.	Ont.	Man.	Sask.	B.C.	Total number of isolates	Percent of total isolates
C1	17	0	3	0	0	0	3	1.5
C2	17A	0	2	1	0	0	3	1.5
C4	23	0	0	0	0	1	1	0.5
C17	56	0	3	1	0	0	4	2.0
C18	15B-IL(Can.)	2	9	90	49	0	150	74.2
C19	10	0	2	0	0	0	2	1.0
C20	11	0	5	18	11	0	34	16.8
C22	32	0	0	1	0	0	1	0.5
C25	38	0	1	2	0	0	3	1.5
C34	32	1	0	0	0	0	1	0.5
		3	25	113	60	1	202	100.0

Table 4. Number of isolates of Puccinia graminis f. sp. secalis from barley and wild barley in 1968

Location	No.
Quebec	0
Ontario	11
Manitoba	54
Saskatchewan	6
British Columbia	0
Total	71

and a selection from 'P. I. 243065' showed outstanding resistance to the composites.

Resistance gene Sr8 conferred resistance to more of the 1968 isolates than any other gene (93%). Sr6 (81%), Sr9a (80%), and Sr9b (79%) also were highly effective against the 1968 stem rust population (Table 5). These values are very similar to those for 1967.

Acknowledgments

The cooperation of those who cared for the rust nurseries and supplied collections of rust is appreciated. Mr. J.H. Campbell did the technical work of the program.

Table 5. Percentage of total isolates avirulent on single identified resistance genes

Resistance genes	Avirulent isolates (%)
Sr1	20.8
Sr5	3.5
Sr6	81.2
Sr7	20.3
Sr8	93.0
Sr9a	80.2
Sr9b	79.7
Sr10	4.0
Sr11	22.3

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LEAF RUST OF WHEAT IN CANADA IN 1968[1]

D.J. Samborski[2]

Disease development and crop losses in Western Canada

Trace amounts of leaf rust were present throughout southern Manitoba on June 12 which is a normal level of leaf rust infection for this area. However, further development was very slow and infections were still light in the middle of August. The cool, wet weather delayed maturity of the crop and allowed considerable development of leaf rust in late fields, where some damage may have resulted. The majority of the wheat crop was not damaged by leaf rust in 1968.

Leaf rust in the rust nurseries

Ratings of leaf rust intensity on 15 wheat varieties grown at nurseries across Canada are shown in Table 1. Nurseries where no leaf rust occurred or where rust intensity could not be estimated are omitted from this table. The reaction of the varieties is very similar to that observed in former years with little or no leaf rust on 'Manitou', 'Exchange', and 'Frontana'.

Table 1. Percentage infection by Puccinia recondita on 17 wheat varieties in uniform rust nurseries at 22 locations in Canada in 1968

Locality	Lee	Thatcher	Selkirk	Red Bobs	Manitou	Marquis	Kenya Farmer	McMurachy	Ramsey	Mindum	Stewart 63	D.T. 184	Thatcher 6x Transfer	Exchange	Frontana	D.T. 191	Noroeste 66
Agassiz, B.C.	5	50	50	50	1	40	2	50	0	0	0	0	0	0	0	0	tr*
Creston, B.C.	20	70	15	70	2	60	20	70	0	0	0	0	0	0	0	0	0
Lacombe, Alta.	0	0	0	tr	0	0	0	0	0	0	0	0	0	0	0	0	0
Lethbridge, Alta.	5	20	3	20	tr	20	5	20	0	0	0	0	0	0	0	0	0
Indian Head, Sask.	0	tr	0	tr	0	tr	0	tr	0	0	0	0	0	0	0	0	0
Melfort, Sask.	15	15	15	25	0	20	15	15	0	0	0	0	0	0	0	0	0
Morden, Man.	40	60	30	70	10	40	50	60	0	0	0	0	0	0	0	0	0
Winnipeg, Man.	50	80	70	80	5	80	30	80	0	0	0	0	0	0	0	0	0
Glenlea, Man.	30	80	60	60	10	60	60	70	0	0	0	0	0	0	0	0	0
Verner, Ont.	2	60	tr	60	tr	50	2	60	0	0	0	0	0	0	0	0	0
Williamstown, Ont.	15	50	10	60	tr	50	10	60	0	0	0	0	0	0	0	0	tr
Douglas, Ont.	0	3	0	5	0	3	0	2	0	0	0	0	0	0	0	0	0
Alfred, Ont.	3	30	2	30	tr	20	2	30	0	0	0	0	0	0	0	0	0
Fort William, Ont.	10	40	2	40	tr	40	10	40	0	0	0	0	0	0	0	0	0
Ottawa, Ont.	tr	30	tr	30	0	30	tr	30	0	0	0	0	0	0	0	0	0
Appleton, Ont.	15	80	5	80	5	70	15	80	0	0	0	0	0	0	0	0	0
Morewood, Ont.	10	40	3	50	tr	40	10	40	0	0	0	0	0	0	0	0	0
St. Catherines, Ont.	5	70	5	70	tr	60	5	70	0	0	0	0	0	0	0	0	0
Macdonald College, Que.	40	60	5	60	tr	70	40	70	0	0	0	0	0	0	0	0	0
Lennoxville, Que.	5	30	2	30	0	20	5	20	0	0	0	0	0	0	0	0	tr
L'Assomption, Que.	tr	5	tr	10	0	2	tr	5	0	0	0	0	0	0	0	0	0
Kentville, N.S.	tr	3	tr	10	0	3	tr	5	0	0	0	0	0	0	0	0	0

* tr = trace.

Physiologic specialization

Physiologic specialization in leaf rust has been studied in the past with the standard differentials, supplementary differentials, single gene lines, or combinations of these sets of differentials. In 1968,

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eight single-gene back-cross lines were used. These lines contain most of the genes present in the earlier sets of differential varieties (1, 2, 3). The distribution of virulence on the individual single gene lines is shown in Table 2. A majority of the isolates were virulent on genes Lr3 and Lr10. All isolates virulent on gene Lr16 were also virulent on Lr10; the commercial variety 'Selkirk', which possesses both of these genes for resistance, was attacked by 11.4% of the isolates. The genes for virulence corresponding to the eight genes for resistance all appear to be independently inherited, and 256 virulence combinations are possible in this system. Too few isolates were studied in 1968 to detect all virulence combinations, and none of the isolates were capable of attacking more than five genes for resistance (Table 3).

Infection types produced on back-cross lines with genes Lr10 and Lr16 were compared with infection types produced on varieties possessing known genes for resistance to leaf rust (Table 4). Interaction between gene Lr10 and an avirulent culture of leaf rust results in a 0; reaction on 'Lee',

Table 2. Virulence of isolates of Puccinia recondita on back-cross lines containing single genes for resistance to leaf rust in Canada in 1968

Resistance genes	Number of isolates from:				Total no. of virulent isolates	% total isolates
	Ont. & Que.	Man.	Sask.	B. C. & Alta		
Lr1	2	2	1	0	5	4.4
Lr2	1	1	0	0	2	1.7
$Lr2^4$	19	2	1	11	33	29.0
Lr3	25	41	28	16	110	96.5
Lr10	22	23	25	15	85	74.4
Lr16	1	3	4	5	13	11.4
Lr17	0	0	2	10	12	10.5
Lr18	18	16	4	1	39	34.2

Table 3. Percentage of isolates virulent on one or more genes for resistance (% of total isolates in each area)

Geographic area	Number of genes for resistance attacked:							
	1	2	3	4	5	6	7	8
Que. & Ont.	6.9	38.0	20.7	31.0	3.4	0	0	0
Man.	28.8	48.9	17.0	4.9	2.4	0	0	0
Sask.	7.1	67.9	21.4	3.6	0	0	0	0
Alta. & B.C.	6.3	18.7	12.5	43.8	18.7	0	0	0

Table 4. Infection types produced on selected wheat varieties by isolates of leaf rust in 1968

Culture number of leaf rust isolates	Host variety and known genotype: T^6X Exchange (Lr10)	T^6X Exchange (Lr16)	Lee (Lr10)	Selkirk (Lr10, Lr16)	Exchange (Lr10, Lr16)	Renown*
10-68	1	2	0;	0;	0;	4
11-68	4	2	4	2	2	4
45-68	4	2	2	2	0;	4
77-68	4	2	4	;1	2	X
44-68	4	4	4	4	4	4

* The gene for resistance conditioning an X reaction is probably Lr14.

'Selkirk', and 'Exchange' and a type 1 reaction on the back-cross line containing Lr10. Obviously, genetic background influences the expression of infection type. Culture 77-68, mesothetic on 'Renown', produces an atypical infection type on 'Selkirk'. Since 'Selkirk' possesses the resistance gene present in 'Renown', the atypical infection type results from the interaction with two genes for resistance, one conditioning a type 2 and the other an x reaction type. The infection types produced by culture 45-68 suggest that 'Lee' and 'Exchange' possess an additional gene or genes for resistance other than Lr10 and Lr16.

Composite collections of leaf rust were used to inoculate the highly resistant varieties 'Agrus', 'Transfer', 'Klein Lucero', 'Klein Titan', 'Maria Escobar', 'Rio Negro', 'Aniversario', 'Wanken', 'Anex', 'Lani', 'Lafron', 'Frex', 'Lex', 'Anfron', 'Preska', and 'Timpaw'. Susceptible-type pustules were obtained on 'Klein Titan', 'Maria Escobar', and 'Rio Negro', and a number of cultures were established. 'Maria Escobar' and 'Rio Negro' showed a similar but not identical pattern of rust reactions to these cultures. 'Klein Titan' was usually moderately resistant to cultures virulent on 'Maria Escobar' and 'Rio Negro', and the latter two varieties were generally resistant to cultures virulent on 'Klein Titan'.

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AIR-BORNE RUST INOCULUM OVER WESTERN CANADA IN 1968[1]

G.J. Green and J.W. Martens[2]

The concentration of rust inoculum in the air over Western Canada in 1968 was measured by trapping urediospores. The method used has been described (1). Spore traps were located at Winnipeg, Morden, and Brandon, Manitoba, and at Indian Head, Regina, and Saskatoon, Saskatchewan.

Table 1. Number of urediospores of stem rust and leaf rust per square inch caught on vaseline-coated slides exposed for 48-hour periods at three locations in Manitoba and three locations in Saskatchewan in 1968

Date	Winnipeg		Morden		Brandon		Indian Head		Regina		Saskatoon	
	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust
May total	0	0	0	2	0	1	0	1	0	2	0	0
June 1-2	0	1	0	1	0	4	0	0	0	0	0	3
3-4	0	0	0	25	0	1	0	7	0	1	0	0
5-6	0	16	0	1	0	5	0	2	0	3	0	0
7-8	0	2	0	1	0	0	0	3	0	4	0	0
9-10	0	2	0	0	0	0	0	0	0	2	0	0
11-12	0	9	0	3	0	0	0	0	0	0	0	0
13-14	0	7	0	4	0	1	0	0	0	1	0	0
15-16	0	0	0	3	0	0	0	0	0	0	0	2
17-18	0	15	0	3	0	0	0	2	0	4	0	8
19-20	0	8	0	28	0	1	0	3	0	6	0	11
21-22	0	2			0	5	0	8	0	1	0	11
23-24	0	11	0	0	0	2	0	1	0	0	0	7
25-26	0	6	0	8	0	0	0	31	0	26	0	13
27-28	0	32	0	59	0	15	0	4	0	12	0	30
29-30	0	0	0	3	0	1	0	4	0	1	0	1
June total	0	111	0	139	0	35	0	65	0	61	0	86
July 1-2	0	4	0	23	0	0	0	1	0	7	0	33
3-4	0	5	0	0	0	1	0	3	0	13	0	29
5-6	0	5	0	193	0	3	0	2	0	5	0	4
7-8	0	17	0	45	0	3			0	11	0	81
9-10	10	224	47	483	2	9	6	59	4	84	0	5
11-12	2	106	1	107	2	21	1	18	0	2	0	5
13-14	0	40	0	77			0	1	0	0	0	13
15-16	0	0	0	2	0	2	0	3	0	6	0	5
17-18	0	81	0	21	0	0	0	2	0	1	0	0
19-20	0	98	18	601	4	69	3	7	5	45	0	0
21-22	3	135	2	59	0	7	0	0	0	5	0	4
23-24	0	13	1	50	0	2	0	2	0	2	0	6
25-26	10	2220	1	461	0	49	0	5	0	8	0	7
27-28	5	42	0	30	1	31	2	38	0	39	1	47
29-30	2	53	0	1	2	69	3	247	2	93	0	6
July total	32	3043	70	2153	11	266	15	388	11	321	1	245

A few spores of leaf rust were caught during May, and a spore shower occurred across Manitoba and southern Saskatchewan between June 1 and June 6 (Table 1). This spore shower probably caused the

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Table 1 (Concluded)

Date	Winnipeg		Morden		Brandon		Indian Head		Regina		Saskatoon	
	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust
July 31-Aug. 1	1	141	1	394	0	39	0	15	0	11	0	8
2-3	0	44	6	146	2	19	0	9	0	15	0	26
4-5	9	538	1	231	7	376	1	13	0	1	0	31
6-7	9	342	0	95	0	8	1	23	0	15	0	0
8-9	2	90	0	70	0	42	0	25	0	14	0	0
10-11	11	403	38	1310	2	73	0	26	1	31	0	3
12-13	9	577	4	541	0	189	0	26	1	78	0	3
14-15	0	3	1	105	1	15	0	9	2	40	0	26
16-17	2	66	14	393	4	103	8	60	20	68	3	3
18-19	7	307	28	997	5	26	0	5	3	4	0	2
20-21	13	507	7	270	4	91	0	1	2	14	0	2
22-23	2	50	4	125	8	80	0	0	0	5	0	0
24-25	0	28	3	144	0	41	12	15	117	131	3	28
26-27	66	598	96	850	1	46	1	5	23	64	0	26
28-29	70	764	90	342	1	30	0	1	21	66	0	0
30-31	1	11	18	86	0	0	7	41	116	204	3	4
Aug. total	202	4469	311	6099	35	1178	30	274	306	761	9	162
TOTAL	234	7623	381	8393	46	1480	45	728	317	1145	10	493

first leaf rust infections in Manitoba, which were found on June 12. Leaf rust spores were caught during most 48-hour exposures at all spore trap locations from June 12 to August 31. A moderate amount of leaf rust developed in Western Canada, and the total number of leaf rust spores caught was about average (1).

Stem rust spores were first caught on July 9 and they appeared erratically from that date to the end of August. Stem rust was first reported on susceptibile varieties in field plots in southern Manitoba on July 23. It developed slowly and was scarce in Western Canada until late September. The total number of stem rust spores caught was the lowest since 1961.

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BRIEF ARTICLES

XANTHOMONAS TRANSLUCENS ON WHEAT IN MANITOBA IN 1968[1]

W.A.F. Hagborg[2]

The most severe outbreak of bacterial black chaff of wheat observed to date in Manitoba occurred south of Morris in 1968. Presumably its development was made possible by the unusually frequent rains that occurred in June and July. In the vicinity of Letellier and St. Joseph, only bacterial black chaff was present, but further south near Altona and Gretna, infection by Leptosphaeria avenaria f. sp. triticea Johnson was also present.

A sample of wheat plants affected by bacterial black chaff was collected by Dr. C. C. Gill on July 19 and August 1. On July 22, fields of 'Manitou' wheat (Triticum aestivum L.) in the milk stage were observed east and west of Letellier with 100% of the plants lesioned and 10 to 20% of the leaf area destroyed. Head discoloration occurred in a patchy distribution. One field of durum wheat (Triticum durum Desf.) was found 3 miles west of St. Joseph with 100% of the plants infected and 50% of the leaf area destroyed.

By August 1, the severity of leaf-area destruction was approaching 100% in the same area, and the disease was traced south to the border of North Dakota.

Xanthomonas translucens f. sp. undulosa (Smith, Jones & Reddy) Habg. was isolated from 'Manitou' wheat collected 1 mile west of St. Joseph, and X. translucens f. sp. cerealis Habg. from durum wheat collected 2 miles further west. X. translucens f. sp. cerealis was also isolated from quack grass (Agropyron repens (L.) Beauv.) and 'Manitou' wheat collected near Gretna, Manitoba.

From the proportion of photosynthesizing tissues destroyed by the bacterial infection, yield losses must have been substantial. For example, by measurement of the threshed grain in the bins, the yield in a 40-acre field of wheat at St. Joseph was estimated to be 18 bu/acre. A field about 10 miles north of the infected field was reported to yield 45 bu/acre, suggesting that the potential yield in the infected field may have been much higher than that obtained. There was no means of ascertaining the yield loss directly.

Bacterial black chaff was also severe on the leaves in experimental plots of a number of wheat and triticale (Secale cereale x Triticum durum) varieties grown at Winnipeg by the Plant Science Department, University of Manitoba. At this locality, X. translucens f. sp. undulosa was isolated from eight collections of 'Triple Dirk', 'Pitic 62', 'Manitou', and an unnamed Mexican variety of wheat and from 'Rosner' triticale.

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OVERWINTERING OF MELOIDOGYNE INCOGNITA IN SOUTHWESTERN ONTARIO[1]

G.W. Bird[2]

Meloidogyne incognita (Kofoid and White, 1919), the southern root-knot nematode, is the most economically important nematode in the vegetable greenhouses of southwestern Ontario. In a study of three Meloidogyne spp., Sayre (1) found that M. incognita failed to overwinter in bare soil, under a cover crop, or in the roots of peach and asparagus. Sayre's experiments were initiated in October and concluded in April. He added finely chopped infected roots to soil in 4-inch diameter drainage tiles buried in a cultivated field.

On May 4, 1967, a half-acre field plot at Harrow was fumigated with a mixture of 1, 3-dichloropropene, 1, 2-dichloropropane, and other related chlorinated C_3 hydrocarbons at 25 gal/acre. Twenty days later M. incognita-infested soil was placed in a 6-inch deep hole at each future seedling site. The plot was infested at the rate of 335 second-stage juveniles per square foot. Late tomato (Lycopersicon esculentum Mill., cv. Heinz 1350) seedlings were planted 2 days later. In October the tomatoes were heavily infected with M. incognita root-galls. On April 29, 1968, the plot was planted with susceptible lettuce (Lactuca sativa L., cv. Fulton). It was harvested on June 13, 1968. In an examination of the lettuce roots, no M. incognita root-galls were observed.

These field observations substantiate Sayre's conclusion that M. incognita does not overwinter in southwestern Ontario soils.

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[1] Canada Department of Agriculture, Research Station, Harrow, Ontario.

[2] Nematologist.

INFLUENCE OF SIX COVER CROPS ON POPULATION DENSITY OF PRATYLENCHUS PENETRANS[1]

G.W. Bird[2]

To control Pratylenchus penetrans (Cobb, 1917) in orchards, it is often necessary to use a pre-plant integrated program, including soil fumigants and fallowing or suitable cover crops. Parker et al. (3) stated that it generally takes two years after removing old trees before orchard soils are suitable for replanting. MacDonald and Mai (2) found that Sudan grass was the most suitable cover crop for use in integrated programs to control P. penetrans in orchard soils. Bird (1) published a control program for combating orchard replant problems in southwestern Ontario.

The following experiment was used to evaluate the influence of six cover crops on an Ontario population of P. penetrans. Ten seeds of a cover crop (Table 1) were planted in each of eight 3-inch clay pots of sandy loam infested at the rate of three P. penetrans/5 g of soil. Similar groups of pots were seeded with five other cover crops. The pots were buried to the soil level in sand in plastic containers and submerged to the soil level in constant-temperature water baths. They were germinated and grown at a soil temperature of 25° C. Sixty days after seeding, nematodes were extracted from the roots with a modified Baermann funnel. Quantitative population estimates (Table 1) were made by adjusting the sample to a known volume and counting the number of P. penetrans in five 1-ml aliquots.

Population densities of P. penetrans in roots of Sudan grass and rye grass were less than those of MacDonald and Mai (2). Of the plants tested, Sudan grass and rye grass appear to be the best cover crops for use in programs for combating orchard replant problems. Orchard sites to be replanted, should remain fallow or in a suitable cover crop during the growing season preceeding soil fumigation. This allows time for living tree roots to decompose and nematodes to migrate out of the roots upward, where they can be controlled with soil fumigants. Fallowing will reduce populations of P. penetrans more than cover crops, but fallowing is often not practical because of soil erosion problems.

Table 1. Pratylenchus penetrans recovered from the roots of six cover crops

Cover crop	Mean* number/g root
Sudan grass (Sorghum vulgare var. sudanense Hitchc.)	4.2 a
Rye grass (Lolium perenne L.)	6.2 a
Sudax (Sudan grass x sorghum hybrid)	7.1 a
Orchard grass (Dactylis glomerata L.)	12.5 a
Alfalfa (Medicago sativa L.)	48.8 b
Hairy vetch (Vicia sativa L.)	52.8 b

* Means followed by different letters are significantly different at the 5% level of probability (Duncan's Multiple Range Test).

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