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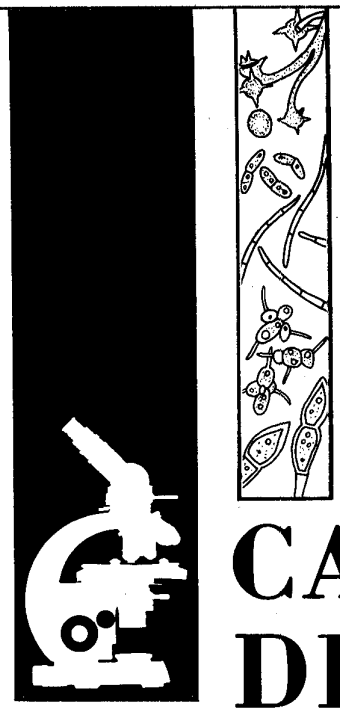

CANADIAN PLANT DISEASE SURVEY

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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."

SCREENING OF POTATO FUNGICIDES IN 1970[1]

L.C.Callbeck[2]

Introduction

Potato late blight caused by Phytophthora infestans (Mont.) de Bary was a major problem on Prince Edward Island in 1964 but was of negligible to minor importance through the five seasons of 1965 to 1969. However, except for 1965, satisfactory epidemics were created in the experimental plots by frequent inoculations.

In 1970, the disease reached epiphytotic proportions and the fungicides selected for the Screening Test were compared under an extremely severe and sustained attack.

Materials and methods

The nine fungicides described briefly below were studied in 1970. Of these, numbers 5, 6, and 9 were being tested for the first time. The description of each fungicide is arranged in order of trade name, guaranteed active ingredient, source, and dosage rate in terms of formulated product.

1. Daconil 2787 75W. 75% tetrachloroisophthalonitrile. Diamond Alkali (Canada) Ltd., Toronto, Ontario. 1.0 and 1.5 lb/acre.

2. Difolatan 4.8F. 4.8 lb/gal N-(1,1,2,2-tetrachloroethylsulfenyl)-cis-Δ-cyclohexene-1, 2-dicarboximide. Chevron Chemical (Canada) Limited, Oakville, Ontario. 0.8 and 1.25 Imp. qt/acre.

3. Dithane M-45 80W. 80% zinc coordinated maneb. Rohm and Haas Company of Canada Limited, West Hill, Ontario. 1.5 lb/acre.

4. DuTer 50W. 50% fentin hydroxide. Philips-Duphar, Amsterdam, Holland. 7.0 oz/acre.

5. Kocide 101. 86% cupric hydroxide. Kennecott Copper Corporation, Houston, Texas, U.S.A. 3.0 lb/acre.

6. MBR 6886 50WP. Confidential. 3M Company, St. Paul, Minnesota, U.S.A. 1.5 lb/acre.

7. Polyram 80W. 80% zinc activated polyethylene thiuram disulfide. Niagara Brand Chemicals, Burlington, Ontario. 1.5 lb/acre.

8. Siaprit. 47% zineb. S.I.A.P.A., Rome, Italy. 3.5 lb/acre. (Available from Green Cross Products, Montreal, Que.)

9. Sperlox M. A zinc coordinated maneb (mancozeb) formulation. Olin Corporation, Fresno, California, U.S.A. 1.5 lb/acre.

Plots of the blight-susceptible variety Green Mountain were planted on June 12, several days later than normal because of wet weather. Each plot was 4 rows wide by 50 feet long and 50 seed pieces were planted in each row. Single rows of the same variety were planted as borders and as buffers between plots. The treatments were randomized and replicated in five ranges.

All rows were sprayed with endosulfan at appropriate times to control insect pests.

The fungicides were applied by a tractor-sprayer unit, the 4-row boom of which carried four nozzles per potato row, two being above the plants and two on drop pipes. The dates of application were July 15, 23, 31; August 10, 17, 25; September 1, 8.

Late blight disease was introduced by sprinkling the border and buffer rows with a water suspension of spores of race 1, 2, 3, 4 late in the evening of July 24 and again early the following morning when the foliage was wet with dew. Lesions were found in these rows on July 28 and in the five unsprayed check plots on August 4. Further inoculations were unnecessary.

During the 30-day period of August 10 (spray 4) to September 8 (final spray), recordable amounts of rain fell on 18 days, totalling 6.32 inches, and trace amounts fell on 4 days. Day and night temperatures were ideal for sporulation of the late blight fungus, humidity was often high, and heavy night dews occurred. Under these conditions the fungus was fruiting almost constantly and the sprayed plots were therefore under an equally constant bombardment by spores. From September 9 until the test was terminated by the application of top killer on September 18, the maximum humidity was over 90 percent on 6 days and there was rain on 4 days. September had the least sunshine ever recorded here for that month.

Defoliation readings were taken regularly and the mean readings, expressed as percentages, are shown in Table 1.

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[2] Plant Pathologist.

Table 1. Percentage defoliation

Treatment	Aug. 23	Sept. 8	Sept. 11	Sept. 14
Daconil 2787 (1.5 lb)	4	10	16	20
Dithane M-45	5	12	18	22
Siaprit	9	20	26	30
Polyram	10	24	28	32
Daconil 2787 (1.0 lb)	7	21	30	34
Difolatan 4.8F (1.25 qt)	8	22	33	35
Difolatan 4.8F (0.8 qt)	9	27	37	40
MBR 6866	16	42	53	58
DuTer	13	40	52	60
Kocide 101	18	45	59	75
Sperlox M	28	50	63	80
Check	40	95	100	100

The tubers were dug, graded, and examined for late blight rot on October 13-14. These data are given in Table 2.

Results and discussion

Daconil 2787 75W, at the 1.5 pound per acre dosage, was the leading fungicide and was followed closely by Dithane M-45 at the same dosage. Plots treated with Daconil at this dosage also produced the highest mean yield, giving the greatest weight of tubers in four of the five replicates. In replicate 5 it was surpassed by a small margin by the same product at the 1.0 pound per acre dosage.

The fungicides being tested for the first time--MBR 6866, Kocide 101, and Sperlox M--were much less effective than the other materials. Kocide 101 and Sperlox M both resulted in low yields and relatively high losses from rot. DuTer, tested in several years, appears to fall into the less effective group.

Table 2. Effects of treatments on yield and rot

Treatment	Total (bu/acre)	Small* (bu/acre)	Rot (bu/acre)	No. 1 (bu/acre)	Rot (%)
Daconil 2787 (1.5 lb)	400.6	75.5	3.9	321.2	1.0
Dithane M-45	379.9	90.8	7.9	281.2	2.1
Daconil 2787 (1.0 lb)	390.7	101.0	9.9	279.8	2.5
Difolatan 4.8F (1.25 qt)	379.7	98.6	5.7	275.4	1.5
Siaprit	360.4	81.6	11.7	267.1	3.2
Difolatan 4.8F (0.8 qt)	359.0	96.1	4.6	258.3	1.3
Polyram	342.3	84.5	9.2	248.6	2.7
DuTer	340.1	99.0	4.8	236.3	1.4
MBR 6866	335.3	90.4	9.9	235.0	2.9
Kocide 101	308.2	95.9	14.5	197.8	4.7
Sperlox M	265.3	78.8	14.5	172.0	5.5
Check	201.5	101.2	7.0	93.3	3.5
LSD 0.05	38.1			29.5	1.6
LSD 0.01	50.8			39.4	2.1

* Below 2¼ inches.

COOPERATIVE SEED TREATMENT TRIALS-1970[1]

H. A. H. Wallace[2]

Abstract

Sixty-six 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), seedling blight of barley (Cochliobolus sativus), and seed rot of flax caused by a complex of seed- and soil-borne microorganisms. In addition, two formulations of Benlate and five of Vitavax were tested for their efficacy in controlling loose smut of barley (Ustilago nuda).

The results show that formulations of thiram, maneb, hexachlorobenzene, Polyram and Vitavax, used alone or in combination, depending on the crop and the disease, can be used as substitutes for mercurial seed dressings, and, in addition, that the systemic fungicides Benlate, Vitavax and Vitaflo control loose smut of barley, against which mercurials are ineffective.

Introduction

In 1970 sixty-six seed treatment chemicals were tested for their efficacy in controlling common bunt of wheat caused by Tilletia foetida (Wallr.) Liro, covered smut of oats caused by Ustilago kolleri (Wille), covered smut of barley caused by Cochliobolus sativus (Ito & Kurib.) Drechsl. ex. Dastur, and seed rots of flax caused by a complex of soil- and seed-borne microorganisms. In addition, seven formulations of systemic fungicides were tested for their efficacy in controlling loose smut of barley caused by Ustilago nuda (Jens.) Rostr..

Materials and methods

Clean seed of 'Red Bobs' wheat (Triticum aestivum L.), naturally smutted seed of 'Vanguard' oats (Avena sativa L.), and naturally smutted seed of 'Palliser' barley (Hordeum distichon L.) were used. One gram of dry spores of the appropriate smut fungus was added to each 200 g of wheat and oat seed, and the mixture was shaken well to distribute the spores over the seed. The barley seed was already heavily infested with smut spores and no additional spores were added. 'Galt' barley (H. hexastichon L.) naturally infected with U. nuda was used for the loose smut test and 'Herta' barley (H. distichon), 100% naturally infected with C. sativus, was used for the seedling blight test. 'Bolley' flax (Linum usitatissimum L.) was used in Series A and B seed rot tests and 'Linott' flax in the Series C test.

The experiment was divided into three sections. Series A was designed to test the efficacy of new experimental products; Series B was a comparison of registered nonmercurial products with the standard mercurial products; and Series C contained products that arrived too late for inclusion in Series A and also several systemic fungicides for the control of loose smut of barley. The source, product name, and chemical name where available, of the treatment materials are listed in Tables 1,2, and 3. Agrox NM and Panogen 15B (Series A), and Ceresan M and Panogen PX (Series B) were included as standards. In Series C the standard chemicals were replaced by late arriving chemicals. The appropriate amount of chemical was applied to 100 g of seed, or to 200 g of seed if the rate was less than 1 oz per bushel, by placing both in a glass jar and shaking until the seed was uniformly covered. Seed was removed from the jar after not more than 3 days; samples consisting of 200 seeds were then placed in paper envelopes and stored in polyethylene bags at 15C for not more than 4 weeks before seeding.

All series of tests were planted at Brandon and Morden, Manitoba. In addition the wheat bunt test (Series B only) was planted at Lethbridge, Alberta. Several chemicals that arrived too late for inclusion at Brandon were used at Morden only (Table 6). Each plot replicate consisted of 200 seeds planted in a row 12 ft long; all rows were planted 9 inches apart, and plots were arranged in a randomized block design. Emergence of barley infected with C. sativus and of flax was recorded 6-8 weeks after seeding. Disease ratings of emerged barley plants were made at the same time by examining 100 plants from each row and rating them on a 0-5 scale. For each treatment an overall rating was calculated as follows:

$$\text{Disease rating \%} = \frac{\text{avg of numerical ratings of individual plants} \times 100}{5}$$

[1] Contribution No. 457 Research Station, Canada Department of Agriculture, Winnipeg 19, Manitoba.

[2] Plant Pathologist.

The percentage of smutted heads was usually based on counts of 200 heads per row; but when infection was very heavy, assessments were based on 100 heads. Most of the results are given as means of eight replicates, four from each planting site. The wheat bunt tests (Series A and C) are means of four replicates at Brandon.

Results and discussion

Bunt infection at Morden was negligible due to heavy rain and therefore results from these tests are not inlcuded. Smut infection of the untreated checks varied from 6.5% to 22.0% for wheat, 3.9% to 9.3% for oats, and 1.3% to 2.3% for barley. This low infection of barley was unexpected because the seed had carried a very high natural spore load. Some chemicals formulated as dusts or suspensions or liquids gave complete control of all covered smut diseases including bunt of wheat. Some of the systemic fungicides completely controlled loose smut of barley, as well. Emergence of untreated flax ranged from 30.6% to 57.7%; some seed treatments were phytotoxic (Series A, in part), some were ineffective, and others were very effective, increasing emergence up to 88.9%. Generally, seedling blight of barley was difficult to control; the best treatments increased emergence by only 8% and lowered the disease rating from 24% to 10%.

Because the low incidence of barley with covered smut made assessment difficult, the results with oat smut, which is more difficult to control, can be used as an indicator.

The results show that the systemic fungicides Benlate and Vitavax gave good control of all smut diseases, including loose smut of barley against which mercurials are ineffective. These products are dusts but Vitaflo is a suspension suitable for use in liquid-type seed treaters. Polyram Liquid controls bunt of wheat but requires further testing for use on oats and barley. Polyram, Res-Q, and Agrox NM are registered products (dusts) that give good control of all smut diseases except the loose smuts; they also improve flax emergence, and decrease seedling blight of barley. Dual Purpose Res-Q and Mergamma NM have the same properties but in addition they are used for control of wireworms. As there are many coded products giving effective control of the fungus diseases, it appears that there are products to replace mercurials.

Table 1. Seed treatment materials used in the cooperative test (Series A)

Treatment no.	Source*	Product name	Chemical name
1		Untreated check	
2-11	Merck	"TN-702-269-"	identity not available
12-21	Green Cross	"SWF-"	identity not available
22-29	Chipman	"TF-"	identity not available
30-39	Nor-Am	"EP-"	identity not available
40-42	Niagara	BEJ 15	identity not available
43-47	Niagara	Liquid Polyram	zinc activated polyethylene thiuram disulfide (30%)
48,49	Niagara	Polyram	zinc activated polyethylene thiuram disulfide (53.5%)
50,51	Du Pont	Manzate D	maneb (80%)
52,53	Du Pont	Benlate	benomyl(methyl 1-[butylcarbamoyl]-2-benzimidazole carbamate) (50%)
52,53	Du Pont	Manzate D	maneb (80%)
54	Du Pont	Arasan 75	thiram (75%)
55,56	Du Pont	Arasan 75	thiram (75%)
55,56	Du Pont	Benlate	benomyl (50%)
57	Du Pont	Arasan 75	thiram (75%)
58	Chipman	Agrox NM	maneb (37.5%) + hexachlorobenzene (10%)
59	Nor-Am	Panogen 15B	methylmercuric dicyandiamide (3.7 oz/gal)
60		Untreated check	

* Merck & Co., Inc., Rathway, New Jersey; Green Cross Products, CIBA Co., Ltd. Montréal, Québec; Chipman Chemicals Ltd., Hamilton, Ontario; Nor-Am Agricultural Products, Inc., Woodstock, Illinois; Niagara Chemicals, Burlington, Ontario; E.I. Du Pont de Nemours & Co., Inc., Wilmington, Delaware.

Table 2. Seed treatment materials used in the cooperative test (Series B)

Treatment no.	Source*	Product name	Chemical name
61		Untreated check	
62	Interprovincial	TCMTB	2-(thiocyanomethylthio)benzothiazole
63	Du Pont	Arasan 75	thiram (75%)
64	Du Pont	Arasan 42-S	thiram (42%)
65	Du Pont	Arasan 70-S	thiram (70%)
66	Du Pont	Benlate	benomyl (50%)
67	Du Pont	Benlate T	benomyl + thiram
68	Uniroyal	Vitavax 201	Vitavax(5,6-dihydro-2-methyl-1,4-oxathiin-3-carboxanilide) + zineb
69	Uniroyal	Vitaflo	Vitavax (17.3% a.i.) + thiram (15.4%)
70	Du Pont	Manzate D	maneb (80%)
71	Du Pont	Manzate 200	mancozeb(zinc coordinated maneb) (80%)
72	Niagara	Polyram	zinc activated polyethylene thiuram disulfide (53.5%)
73	Green Cross	Res-Q	hexachlorobenzene (20%) + captan (20%) + maneb (15%)
74	Chipman	Agrox NM	maneb (37.5%) + hexachlorobenzene (10%)
75	Chipman	Mergamma NM	maneb (37.5%) + lindane (18.75%)
76	Green Cross	Dual Purpose Res-Q	hexachlorobenzene (16%) + captan (16%) + maneb (12%) + lindane (30%)
77	Nor-Am	Panogen 15B	methylmercuric dicyandiamide (3.7 oz/gal)
78	Du Pont	Ceresan M	ethyl mercury p-toluene sulfonanilide (7.7%)
79	Nor-Am	Panogen PX	methylmercuric dicyandiamide (0.9%)
80	Standard	Formaldehyde	formaldehyde (37% w/w)

* Interprovincial Cooperatives Ltd., Winnipeg, Manitoba; E.I. Du Pont de Nemours & Co., Inc., Wilmington, Delaware; Uniroyal Chemical Division, Elmira, Ontario; Niagara Chemicals, Burlington, Ontario; Green Cross Products, CIBA Co., Ltd., Montréal, Québec; Chipman Chemicals Ltd., Hamilton, Ontario; Nor-Am Agricultural Products, Inc., Woodstock, Illinois; Standard Chemical Co., Winnipeg, Manitoba.

Table 3. Seed treatment materials used in the cooperative test (Series C)

Treatment no.	Source*	Product name	Chemical name
81		Untreated check	
82-86	Interprovincial	TCMTB	2-(thiocyanomethylthio)benzothiazole
87,88	Uniroyal	Vitavax #1	5,6-dihydro-2-methyl-1,4-oxathiin-3-carboxanilide
89-92	Uniroyal	Vitavax #2, #3	Vitavax + maneb
93-95	Uniroyal	Vitavax #4	Vitavax + thiram
96	Uniroyal	Vitaflo	Vitavax (17.3% a.i.) + thiram (15.4%)
97	Du Pont	Arasan 50-Red	thiram (50%)
98	Chemagro	B1843 (50%)	trans-1,2 bis(n-propylsulfonyl)ethylene
99,100	Rohm & Haas	"RHC-"	identity not available

* Interprovincial Cooperatives Ltd., Winnipeg, Manitoba; Uniroyal Chemical Division, Elmira, Ontario; E.I. Du Pont de Nemours & Co., Inc., Wilmington, Delaware; Chemagro Corporation, Kansas City, Missouri; Rohm & Haas Co. of Canada Ltd., West Hill, Ontario.

Table 4. Results of cooperative seed treatment trials (Series A)*

Treatment no.	Product name	Formulation**	Dosage (oz/bu)	Smutted heads (%)			Barley seedling blight		Flax	
				Wheat*	Oats	Barley	Emergence (%)	Disease rating (%)	Dosage (oz/bu)	Emergence (%)
1	Untreated check			8.66	9.25	2.32	63.9	24.3		50.1
2	TN-702-269-1	L	1.00	0.00	0.00	0.04	63.3	14.4	2.00	44.4
3	TN-702-269-1		2.00	0.00	0.00	0.00	64.0	17.1	4.00	32.4
4	TN-702-269-2	L	1.00	0.00	0.22	0.00	61.2	18.2	2.00	50.6
5	TN-702-269-2		2.00	0.00	0.00	0.12	66.1	20.2	4.00	41.4
6	TN-702-269-3	L	1.00	0.32	0.00	0.00	62.6	22.3	2.00	47.9
7	TN-702-269-3		2.00	0.14	0.00	0.00	63.3	21.0	4.00	40.8
8	TN-702-269-4	L	1.00	0.14	0.00	0.08	61.8	17.8	2.00	44.8
9	TN-702-269-4		2.00	0.00	0.00	0.00	64.1	15.5	4.00	33.4
10	TN-702-269-5	L	1.00	0.00	0.04	0.04	67.9	14.4	2.00	49.1
11	TN-702-269-5		2.00	0.14	0.00	0.04	63.6	14.5	4.00	40.6
12	SWF 1150	D	1.00	0.00					4.00	82.4
			2.00		0.32	0.00	65.9	13.0		
13	SWF 2250	D	1.00	0.00					4.00	81.3
			2.00		0.20	0.00	68.8	18.1		
14	SWF 2330	D	1.00	0.00					4.00	80.5
			2.00		0.00	0.00	65.6	14.9		
15	SWF 2340	D	1.00	0.00					4.00	76.3
			2.00		0.00	0.00	68.3	13.2		
16	SWF 2350	D	1.00	0.00					4.00	80.5
			2.00		0.00	0.04	70.2	15.8		
17	SWF 2360	D	1.00	0.11					4.00	71.3
			2.00		0.05	0.00	65.6	25.9		
18	SWF 2370	D	1.00	0.23					4.00	74.3
			2.00		0.22	0.00	67.1	16.0		
19	SWF 2380	D	1.00	0.53					4.00	75.1
			2.00		0.68	0.03	65.6	18.8		
20	SWF 2390	D	1.00	0.11					4.00	88.4
			2.00		0.99	0.17	68.2	20.5		
21	SWF 2400	D	1.00	0.78					4.00	72.9
			2.00		0.00	0.00	70.4	17.6		
22	TF 3018	D	2.00	0.00	0.08	0.00	64.5	17.6	4.00	86.6
23	TF 3019	D	2.00	0.00	0.22	0.00	66.3	16.3	4.00	74.8
24	TF 3020	D	2.00	0.11	0.41	0.00	68.9	19.6	4.00	80.1
25	TF 3021	D	2.00	0.00	0.04	0.00	68.3	16.7	4.00	81.1
26	TF 3022	D	2.00	0.00	0.00	0.00	68.0	22.0	4.00	76.8
27	TF 3023	D	2.00	0.00	0.00	0.03	70.5	18.4	4.00	72.0
28	TF 3024	D	2.00	0.00	0.10	0.00	65.3	17.8	4.00	80.1
29	TF 3025	D	2.00	0.00	0.00	0.00	68.4	18.4	4.00	86.6
30	EP 406-B	SL	1.00	2.57	4.92	2.00	58.3	21.1	2.00	46.4
31	EP 406-B	SL	1.50	0.39	0.26	1.78	59.0	21.3	3.00	46.3
32	EP 406-B	SL	3.00	0.26	0.28	0.72	56.0	21.8	4.00	48.6
33	EP 407-B	SL	0.50	0.97	0.00	2.10	63.9	22.7	1.00	50.9
34	EP 407-B	SL	1.00	3.28	0.94	1.62	61.4	20.0	2.00	49.5
35	EP 461-A	SL	1.00	0.00	2.58	1.44	61.4	23.6	2.00	44.6
36	EP 461-A	SL	2.00	0.11	0.37	0.35	56.2	26.8	3.00	47.5
37	EP 461-A	SL	4.00	0.00	0.00	0.00	58.8	23.9	4.00	46.3
38	EP 493	SL	0.50	0.11	1.87	0.11	63.7	19.9	1.00	82.3
39	EP 493	SL	1.00	0.00	0.04	0.00	65.5	18.8	2.00	77.8
40	BEJ-15EC	L	1.00	0.00	0.04	1.15	54.7	18.9	2.00	47.5
41	BEJ-15EC	L	2.00	0.00	0.00	0.50	50.1	14.3	4.00	42.8
42	BEJ-15EC	L	3.00	0.76	0.00	0.66	45.1	20.3	6.00	38.8
43	Liquid Polyram	L	1.00	0.11	0.73	0.42	62.5	24.4	2.00	67.1
44	Liquid Polyram	L	1.50	0.00	0.00	0.00	64.2	19.1	3.00	81.0
45	Liquid Polyram	L	2.00	0.00	1.83	0.00	65.6	21.5	4.00	77.0
46	Liquid Polyram	L	2.50	0.00	0.26	0.17	64.9	17.1	5.00	72.9
47	Liquid Polyram	L	3.00	0.00	0.08	0.13	56.6	16.8	6.00	73.8
48	Polyram 53.5	D	1.00	0.00	1.24	0.05	67.1	17.9	2.00	68.3
49	Polyram 53.5	D	2.00	0.00	0.69	0.05	65.2	19.2	4.00	78.5
50	Manzate D	WP	1.00	0.00	0.00	0.00	71.4	16.9	1.50	83.0
51	Manzate D	WP	2.00	0.00	0.04	0.00	67.6	15.4	3.00	80.9
52	Benlate +	WP	2.00	0.14	0.00	0.00	59.2	23.4	2.00	71.3
	Manzate D	WP	1.00						1.00	
53	Benlate +	WP	4.00	0.00	0.00	0.00	56.4	16.1	3.00	73.5
	Manzate D	WP	2.00						2.00	

Table 4 (Cont'd.)

Treatment no.	Product name	Formulation**	Dosage (oz/bu)	Smutted heads (%) Wheat*	Oats	Barley	Barley seedling blight Emergence (%)	Disease rating. (%)	Flax Dosage (oz/bu)	Emergence (%)
54	Arasan 75	WP	1.00	0.12	0.74	0.04	64.7	18.0	2.00	88.9
55	Benlate +	WP	2.00	0.00	0.00	0.00	55.4	22.4	2.00	67.5
	Arasan 75	WP	1.00						1.00	
56	Benlate +	WP	4.00	0.00	0.00	0.00	56.2	29.6	3.00	66.3
	Arasan 75	WP	2.00						2.00	
57	Arasan 75	WP	2.00	0.00	0.32	0.04	65.6	17.9	3.00	71.4
58	Agrox NM	D	1.00	0.00					4.00	78.3
			2.00		0.21	0.00	63.6	17.8		
59	Panogen 15B	L	0.75	0.00	0.00	0.00	68.8	15.4	1.50	80.4
60	Untreated check			6.48	3.88	1.32	65.6	22.0		57.7

* Results for wheat bunt are from the test at Brandon only. All other results are from tests at Brandon and Morden.

** Formulation code: L = liquid; D = dust; SL = slurry; WP = wettable powder.

Table 5. Results of cooperative seed treatment trials (Series B)*

Treatment no.	Product name	Formulation**	Dosage (oz/bu)	Smutted heads (%) Wheat	Oats	Barley	Barley seedling blight Emergence (%)	Disease rating (%)	Flax Dosage (oz/bu)	Emergence (%)
61	Untreated check			18.57	9.32	2.08	64.6	24.1		36.0
62	TCMTB	L	0.90	0.00	0.00	0.00	63.7	22.3	1.80	43.5
63	Arasan 75	WP	1.33	0.06	0.46	0.22	64.3	18.8	2.00	45.6
64	Arasan 42S	SU	2.40	0.06	1.71	0.05	63.9	22.9	3.00	47.5
65	Arasan 70S	SL	1.43	0.19	1.96	0.16	64.3	16.5	2.00	50.3
66	Benlate	WP	2.00	0.00	0.00	0.00	61.2	33.2	3.00	30.4
67	Benlate T	WP	3.33	0.00	0.00	0.00	66.3	26.3	3.33	46.1
68	Vitavax 201	D	2.63	0.00	0.00	0.00	70.2	11.2	4.00	49.5
69	Vitaflo	SU	2.55	0.00	0.12	0.00	68.1	17.6	4.25	43.5
70	Manzate D	D	2.00	0.00	0.00	0.00	70.9	11.0	3.00	58.4
71	Manzate 200	D	2.00	0.06	0.10	0.08	68.3	12.5	3.00	59.9
72	Polyram	D	1.00	0.19					4.00	52.6
	Polyram		2.00		2.54	0.00	66.3	17.7		
73	Res-Q	D	1.00	0.00					4.00	44.0
	Res-Q		2.00		0.52	0.00	69.6	16.4		
74	Agrox NM	D	1.00	0.06					4.00	56.5
	Agrox NM		2.00		0.00	0.00	66.5	14.1		
75	Mergamma NM	D	2.00	0.06	0.04	0.00	65.1	18.3	4.00	51.5
76	Dual Purpose Res-Q	D	1.25	0.00					5.00	50.3
	Dual Purpose Res-Q		2.50		1.98	0.00	67.3	19.6		
77	Panogen 15B	L	0.75	0.06	0.08	0.00	67.8	13.8	1.50	57.8
78	Ceresan M	D	0.50	0.00	0.00	0.00	66.7	10.8	1.50	50.8
79	Panogen PX	D	2.00	0.13	0.00	0.12	66.9	10.2	5.50	48.5
80	Formalin 1/320	L				0.57	31.2	11.8		
81	Untreated check			21.96						

* Means of tests at two locations: Brandon and Lethbridge for wheat bunt, Brandon and Morden for all other tests.

** Formulation code: L = liquid; WP = wettable powder; SU = suspension; SL = slurry; D = dust.

Table 6. Results of cooperative seed treatment trials (Series C)*

Treatment no.	Product name	Formulation**	Dosage (oz/bu)	Smutted heads (%) Wheat*	Oats	Barley	Barley seedling blight Emergence (%)	Disease rating (%)	Flax Dosage (oz/bu)	Flax Emergence (%)	Barley loose smut (%)
61	Untreated check			8.90	7.46	2.30	64.1	24.9		30.6	6.40
66	Benlate	WP	2.00								1.48
67	Benlate T	WP	3.33								1.12
68	Vitavax 201	D	2.63								0.25
82	2364 1	L	0.45	0.00	0.22	0.19	63.5	23.9	0.90	35.3	
83	2364 1	L	0.68	0.55	0.00	0.11	67.4	24.4	1.36	35.0	
84	2364 1	L	0.90	0.00	0.00	0.08	66.5	26.2	1.80	38.0	
85	2364 d	D	2.40	0.00	0.14	0.00	62.9	25.9	2.40	34.1	
86	2364 d	D	3.60	1.79	0.10	0.00	64.2	22.1	3.60	30.6	
87	Vitavax #1	SU	1.35	0.00	0.14	0.00	66.5	21.6	2.70	36.8	1.44
88	Vitavax #1	SU	1.80	0.61	0.00	0.00	64.1	21.3	3.60	35.3	0.25
89	Vitavax #2	SU	2.40	0.00	0.80	0.00	63.7	23.0	2.40	41.1	0.10
90	Vitavax #2	SU	3.60	0.00	0.00	0.00	63.2	17.2	3.60	41.8	0.00
91	Vitavax #2	SU	4.80	0.00	0.00	0.00	61.1	20.3	4.80	39.9	0.00
92	Vitavax #3	SU	2.55	0.00	0.00	0.00	65.1	19.4	2.55	39.3	0.04
93	Vitavax #4	SU	2.40	0.32	0.00	0.00	62.8	23.3	2.40	38.8	0.52
94	Vitavax #4	SU	3.60	0.00	0.00	0.00	62.5	18.3	3.60	43.4	0.04
95	Vitavax #4	SU	4.80	0.00	0.00	0.00	62.5	22.5	4.80	41.9	0.08
96	Vitaflo	SU	2.55	0.00	0.00	0.00	66.9	24.9	2.55	38.5	0.04
97	Arasan 50 red	D	2.00	0.00	0.40	0.00	66.6	21.5	3.00	41.6	
98	B 1843	WP	2.00		0.30	0.00	66.9†	24.2†	3.00	41.8†	
99	RHC 501	D	2.00		0.41†	0.00†	67.0†	20.3†	4.00	47.8†	
100	RHC 502	D	2.00		0.63†	0.00†	69.1†	22.6†	4.00	47.3†	
101	Untreated check				7.27†	1.58†	64.6†	23.4†		29.8†	

* The results for wheat bunt are from the test at Brandon only. Results marked † are from tests at Morden only. The remaining figures are from tests at Brandon and Morden.

** Formulation code: WP = wettable powder; D = dust; SU = suspension.

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AIR–BORNE RUST INOCULUM OVER WESTERN CANADA IN 1970[1]

G. J. Green [2]

The amount of rust inoculum in Western Canada in 1970 was investigated by the same method used in previous years. Vaseline-coated microscope slides were exposed at six locations in Manitoba and Saskatchewan in spore traps that held the coated surface at an angle of 45° from the vertical. Care was taken to prevent contamination of the slides during preparation at Winnipeg. They were sent to the spore trap locations, except Saskatoon, in protective wooden frames wrapped in paper. After the 48-hour exposure they were returned to Winnipeg where urediospores were counted by means of a microscope. Slides exposed at Saskatoon were prepared and examined by the staff of the Canada Department of Agriculture Research Station, Saskatoon, Sask.

There was abundant rust inoculum in Western Canada in 1970. Despite the excellent stem rust resistance and moderate leaf rust resistance of the wheat varieties grown in the rust area, more spores were trapped than in any year since 1964. The influence of the oat crop on the number of spores caught is uncertain. The oat varieties grown are susceptible to stem rust and crown rust. Heavy infections of both rusts developed in late fields in Manitoba and south-eastern Saskatchewan, especially in the Red River Valley. This epiphytotic probably contributed many of the spores caught after mid-August at Winnipeg and Morden. Many of the leaf rust spores caught at Regina and Saskatoon were probably produced on susceptible Thatcher wheat in Saskatchewan.

A few leaf rust spores were caught in May (Table 1) but air-borne spores were unimportant at that time because the crop in Manitoba and south-eastern Saskatchewan was planted very late. It was June 24 before the Dominion Bureau of Statistics reported that seeding was nearly complete in Manitoba. The

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 1970

	Winnipeg		Morden		Brandon		Indian Head		Regina		Saskatoon	
Date	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 19-20	0	0	0	0	0	0	0	0			0	0
21-22	0	0	0	0	0	0	0	0	0	0	0	0
23-24	0	1	0	0	0	0	0	1	0	0	0	0
25-26	0	1	0	0	0	0	0	0	0	0	0	0
27-28	0	1	0	0	0	0	0	0	0	0	0	0
29-30	0	0	0	0	0	0	0	0	0	0	0	0
31- 1	0	0	0	0	0	0	0	0	0	0	0	0
May Total	0	3	0	0	0	0	0	1	0	0	0	0
June 2- 3	0	0	0	0	0	0	0	0	0	0	0	0
4- 5	0	0	0	0	0	0	0	0	0	0	0	0
6- 7	0	0	0	27	0	2	0	0	0	0	0	0
8- 9	2	156	5	165	0	11	0	4	1	1	0	0
10-11	0	2	0	0	0	0	0	2	0	0	0	0
12-13	0	0	1	0	0	0	0	0	0	5	0	0
14-15	0	0	0	0	0	0	0	0	0	1	0	0
16-17	0	0	0	0	0	0	0	1	0	0	0	0
18-19	0	1	0	0	0	0	0	0	0	0	0	0
20-21	0	0	0	0	0	0	0	5	0	0	0	0
22-23	4	9	0	66	1	3	0	0	0	0	0	0
24-25	0	0	0	2	0	5	0	4	0	2	0	0
26-27	5	27	2	22	2	15	0	20	2	20	0	4
28-29	0	0	0	0	1	11	0	4	0	0	0	7
30- 1	2	7	4	22	1	23	0	0	0	0	0	1
June Total	13	202	12	304	5	70	0	40	3	29	0	12

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[2] Plant Pathologist.

Table 1 (Cont'd.)

Date	Winnipeg Stem rust	Winnipeg Leaf rust	Morden Stem rust	Morden Leaf rust	Brandon Stem rust	Brandon Leaf rust	Indian Head Stem rust	Indian Head Leaf rust	Regina Stem rust	Regina Leaf rust	Saskatoon Stem rust	Saskatoon Leaf rust
July 2- 3	0	1	0	4	0	0	0	1	0	0	0	25
4- 5	0	0	0	0	0	2	0	14	2	6	0	84
6- 7	0	2	0	4	0	1	0	4	0	4	0	63
8- 9	0	1	0	1	0	0	4	22	0	2	0	19
10-11	0	1	11	50	0	1	0	1	0	1	0	20
12-13	0	1	0	0	0	0	0	0	0	13	0	0
14-15	0	1	0	8	0	1	0	12	1	16	0	9
16-17	0	16	0	0	0	0	2	48	5	18	0	15
18-19	0	5	0	0	0	0	0	0	0	4	0	16
20-21	223	839	5	16	2	48	0	6	2	119	0	110
22-23	401	1307	86	315	7	23	0	4	4	16	0	107
24-25	1	1	5	26	0	14	0	13	1	36	0	158
26-27	4	22	0	0	0	4	14	75	22	93	0	338
28-29	2	16	1	5	0	1	11	101	19	214	0	352
30-31	15	144	21	172	6	89	21	422	15	376	0	365
July Total	646	2357	129	601	15	184	52	723	71	918	0	1681
Aug. 1- 2	13	184	4	7	14	370	28	559	43	1249	0	784
3- 4	5	36	46	401	6	66	5	162	27	954	0	184
5- 6	59	305	156	1157	22	120	15	516	28	2180	0	167
7- 8	60	219	213	2311	60	1027	17	400	2	422	4	276
9-10	22	381			72	1678	2	109	13	641	0	376
11-12	84	509	417	5450	19	413	57	866	63	4045	24	695
13-14	345	1555	561	3696	47	1304	8	480	9	148	8	175
15-16	135	517	118	758	53	438	83	724	79	1667	36	701
17-18	575	3787	955	2941	176	1211	22	298	50	469	7	212
19-20	409	762	375	701	101	628	128	994	56	1389	17	135
21-22	203	257	371	1519	133	292	43	313	28	287	1	268
23-24	731	3453	496	3113	281	1689	82	225	233	831	21	359
25-26	2048	3764	2816	4409	1410	2400	718	1431	874	4107	91	204
27-28	414	424	255	302	814	1511	193	367	43	113	35	40
29-30	59	83	34	83	84	226	74	139	163	1039	4	19
31- 1	154	171	65	91	81	199	96	26	21	36		
Aug. Total	5316	16,407	6882	26,939	3373	13,572	1571	7609	1732	19,577	248	4595
TOTAL	5975	18,969	7023	27,844	3393	13,826	1623	8373	1806	20,524	248	6288

first spore shower occurred on June 6-9 with most spores falling in Manitoba. Spores were not caught again in quantity until June 22. Wheat leaf rust was first found on June 22 and stem rust on June 23. Leaf rust infections in early fields and stem rust infections on wild barley (Hordeum jubatum L.) could have produced some of the spores that were caught but the comparatively large number of stem rust spores suggests that inoculum was brought in from the south. Stem rust was not observed commonly on wild barley until early August. Apparently most of the large numbers of spores caught on July 20-23 were from the south but most of the large and increasing numbers of spores caught after the end of July probably originated locally.

STEM RUST OF OATS IN CANADA IN 1970[1]

J. W. Martens[2]

Prevalence and crop losses in Western Canada

In 1970 stem rust of oats caused by Puccinia graminis Pers. f. sp. avenae Eriks. & E. Henn. was first found in Manitoba on July 20 and it developed rapidly to produce the most severe epidemic since 1955. Abundant inoculum combined with a considerable acreage of late-seeded oats resulted in heavy losses. Stem rust infections of over 30% were common in Manitoba and eastern Saskatchewan before the crop had reached the dough stage; infections of up to 80% occurred in some late fields in Manitoba. Light infections of rust occurred as far west as Assiniboia, Sask., and northward beyond Nipawin, Sask. Preliminary estimates of combined crown and stem rust damage in Manitoba indicate losses in excess of 10 million bushels, and more than half of the loss is attributable to stem rust.

Uniform rust nurseries

Oat stem rust infections were relatively light in rust nurseries grown at 35 locations across Canada (Table 1). Rust was observed in only 9 of the nurseries, and infections of 20% or more occurred only at Kentville, N.S., and Brandon and Morden, Man. The infections in Manitoba and Saskatchewan nurseries are not indicative of the considerably heavier infections observed in fields during extensive disease surveys in these areas late in the growing season.

Identification and distribution of physiologic races

Physiologic races were identified by the methods used in previous years (1). In addition to varieties with the genes listed in Table 2, a supplementary set consisting of 'Kyto' (pg 12), 'Saia', and 'R. L. 2926' (pg 13) (2) was used. All 256 isolates were avirulent on Kyto and Saia; two cultures of race C1 from Manitoba and one culture of race C16 from Nova Scotia were virulent on R.L. 2926. Physiologic race C10 continued to predominate (67% of all isolates) in Western Canada (Table 2); race C20, previously found only in trace amounts in 1966, and race C23, first found in 1969, comprised 17% and 11%, respectively, of all isolates from this region. Races C3 and C5, once dominant, have almost disappeared. In Eastern Canada, race C10 appears to have increased but the number of isolates is too small to attach any signigicance to this indication. The discovery of two races, C1 from Manitoba and

Table 1. Percentage infection by Puccinia graminis f. sp. avenae on 12 oat varieties at 9 uniform rust nurseries* in Canada in 1970

Locality	Bond	Trispernia	Landhafer	CI 4023	Saia	Rodney ABDH	CI 3034	Rodney	Harmon	R.L. 2924	R.L. 2925	R.L. 2926
Indian Head, Sask.	0	tr**	0	0	0	0	0	tr	0	0	0	0
Brandon, Man.	20	tr	0	0	0	0	0	tr	tr	5	5	tr
Morden, Man.	20	tr	tr	5	tr	10	3	30	40	10	5	tr
The Pas, Man.	tr	0	0	0	0	0	0	10	10	5	tr	0
Guelph, Ont.	tr	0	0	0	0	tr	0	0	0	0	0	0
Thunder Bay, Ont.	tr	0	0	tr	0	0	0	0	0	0	20	0
Appleton, Ont.	tr	0	0	0	0	5	0	5	tr	tr	0	tr
New Liskeard, Ont.	10	0	0	0	0	0	0	tr	0	tr	0	tr
Kentville, N.S.	0	0	0	tr	0	0	0	5	0	20	tr	0

* No rust was observed in 23 other nurseries located at Agassiz and Creston, B.C.; Edmonton, Beaverlodge, Lacombe, and Lethbridge, Alta.; Scott and Melfort, Sask.; Apple Hill, Kemptville, New Liskeard, Ottawa, and Vineland, Ont.; L'Assomption, Lennoxville, Macdonald College, Normandin, Québec, and La Pocatière, Qué.; Truro, N.S.; Fredericton, N.B.; Charlottetown, P.E.I.; and St. John's, Nfld.

** tr = trace infection

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[2] Plant Pathologist.

Table 2. Distribution of physiologic races of oat stem rust in Canada in 1970

Race formula no.	Virulence formula (effective/ineffective Pg host genes)	No. of isolates from N.S.	Ont.	Man.	Sask.	Total isolates	Percentage of total isolates
	A) Combined isolates from all hosts (B + C)						
C1	1, 2, 3, 4, 8/9			2		2	0.8
C3	2, 8/1, 3, 4, 9			5		5	2.0
C5	4, 9/1, 2, 3, 8			2	2	4	1.6
C8	3, 8/1, 2, 4, 9		2			2	0.8
C9	8/1, 2, 3, 4, 9	1	8			9	3.5
C10	9/1, 2, 3, 4, 8		8	121	36	165	64.4
C16	1, 4, 8/2, 3, 9	1				1	0.4
C20	/1, 2, 3, 4, 8, 9		2	28	11	41	16.0
C23	2, 4, 9/1, 3, 8			14	13	27	10.5
Total		2	20	172	62	256	
	B) Isolates from cultivated oats with stem rust resistance						
C1				2		2	1.3
C3				2		2	1.3
C8			1				0.6
C9			7			7	4.4
C10			8	79	23	110	69.6
C16		1				1	0.6
C20				24	9	33	20.7
C23				2	1	3	1.9
Total		1	16	109	33	159	
	C) Isolates from wild oats and varieties with no stem rust resistance						
C3				3		3	3.1
C5				2	2	4	4.1
C8			1			1	1.0
C9		1	1			2	2.1
C10				42	13	55	56.7
C20			2	4	2	8	8.2
C23				12	12	24	24.7
Total		1	4	63	29	97	

Table 3. Frequency of virulence in the stem rust population on various types of resistance in Canada in 1970

Geographic area	Percentage of isolates virulent on varieties with the following genes for resistance: Pg-1	Pg-2	Pg-3	Pg-4	pg-8	pg-9	pg-13	Total no. isolates	Mean* virulence capability
Eastern Canada	86.3	90.9	100.0	86.3	54.5	54.5	4.5	22	4.77
Western Canada	99.1	85.5	99.1	85.9	97.0	19.7	0.8	234	4.87

* Mean virulence capability = no. of isolates virulent on Pg-1 + . . . + pg-13/total no. of isolates.

C16 from Nova Scotia, with virulence on resistance conferred by pg 13 is significant. These are the first field isolates with virulence on this resistance; they were obtained from R. L. 2926 in the uniform rust nurseries. Evidently virulence on pg 13 resistance exists in the pathogen population even though there has been no selection pressure for it in North America. However, the presence of this virulence in races such as C1 and C16 presents no immediate problem to the production of resistant varieties because this resistance is being used in conjunction with other types that have effective resistance to these races.

The virulence range of the rust population has been maintained at a very high level (Table 3). Only pg 8 in Eastern Canada and pg 9 and pg 13 in both Eastern and Western Canada can be considered as significantly effective. Since Pg 2 and Pg

4 are the only types of resistance present in commercial oat varieties, conditions favoring rust development could again result in serious crop losses in 1971.

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CROWN RUST OF OATS IN CANADA IN 1970[1]

G. 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 near Holland, Manitoba, on July 20th. Crown rust increased rapidly throughout the province and in adjacent areas of south-eastern Saskatchewan. By mid August the disease had reached epidemic proportions throughout most of this area. The intensity of the epidemic in fields in the vicinity of Stonewall, Manitoba, was more severe than in any naturally occurring field epidemic observed by the author since 1962.

Preliminary estimates of yield reductions due to the combined crown and stem rust epidemics on oats in Manitoba in 1970 are in excess of 10 million bushels. While it is difficult to determine the extent to which each rust contributed to the loss, crown rust was more damaging than in 1969 when it was responsible for losses of about 3.5 million bushels (1). Yield loss estimates were calculated in a previously described manner (2), and only late maturing fields were included in these calculations. The overall loss from oat rusts in Manitoba in 1970 is in excess of $5 million, at a price of $0.50 per bushel oats. Losses in Manitoba during 1969 and 1970 from rust epidemics highlight the need for the development of rust resistant oat varieties.

Rating of crown rust intensity on 12 oat (Avena sativa L.) varieties grown in nurseries in Saskatchewan, Manitoba Ontario, Quebec, and Nova Scotia are presented in Table 1. Omitted from this table are nurseries in which no crown rust was found on any of the 12 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 lines containing crown rust resistance genes Pc 38 (R.L. 2924) and Pc 39 (R.L. 2925) were not attacked by crown rust at any of the locations across Canada, and appear to afford effective protection to this disease.

Saia oats, a diploid species, also provided effective resistance in crown rust nurseries across Canada, but this resistance is more difficult to incorporate in commercial hexaploid oats because the intercrosses are often sterile.

Distribution of physiologic races

The frequency of occurrence and distribution of 25 physiologic races of crown

Table 1. Percentage infection of crown rust on 12 oat varieties at 18 localities in Canada in 1970

Location	Bond	Trispernia	Landhafer	CI 4023	Saia	Rodney ABDH	CI 3034	Rodney	Harmon	RL 2924	RL 2925	RL 2926
Indian Head, Sask.	1	0	0	0	0	tr*	0	tr	0	0	0	0
Melfort, Sask.	tr	0	tr	tr	0	0	0	tr		0	0	tr
Brandon, Man.	80	0	20	80	0	60	40	60	40	0	0	50
The Pas, Man.	tr	0	tr	tr	0	0	0	tr	tr	0	0	0
Morden, Man.	90	80	80	80	tr	80	80	100	80	0	0	70
Williamstown, Ont.	10	0	tr	tr	0	10	0	10	tr	0	0	tr
Apple Hill, Ont.	5	0	5	tr	0	tr	tr	5	5	0	0	tr
Thunder Bay, Ont.	10	0	0	10	0	5	5	5	5	0	0	10
Kemptville, Ont.	30			10	0	10	10	5	5	0	0	10
Guelph, Ont.	tr	0	tr	1	0	tr	2	1	tr	0	0	tr
Ottawa, Ont.	90	tr	tr	70	0	30	80	80	80	0	0	tr
Appleton, Ont.	80	10	10	30	0	10	20	60	60	0	0	10
New Liskeard, Ont.	90	5	10	80	0	80	50	80	90	0	0	50
Vineland, Ont.	80	20	30	80	tr	50		80	60	0	0	10
La Pocatière, Qué.	20	0	0	10	0	5	10	10	20	0	0	tr
Macdonald College, Qué.	30	0	0	20	0	5	10	20	tr	0	0	tr
Normandin, Qué.	10	0	0	tr	0	tr	tr	tr	tr	0	0	0
Kentville, N.S.	20	0	0	10	0	5	5	20	10	0	0	5

* tr = trace infection, less than 1%

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Table 2. Distribution of physiologic races of crown rust in Canada in 1970

Physiologic race	West		East		W & E Totals	
	No. of isolates	% of all isolates	No. of isolates	% of all isolates	No. of isolates	% of all isolates
202	1	0.6	1	2.0	2	0.9
203	1	0.6	6	12.0	7	3.1
210	1	0.6	3	6.0	4	1.8
216	4	2.3	12	24.0	16	7.2
226	1	0.6	1	2.0	2	0.9
236	1	0.6	0	0.0	1	0.5
239	0	0.0	1	2.0	1	0.5
241	1	0.6	0	0.0	1	0.5
259	0	0.0	2	4.0	2	0.9
264	56	33.0	6	12.0	62	27.9
274	0	0	1	2.0	1	0.5
276	5	3.0	0	0.0	5	2.2
290	1	0.6	0	0.0	1	0.9
295	15	9.0	3	6.0	18	8.1
325	29	17.0	3	6.0	32	14.4
326	44	26.0	7	14.0	51	22.9
327	3	1.7	0	0.0	3	1.3
341	1	0.6	2	4.0	3	1.3
394	1	0.6	0	0.0	1	0.5
409	1	0.6	0	0.0	1	0.5
415	1	0.6	1	2.0	2	0.9
446	1	0.6	0	0.0	1	0.5
451	0	0.0	1	2.0	1	0.5
2, 10	1	0.6	0	0.0	1	0.5
1, 3, 7, 10	1	0.6	0	0.0	1	0.5
Total races	21		15		25	
Total isolates	170		50		220	
Race:Isolate ratio	1:8		1:3.3			

Table 3. Percentage of Canadian crown rust isolates virulent on differential host varieties, 1966 to 1970

Location and year	Anthony	Victoria	Appler	Bond	Landhafer	Santa Fe	Ukraine	Trispernia	Bondvic	Saia
Western Canada										
1970	96	86	97	99	93	92	75	55	55	2
1969	92	62	93	94	82	82	87	30	30	5
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										
1970	82	66	84	92	42	42	84	18	18	0
1969	50	44	50	93	21	24	97	7	7	10
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

rust identified from 220 Canadian isolates is presented in Table 2. Although 21 physiologic races were identified in the west, four of these, 264, 295, 325, and 326, comprised 85% of the isolates. These races, as well as most of the others isolated, attacked almost all of the standard differential varieties of crown rust.

Fifteen physiologic races were identified from 50 isolates obtained from Eastern Canada. The 'Victoria-Virulent' races 203, 210, 216, 264, and 326 comprised 68% of the population. Though virulence on 'Landhafer', 'Santa Fe', Trispernia', and 'Bondvic' in the east increased markedly from previous years, it did not reach the very high levels observed in the west.

Despite some differences in the race populations of Eastern and Western Canada, the major virulent races 264 and 326, occurred in abundance in both regions. There was also a marked reduction in the occurrence of relatively avirulent biotypes of the 220 to 239 race group in both areas.

Virulence on the differential varieties

The percentage of crown rust isolates virulent on each differential variety is shown in Table 3. The situation in Eastern Canada indicates greatly increased virulence on 'Landhafer' and 'Santa Fe' which, prior to 1969, had never been attacked by more than 10% of eastern isolates. Record levels of virulence also occurred on 'Anthony', 'Victoria', 'Appler', and 'Bond', in the east.

In Western Canada, the virulence on all the differential varieties except 'Saia' was so high in 1970 that the future use of this set of varieties as crown rust differentials in Canada is no longer feasible. It is anticipated that a new set of crown rust resistance genes, each incorporated singly in isogenic lines of the variety 'Pendek', will be used to differentiate crown rust races in Canada in the future.

Acknowledgments

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LEAF RUST OF WHEAT IN CANADA IN 1970[1]

D. J. Samborski [2]

Disease development and crop losses in Western Canada

Leaf rust was first found in Manitoba on June 22, which is a little later than usual. However, the initial infection was much heavier than usual. By the end of July, leaf rust was prevalent in most of Western Canada, with moderately severe infections on common wheat (*Triticum aestivum* L.) varieties, including 'Manitou' and 'Neepawa'. Infections of 60% or more were common in fields in the dough stage.

Rust losses were difficult to estimate in 1970. Crops in much of Manitoba and eastern Saskatchewan were late, and maturity varied widely from field to field. Preliminary estimates based on field observations indicate the average loss from wheat leaf rust was about 5% of the potential yield.

Leaf rust in the rust nurseries

Ratings of leaf rust intensity on 16 wheat varieties grown at nurseries across Canada are shown in Table 1. Leaf rust was widely distributed in Canada and severe infections occurred on the susceptible variety 'Red Bobs' at a number of locations. In Manitoba and Saskatchewan, leaf rust was more severe on 'Manitou' than in previous years.

Physiologic specialization

In 1970, field collections of leaf rust were established on 'Little Club' wheat in the greenhouse and one single-pustule isolate was taken from each collection. Extensive surveys in Manitoba and Saskatchewan resulted in collections of leaf rust from most areas

Table 1. Percentage infection by *Puccinia recondita* on 16 wheat varieties in uniform rust nurseries at 23 locations in Canada in 1970

Location	Lee	Pitic 62	Selkirk	Red Bobs	Manitou	Neepawa	Kenya Farmer	R.L. 5404	Hercules	Mindum	Stewart 63	DT 316	Exchange	Frontana	Tc^6 X Transfer	R.L. 4255
Agassiz, B.C.	0	tr*	tr	10	2	tr	0	tr	0	0	0	0	0	0	0	0
Creston, B.C.	tr	30	20	80	tr	tr	tr	5	5	0	1	10	0	0	0	tr
Edmonton, Alta.	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Lacombe, Alta.	tr	tr	0	2	tr	tr	tr	0	0	0	0	0	0	0	0	0
Indian Head, Sask.	40	25	30	60	25	20	35	5	10	0	0	10	0	0	0	0
Scott, Sask.	5	5	10	20	5	5	5	15	0	0	0	0	0	0	0	0
Melfort, Sask.	40	25	25	50	20	20	20	20	5	0	0	5	0	0	0	0
Brandon, Man.	60	50	30	70	30	20	30	25	15	0	tr	5	0	0	0	0
The Pas, Man.	50	25	25	80	30	20	25	10	0	0	0	0	0	0	0	0
Morden, Man.	70	70	50	80	50	40	60	20	10	tr	tr	20	3	1	0	tr
Williamstown, Ont.	5	tr	5	60	0	0	tr	10	10	0	0	10	0	0	0	0
Kemptville, Ont.	tr	tr	tr	40	tr	tr	tr	0	0	0	0	5	0	0	0	0
Fort William, Ont.	60	35	35	80	35	30	35	25	10	0	0	5	0	0	0	0
Apple Hill, Ont.	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0
Ottawa, Ont.	10	3	tr	40	2	tr	10	5	10	0	0	tr	0	0	0	0
Appleton, Ont.	10	tr	10	50	1	tr	25	5	10	0	0	0	0	0	0	0
Vineland, Ont.	20	20	tr	60	tr	tr	25	10	15	0	0	15	0	0	0	0
La Pocatière, Qué.	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0
Québec, Qué.	5	tr	tr	60	tr	tr	5	tr	5	0	0	5	0	0	0	0
Macdonald College, Qué.	tr	0	0	30	0	0	tr	tr	5	0	0	3	0	0	0	0
Lennoxville, Qué.	tr	0	0	40	0	0	0	0	3	0	0	3	0	0	0	0
Normandin, Qué.	15	tr	0	50	tr	tr	20	tr	5	0	0	tr	0	0	0	0
Kentville, N.S.	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0

* tr = trace

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Table 2. Virulence of isolates of Puccinia recondita on backcross lines containing single genes for resistance to leaf rust in Canada in 1970

Resistance genes	No. of isolates from:							Total no. of virulent isolates	% total isolates
	Maritimes	Qué.	Ont.	Man.	Sask.	Alta.	B.C.		
Lr 1	0	0	5	1	1	0	0	7	3.4
Lr 2A	0	0	4	1	0	0	0	5	2.4
Lr 2D	5	7	14	2	0	3	7	38	18.2
Lr 3	6	6	19	80	78	6	7	202	97.1
Lr 10	5	7	14	35	37	6	7	111	53.4
Lr 16	0	0	0	7	4	2	0	13	6.3
Lr 17	0	0	0	4	1	3	5	13	6.3
Lr 18	5	7	14	16	6	0	0	48	23.1

Table 3. Virulence combinations of Puccinia recondita isolates on backcross lines containing single genes for resistance to leaf rust in Canada in 1970

Virulence formula (effective/ineffective host genes)	No. of isolates from:							Total no. of isolates
	Maritimes	Qué.	Ont.	Man.	Sask.	Alta.	B.C.	
1, 2A, 2D, 10, 16, 17, 18, /3	1	1	3	34	40	0	0	79
1, 2A, 2D, 16, 17, 18/3, 10	0	1	2	20	27	2	0	52
1, 2A, 2D, 10, 16, 17/3, 18	0	0	1	9	2	0	0	12
1, 2A, 2D, 10, 16, 18/3, 17	0	0	0	1	1	0	0	2
1, 2A, 3, 16, 17, 18/2D, 10	0	0	1	0	0	0	0	1
1, 2A, 3, 10, 16, 17/2D, 18	0	1	0	0	0	0	0	1
2A, 2D, 16, 17, 18/1, 3, 10	0	0	1	0	1	0	0	2
1, 2A, 2D, 17, 18/3, 10, 16	0	0	0	6	3	1	0	10
1, 2A, 2D, 16, 18/3, 10, 17	0	0	0	1	0	0	0	1
1, 2A, 2D, 16, 17/3, 10, 18	0	0	1	5	3	0	0	9
1, 2A, 16, 17, 18/2D, 3, 10	0	0	0	0	0	0	2	2
1, 2A, 3, 16, 17/2D, 10, 18	0	2	2	0	0	0	0	4
1, 2A, 2D, 17/3, 10, 16, 18	0	0	0	1	1	0	0	2
1, 2A, 2D, 16/3, 10, 17, 18	0	0	0	1	0	0	0	1
2A, 10, 16, 18/1, 2D, 3, 17	0	0	0	1	0	0	0	1
1, 16, 17, 18/2, 2D, 3, 10	0	0	0	1	0	0	0	1
1, 2A, 16, 18/2D, 3, 10, 17	0	0	0	0	0	2	5	7
1, 2A, 16, 17/2D, 3, 10, 18	5	4	7	0	0	0	0	16
10, 16, 17/1, 2A, 2D, 3, 18	0	0	4	0	0	0	0	4
1, 2A, 18/2D, 3, 10, 16, 17	0	0	0	0	0	1	0	1

of these provinces. Most of the collections in Manitoba and Saskatchewan were obtained from 'Manitou', which does not possess any of the seedling genes for leaf rust resistance that are present in the single-gene lines currently being used as differential hosts. This removes any influence of host selection on the distribution of virulence on these single-gene lines. It does introduce a serious bias in studies on the prevalence of virulence on 'Manitou'.

In 1970, eight single-gene backcross lines were used to study physiologic specialization in leaf rust. The distribution of virulence on the individual single-gene lines is shown in Table 2. These results are very similar to those obtained in 1969 (1). The leaf rust populations in eastern Canada, Alberta, and British Columbia are characterized by virulence on gene Lr2D. However, isolates from eastern Canada were avirulent on gene Lr17 and virulent on gene

Lr18, while those from Alberta and British Columbia were virulent on gene Lr17 and avirulent on gene Lr18.

Twenty virulence combinations were obtained in 1970 (Table 3). The majority of isolates from Manitoba and Saskatchewan were virulent on only gene Lr3 or on genes Lr3 and Lr10.

The commercial variety 'Manitou' possesses gene Lr13 that conditions an adult plant type of resistance with considerable necrosis and small, sporulating pustules. 'Manitou' was resistant to leaf rust in the field when first released but considerable levels of infection have developed on 'Manitou' in the last 2 years. In 1970, adult plants of 'Manitou' were inoculated in the greenhouse with 85 isolates of leaf rust from Manitoba and Saskatchewan. 'Manitou' was resistant to 26 isolates, moderately susceptible to 21 isolates, and susceptible to 38 isolates. These isolates were largely obtained from collections made on 'Manitou', and virulent strains of leaf rust would be expected to predominate. However, similar collections made in 1968 yielded a much lower percentage of virulent cultures (1).

Composite collections of leaf rust were used to inoculate the varieties 'Agatha', 'Transfer', 'Klein Lucero', 'Aniversario', 'Wanken', 'Rio Negro', 'El Gaucho', 'Terenzio', 'Preska', 'Timpaw', 'Timgalen', 'Agent', 'Einkorn', 'Tobari 66', 'Bonanza', 'Huelquen', 'Klein Rendidor', 'Hopps', 'Rafaela', 'Castilla', and 'Trintecinco'. Susceptible-type pustules were obtained on a number of these varieties and single pustule isolates were established. These isolates were studied on the single gene lines and the resistant varieties. The patterns of rust reactions obtained indicate that 'Timgalen' possesses only gene Lr10, 'Trintecinco' has gene Lr1, 'Tobari 66' and 'Bonanza' have gene Lr1 plus an additional gene or genes conditioning a moderate level of resistance. 'Huelquen' has one unknown gene conditioning an X reaction. 'Hopps' and 'Klein Rendidor' gave a type 2+ to 3 reaction to most isolates. 'El Gaucho' and 'Rafaela' each appear to have one gene for seedling resistance to leaf rust. Two isolates virulent on 'El Gaucho' were obtained and both isolates were virulent on 'Aniversario' which was resistant to all other isolates.

Susceptible-type pustules were not observed on 'Einkorn', 'Agent', 'Timpaw', 'Preska', 'Transfer', and 'Agatha'. Several isolates conditioning a type 1+ reaction on 'Transfer' were obtained from Nova Scotia. These isolates are probably heterozygous for virulence on gene Lr9 (2).

A number of these varieties probably possess genes for adult plant resistance and studies are in progress on those varieties where cultures virulent on seedling plants are available.

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STEM RUST OF WHEAT, BARLEY, AND RYE IN CANADA IN 1970[1]

G. J. Green [2]

Prevalence and importance in Western Canada

Wheat stem rust (*Puccinia graminis* Pers. f. sp. *tritici* Eriks. and E. Henn.) has been scarce in Western Canada in recent years. In 1970 it was more widespread and prevalent than it has been since 1965 but infections were generally moderate on susceptible plants and there was little damage to commercial fields. Urediospores were deposited in Manitoba and south-eastern Saskatchewan on June 6-9, and the first wheat stem rust infection was observed at Morden, Manitoba on June 23. Rust developed slowly on susceptible wild barley (*Hordeum jubatum* L.) and on susceptible wheat varieties in experimental plots. Moderate infections developed in a few fields of the Mexican variety Pitic 62, which is susceptible to a few uncommon races. Mere traces of rust were found in farm fields on the resistant varieties Manitou, Selkirk, and Neepawa. The resistance of the widely grown varieties delayed rust development, but by September, stem rust could be easily found on wild barley in Manitoba and much of Saskatchewan.

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

Wheat stem rust was widespread in 1970, occurring in 17 rust nurseries from British Columbia to Quebec (Table 1). However, because the epiphytotic developed slowly, infections were light in all nurseries except the one at Morden, Manitoba. Moderate infections developed on the susceptible varieties Red Bobs and Mindum, but Lee, which is susceptible to 15B, was not heavily

Table 1. Percentage infection of stem rust (*Puccinia graminis* f. sp. *tritici*) on 15 wheat varieties in uniform rust nurseries at 17 locations* in Canada in 1970

	Common wheat											Durum wheat			
Location	Red Bobs	Lee	Pitic 62	Selkirk	Manitou	Neepawa	Kenya Farmer	R.L. 5404	Thatcher[6] X Transfer	Exchange	Frontana	Mindum	Stewart 63	Hercules	D.T. 316
Creston, B.C.	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Edmonton, Alta.	tr**	0	0	0	0	0	0	0	0	0		tr	0	0	0
Melfort, Sask.	5	tr	0	0	0	0	0	0	0	0	0	0	0	0	0
Indian Head, Sask.	40	tr	0	0	0	0	0	tr	0	0	0	0	0	0	0
Brandon, Man.	60	10	0	0	0	0	0	tr	tr	tr	0	20	0	0	0
The Pas, Man.	10	tr	0	0	0	0	0	0	0	tr	0	5	0	0	0
Morden, Man.	80	5	tr	tr	tr	tr	tr	1	10	10	tr	50	0	tr	tr
Glenlea, Man.	40	10	2	tr	tr	tr	tr	tr	tr	tr	tr	tr	0	tr	tr
Thunder Bay, Ont.	10	30	0	0	0	0	0	20	1	tr	0	40	0	0	0
Guelph, Ont.	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kemptville, Ont.	tr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ottawa, Ont.	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Appleton, Ont.	tr	0	0	0	0	tr	0	0	0	0	0	0	0	0	0
New Liskeard, Ont.	50	tr	0	0	0	0	0	1	tr	20	0	20	0	0	1
Vineland, Ont.	40	tr	tr	0	0	0	0	0	0	0	0	tr	0	0	0
Macdonald College, Qué.	tr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Québec, Qué.	tr	0	0	0	0	0	0	0	0	0	0	1	0	0	0

* No rust was observed in nurseries at 15 locations: Agassiz, B.C.; Beaverlodge, Lacombe, and Lethbridge, Alta.; Scott, Sask.; Williamstown and Apple Hill, Ont.; La Pocatière, Lennoxville, and Normandin, Qué.; Kentville and Truro, N.S.; Fredericton, N.B.; Charlottetown, P.E.I.; St. John's, Nfld.

** tr = trace

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infected. Pitic 62 is susceptible to several new races but it was not heavily attacked in any nursery. The commercial varieties Selkirk, Manitou, Neepawa, Stewart 63, and Hercules were highly resistant in all nurseries. The test variety D.T. 316 and Kenya Farmer also were highly resistant. Kenya Farmer has been in the rust nurseries since 1954 and has rarely had more than a trace of stem rust. R.L. 5404, a hexaploid derivative of Aegilops squarrosa L. was infected at Thunder Bay, Ontario, (20%) but was nearly free from stem rust at all other locations. Thatcher[6] x Transfer is a leaf rust resistant Thatcher that reacts like Thatcher to stem rust. It had about the same amount of rust as Lee, the other 15B-susceptible variety. Exchange and Frontana are sources of leaf rust resistance that rarely show much stem rust.

The amount of stem rust on rye (Secale cereale L.) and barley (Hordeum vulgare L.) (Table 2) was greater than normal but slightly less than in 1969. Rye stem rust (P. graminis f. sp. secalis) continues to be widely distributed and the small amount of rust on barley probably resulted from the early maturity of the crop.

Distribution of physiologic races

Physiologic races were identified by the virulence formula method (Table 4) and by six "standard" differential hosts (Triticum aestivum L. 'Marquis' and 'Reliance'; T. durum Desf. 'Arnautka' and 'Mindum'; T. monococcum L. 'Einkorn'; and T. dicoccum Schrank 'Vernal'). Rust was collected mainly

Table 2. Percentage infection of stem rust (Puccinia graminis) on three varieties of barley and one variety of rye in uniform rust nurseries at 17 locations* in Canada in 1970

Location	Barley			Rye
	Mont-calm	Park-land	C.I. 10644	Pro-lific
Agassiz, B.C.	0	0	0	20
Creston, B.C.	40	25	10	60
Lacombe, Alta.	0	0		tr**
Brandon, Man.	1	tr	tr	0
The Pas, Man.	0	1	tr	0
Morden, Man.				1
Thunder Bay, Ont.	10	tr	tr	40
Williamstown, Ont.	0	0	0	25
Kemptville, Ont.	0	0	0	20
Ottawa, Ont.	0	0	0	40
Appleton, Ont.	1	10	5	60
Vineland, Ont.	0	0	0	50
Macdonald College, Qué.	0	0	0	25
Québec, Qué.	0	0	0	50
Kentville, N.S.	0	0	0	tr
Truro, N.S.	0	0	0	tr
Fredericton, N.B.	0	0	0	90

* No rust was observed in nurseries at 13 locations: Edmonton, Beaverlodge, and Lethbridge, Alta.; Scott, Melfort, and Indian Head, Sask.; Guelph and New Liskeard, Ont.; La Pocatière, Lennoxville, and Normandin, Qué.; Charlottetown, P.E.I.; Doyles, Nfld.

** tr = trace

Table 3. Distribution by provinces of physiologic races of Puccinia graminis f. sp. tritici collected on wheat, barley, and grasses in 1970

Virulence formula number	Physiologic race number	Number of isolates from						Total number of isolates	Percent of total isolates
		Qué.	Ont.	Man.	Sask.	Alta.	B.C.		
C1	17	1	0	1	0	0	0	2	1.0
C9	15B-1L(Can.)	0	0	1	0	0	0	1	0.5
C16	38-39	0	0	0	0	0	1	1	0.5
C17	11,56	0	2	0	0	0	1	3	1.5
C18	15B-1L(Can.)	3	5	78	39	2	0	127	62.2
C20	11	0	0	2	0	0	0	2	1.0
C27	23-59	0	0	0	0	0	1	1	0.5
C33	15B-1L(Can.)	0	4	19	11	0	0	34	16.6
C35	32-113	0	1	11	4	0	0	16	7.8
C36	48	0	0	0	1	0	0	1	0.5
C38	15B-1L(Can.)	0	0	4	5	0	0	9	4.4
C39	32-113	0	1	0	0	0	0	1	0.5
C40	32-113	0	0	1	1	0	0	2	1.0
C41	32-113	0	0	1	0	0	0	1	0.5
C42	15	0	0	1	1	0	0	2	1.0
C43	32	0	0	0	1	0	0	1	0.5
Total wheat stem rust isolates		4	13	119	63	2	3	204	100.0
Rye stem rust isolates		0	3	74	21	0	2	100	

Table 4. Virulence formulas, formula numbers, and corresponding physiologic race numbers used from 1964 to 1970

Year found	Formula number	Virulence formula (Effective/Ineffective host genes)	Physiologic race
1964	C1	1, 5, 6, 7, 9a, 9b, 10, 11, 13/8, 14, 15, 16	17
	C2	5, 6, 7, 9a, 9b, 10, 13/8, 11, 14, 15, 16	17A
	C3	5, 6, 9a, 11/7, 8, 9b, 10	29-4(Can.)
	C4	5, 6, 11/7, 15, 16	23
	C5	5, 9a, 9b, 11/6, 7, 8, 10, GB	29-1(Can.)
	C6	5, 9a, 9b, 11, GB/6, 7, 8, 10	29-2(Can.)
	C7	5, 11, GB/6, 7	48
	C8	5, 11/6, 7, GB	48A
	C9	6, 7, 8, 9a, 9b, 10, 13, 15/1, 5, 11, 14, 16	15B-1L(Can.)
	C10	6, 7, 8, GB/1, 5, 9a, 9b, 10, 11, 13, 14, 15, 16	15B-1(Can.)
	C11	6, 7, 8/5, 9a, 9b, 10, 11, GB	15B-4(Can.)
	C12	6, 7, 9a, 9b, 10, 11/5, 8	11
	C13	1, 6, 7, 10, 11, 13/5, 8, 9a, 9b, 14, 15, 16	32,113
	C14	6, 7, 10, 11/5	14,38
	C15	6, 7, 10/5, 8, 9a, 9b, 11	11,32,113
	C16	6, 7, 11/1, 5, 10, 15, 16	39
	C17	1, 6, 8, 9a, 9b, 11, 13/5, 7, 10, 15, 16	11,56
	C18	6, 8, 9a, 9b, 13, 15/1, 5, 7, 10, 11, 14, 16	15B-1L(Can.)
	C19	1, 6, 10, 11/5, 7, 15, 16	10,38
	C20	1, 7, 8, 11/5, 6, 9a, 9b, 10, 14, 15, 16	11,87
	C21	9a, 11/5, 6, 7, 8, 9b, 10	32
	C22	1, 9a, 13, 16/5, 6, 7, 8, 9b, 10, 11, 14, 15	32
	C23	/5, 6, 7, 10, 15, 16	38
1965	C24	5, 7, 9a, 9b, 10/6, 8, 11	17
	C25	/5, 6, 7, 10, 11	38
	C26	6, 7, 8, 9b, 13, 15/1, 5, 9a, 10, 11, 14, 16	15B-4(Can.)
	C27	6, 11/5, 7, 10, 15, 16	33,59
	C28	1, 6, 8, 9b, 11/5, 7, 9a, 10	18,54
	C29	1, 5, 6, 7, 9a, 10, 11/8, 9b	17
	C30	1, 9a, 9b/5, 6, 7, 8, 10, 11	29
1966	C31	5, 6, 7, 10, 11/	27
1967	C32	1, 9a, 9b, 11/5, 6, 7, 8, 10	32
1968	C33	6, 9a, 9b, 13, 15/1, 5, 7, 8, 10, 11, 14, 16	15B-1L(Can.)
	C34	1, 6, 7, 9a, 9b, 11/5, 8, 10, 13, 14, 15, 16	32
1969	C35	1, 10, 11, 13/5, 6, 7, 8, 9a, 9b, 14, 15, 16	32-113
	C36	5, 6, 7, 11/10, 15, 16	48
	C37	6, 8, 9a, 9b, 11, 13/1, 5, 7, 10, 14, 15, 16	15
1970	C38	6, 8, 9a, 9b, 13/1, 5, 7, 10, 11, 14, 15, 16	15B-1L(Can.)
	C39	1, 6, 10, 13/5, 7, 8, 9a, 9b, 11, 14, 15	32-113
	C40	1, 6, 10, 13/5, 7, 8, 9a, 9b, 11, 14, 15, 16	32-113
	C41	1, 10, 13/5, 6, 7, 8, 9a, 9b, 11, 14, 15, 16	32-113
	C42	6, 8, 9a, 9b, 11, 13, 15/1, 5, 7, 10, 14, 16	15
	C43	1, 6, 7, 8, 11/5, 9a, 9b, 10, 13, 14, 15	32

from susceptible varieties of wheat and wild grasses. The few collections from selective, resistant varieties were not an important source of bias.

In 1970, 204 isolates of wheat stem rust were identified as 16 races (Table 3), the largest number identified since 1964. Six of them are new and interesting races.

Race C18 (15B-1L) continues to predominate but its prevalence declined from 82% of the isolates in 1969 to 62% in 1970. Race C33 (15B-1L), second in order of prevalence, increased from 6.4% of the isolates in 1964 to 16.6% in 1970, and race C35 (32-113), third in prevalence, increased very slightly to 7.8% of the isolates. Races C18 and C33 do not threaten the varieties now grown in Western Canada. Race C33 was first found in 1967 and has increased steadily since then. It is like C18 except that it is virulent on varieties carrying resistance gene Sr8 that are resistant to C18. Race C35 can attack the Mexican variety Pitic 62 that has recently been licensed in Canada and it has moderate virulence on the Thatcher derivatives Manitou and Neepawa that are very important in Western Canada. It is a potential threat to Pitic 62 and under favorable conditions can develop on Manitou and Neepawa, but its failure to increase appreciably over 1969 levels suggests that it will not be important on Thatcher derivatives in future years. Race C17 (2 isolates of "standard" race 56 and one of race 11) seems

close to extinction. Race 56 predominated from 1935 to 1950 and from 1957 to 1963. It has been present in Canada each year since 1931. Race C20 (11) was one of the first races found with virulence on Manitou, but like several other races with this virulence, it seems to be disappearing.

Six new races, C38 to C43 (Table 4), were found in 1970. They are biotypes of common "standard" races and are distinguishable from older cultures of these races on the "single-gene lines". Race C38 is like race C18 (15B-1L) except that it is virulent on resistance gene Sr15. Races C39, C40, C41, and C43 are variants of the "standard" race 32-113 complex, and race C42 resembles C18 (15B-1L) except that it is avirulent on Sr11 and on Lee. The new strains differ from older ones by virulence or avirulence on a single resistance gene, showing that virulence on single resistance genes changes frequently in the rust population.

In the past year uncertainties concerning the reactions of the "single-gene lines" Marquis-Sr13 and Marquis-Sr16 have been clarified and these gene numbers have been added to formulas C22 and C33. Similarly, Sr14 and Sr15 have been added to formula C33. The variety Renown, said to carry Sr17, has been used during the past year. It will also be added to the formulas when the data warrants. The addition of information to the formulas of prevalent races is preferable to writing new formulas because it avoids a proliferation of formulas and numbers for the same races. Some genes have been left out of certain formulas because the Marquis resistance is epistatic to them and others have been left out until more data is obtained. Most of the omissions concern uncommon races.

In Tables 3 and 4, a comma between "standard" race numbers indicates separate races, a dash indicates a race group in which there is difficulty in separating the races.

In addition to the 204 isolates of wheat stem rust, 100 isolates of rye stem rust were obtained. This is the third consecutive year that rye stem rust has been prevalent in Canada.

The effectiveness of the identified resistance genes (Table 5) has not changed much in recent years because race C18 has predominated. The main change in 1970 was the reduced effectiveness of Sr8 brought about by the increased prevalence of race C33.

Table 5. Percent of total isolates avirulent on single identified resistance genes and number of avirulent races in 1970

Resistance gene	Avirulent isolates (%)	Number of avirulent races
Sr 1	13.8	8
Sr 5	1.5	2
Sr 6	90.7	13
Sr 7a	4.0	6
Sr 8	71.1	7
Sr 9a	87.2	7
Sr 9b	87.2	7
Sr 10	11.3	5
Sr 11	14.3	9
Sr 13	97.0	11
Sr 14	0	
Sr 15	80.3	4
Sr 16	0	

Composite collections of urediospores from all isolates were used to inoculate 28 varieties that had been highly resistant in earlier tests. The varieties highly resistant to the composite collections are: Frontana-K58-Newthatch II-50-17, ND264, Wis. 261, St 464, C.I. 8155, Agent, Romany, Bonny, Tama, Majus, Grandes Blances, Els 6304-6-B, Esp 518/9, R.L. 5244 (Triticum monococcum), Marquis with R.L. 5244 resistance, C.T. 928, D.T. 191, D.T. 316, D.T. 317, D.T. 320, and WRT 240 (a line of Manitou with a rye translocation). Varieties that had rare susceptible infections are: Mida-McMurachy-Exchange II-47-26, Minn. II-54-30, Minn. II-58-14, Chris, C.T. 296, C.T. 299 and Giza 144. Varieties with C.T. numbers are from the Western Canadian Spring Wheat Cooperative Test, and varieties with D.T. numbers are from the Durum Test.

Acknowledgments

The cooperation of those who cared for the rust nurseries and forwarded rust collections for race identification is gratefully acknowledged. Mr. J.H. Campbell did the technical work of the program.

IMPORTANCE OF FOLIAGE DISEASES OF WINTER WHEAT IN ONTARIO IN 1969 AND 1970[1]

W. C. James[2]

Abstract

Surveys of foliage diseases of winter wheat (Triticum aestivum L.) grown in Ontario were conducted in 1969 and 1970. Approximately 750 acres per annum, from 63 and 50 fields respectively, were sampled in proportion to the winter wheat acreage in twelve counties. The percentage leaf area affected by each disease was recorded for the top four leaves in May 1969 and the top two in June 1969 and June 1970. In May 1969 the average percentages of leaf area affected by powdery mildew on the top four leaves were 0 (flag leaf), 0.05, 0.41, and 1.14; corresponding percentages for leaf rust were 0, 0.01, 0.03, and 0.06. In June 1969, mildew affected 0.23% and 3.53% and leaf rust 0.46% and 1.08% of the areas of first (flag) and second leaves, respectively. In June 1970, the corresponding percentages for mildew were 1.47 and 3.27; and for leaf rust 3.27 and 3.53. Powdery mildew and leaf rust accounted for an average yield loss of approximately 1 to 2%. Septoria diseases were difficult to assess and consequently their importance could not be evaluated. Spindle streak mosaic decreased yield by approximately 3% and combined with barley yellow dwarf probably had the most significant effect on yield. The total loss in yield from powdery mildew, leaf rust, and spindle streak mosaic was approximately 5% per year which represents an average loss of 2 bushels/acre, worth $3.40. For the total acreage of 350,000 acres, this represents a loss of $1.25 million per annum.

Introduction

Creelman (4) concluded that most of the plant disease surveys conducted in Canada were qualitative and merely involved the collection, identification, and cataloguing of diseases occurring on plants. The results of these surveys, conducted from 1920 to 1960, have been summarized by Conners (3). However, there has been little emphasis on quantitative surveys designed to assess the incidence and severity of diseases on a particular crop with a view to estimating the consequent losses in yield.

This paper deals with a survey designed to assess the incidence and severity of foliage diseases of the winter wheat crop in Ontario in 1969 and 1970 and to determine the consequent economic loss. The crop occupied approximately 350,000 acres in 1969 and produced 15 million bushels, worth about $25 million (13). An effort was made to satisfy as many as possible of the requirements of a well conducted survey, within the practical limitations imposed, using the facilities available to the Canada Department of Agriculture.

Materials and methods

The number of segments selected per county was based on the acreage of winter wheat (Triticum aestivum L.) in the 1961 Census figures. The survey covered 12 counties (Fig. 1), in which approximately 70% of the winter wheat in Ontario is grown. The remainder of the winter wheat acreage is distributed in other counties, and it was considered that the enormous effort involved to survey this vast area was not justified. The survey area was divided into approximately 5,000 segments (each segment equivalent to approximately 1,000 acres) and segments were chosen from each county at random. A 1% sampling rate was attempted and the distribution of the 50 segments chosen was reported by James et al. (8). These segments were originally selected by the Dominion Bureau of Statistics (DBS) in 1967 to determine the yield per acre of winter wheat in Ontario. Each segment was divided into 4 approximate quarters in 1969 and one quarter was selected at random. Within the chosen quarter one field of winter wheat per farm was examined. The names and addresses of the farmers within the selected area were provided by DBS.

Aerial photographs of segments were used in conjunction with maps to increase survey efficiency by reducing the time spent in locating farms; the method is summarized below. The locations of the segments were marked on a small-scale map (Fig. 1) of the twelve counties and later transferred to a road map so that a route passing through all

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the segments could be scheduled. The road map was used to locate the area in the large-scale map (Fig. 2), which was then used to locate the exact position of the segment. Aerial photographs of the segments were obtained from the Canada Department of Energy, Mines and Resources and were used to identify farms and fields (Fig. 3). Fig. 3 represents the boxed area in Fig. 2. If it was difficult to establish the orientation of the aerial photograph, the position of a farm or any other physical feature was used as a guide to compare the photograph with the segment. Within the selected quarter of the segment, each of the farms (Fig. 3, No. 1,2,and 3) was visited and where possible one winter wheat field per farm was surveyed; if a farm had more than one field of winter wheat, one field was chosen at random. Successive quarters within segments were examined if a winter wheat field could not be found. In 1969, 63 fields were visited on two separate occasions approximately one month apart. The first sampling was conducted during the last week of May when the crops were at growth stages 8-9 (10) and the second during the last week of June when the crops were at growth stages 10.5.4-11.1 (grain milky ripe). In an effort to sample crops at the same growth stage, the earlier maturing crops in the southern counties were sampled first. In 1970 the survey was repeated, but due to shortage of time only 50 fields, on the same farms as 1969, were surveyed and only one visit was made, during the last week of June.

In 1969 the sampling system involved selecting 3 culms per acre up to a maximum of 25 culms per field; the culms were selected at equal intervals along a W pattern in the field, having chosen the site of the first sampling point using random numbers from 1 to 30; e.g. if 5 was the random number chosen, the first culm was picked 5 paces from the edge of the crop. During the May sampling, disease assessments were recorded for the laminae of the top four leaves on the culm (leaf 1 = flag leaf). For each leaf an assessment was made of the percentage of leaf area 'affected' by powdery mildew (Erysiphe graminis DC) ex Merat, spindle streak mosaic virus, and leaf rust (Puccinia recondita Rob. ex. Desm. f. sp. tritici). 'Affected' area in this context included the lesion and any yellowing associated with the disease. Any doubtful symptoms were checked by taking an infected leaf sample back to the laboratory for incubation and plating on agar to identify the causal organism. The percentage of leaf area remaining green was also assessed and a value was derived for the percentage leaf area dead due to causes other than disease. The premature chlorosis of leaves observed in some fields was recorded as dead leaf area. For the June sample only mildew and leaf rust were assessed because the symptom expression was poor for spindle streak mosaic. The assessments in June were made only for the flag and second leaves because leaves 3 and 4 were usually dead. Standard area diagrams illustrating each disease were used to achieve consistency between assessments.

In 1970, 30 culms were chosen from each field at approximately equal intervals along one diagonal, having chosen the site of the first culm at random. The top two leaves on each culm were assessed for disease, using the method employed in 1969. One visit was made during the last week of June and the first few days of July when the crops were at growth stage 11.1 to 11.2 (milky - mealy ripe). The sampling method was changed in 1970 because the method used in 1969 was very time consuming and there was also evidence that sampling 30 tillers along one diagonal was adequate for our purpose.

In this paper a primary sampling unit represents all plants within one field; a secondary unit represents a plant within a field. The secondary units selected from one field constitute a subsample, and the aggregate of the primary units selected constitutes a sample. The disease assessments were recorded in the field on 80-column sheets and the computer cards were punched directly from these sheets to save time and to avoid transcribing errors. After the data had been analysed the necessary tables were prepared by Dr. C.S. Shih, Statistical Research Services, C.D.A., Ottawa. No attempt was made to assess any diseases except those which affected the foliage.

Results and discussion

Frequency of occurrence of diseases - The frequency of occurrence of diseases found in the samples is to some extent a measure of the distribution of the pathogen. A high occurrence reflects a wide distribution of the disease, and a low occurrence suggests that the converse is true. Powdery mildew and leaf rust were recorded in all subsamples during May and June 1969 and June 1970. Therefore, on the basis of frequency of occurrence in relation to subsamples, no differences in the distribution of these diseases were detected. However, the frequency of occurrence of diseases found on particular leaves (Table 1) showed that in May 1969 a higher percentage of leaves was infected with mildew than with leaf rust. Both diseases had affected a higher percentage of lower leaves; but this phenomenon was more marked for mildew, indicating that the crops had been infected with mildew earlier in the season. However in the June 1969 assessment a higher percentage of the top two leaves were infected with leaf rust than with mildew. Thus, a changeover had occurred concerning the relative importance of mildew and leaf rust between May and June 1969. This was probably due to higher June temperatures which favored the development of leaf rust, coupled with the fact that the disease had

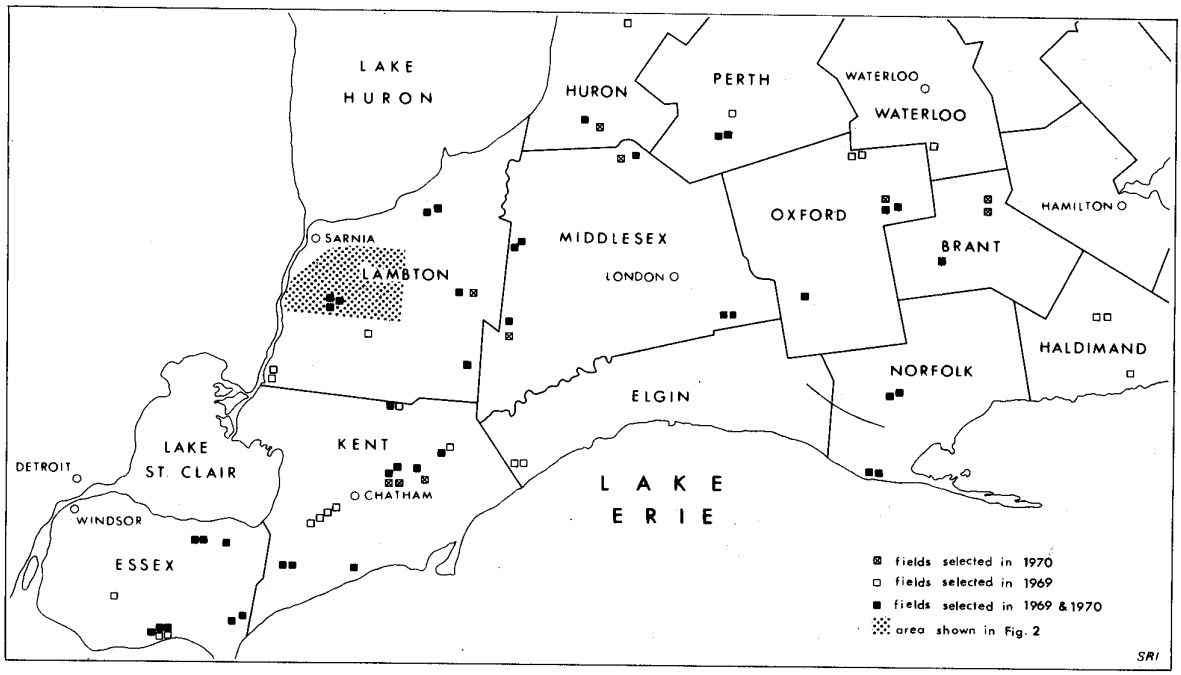

Figure 1. Location of winter wheat fields sampled in 1969 and 1970.

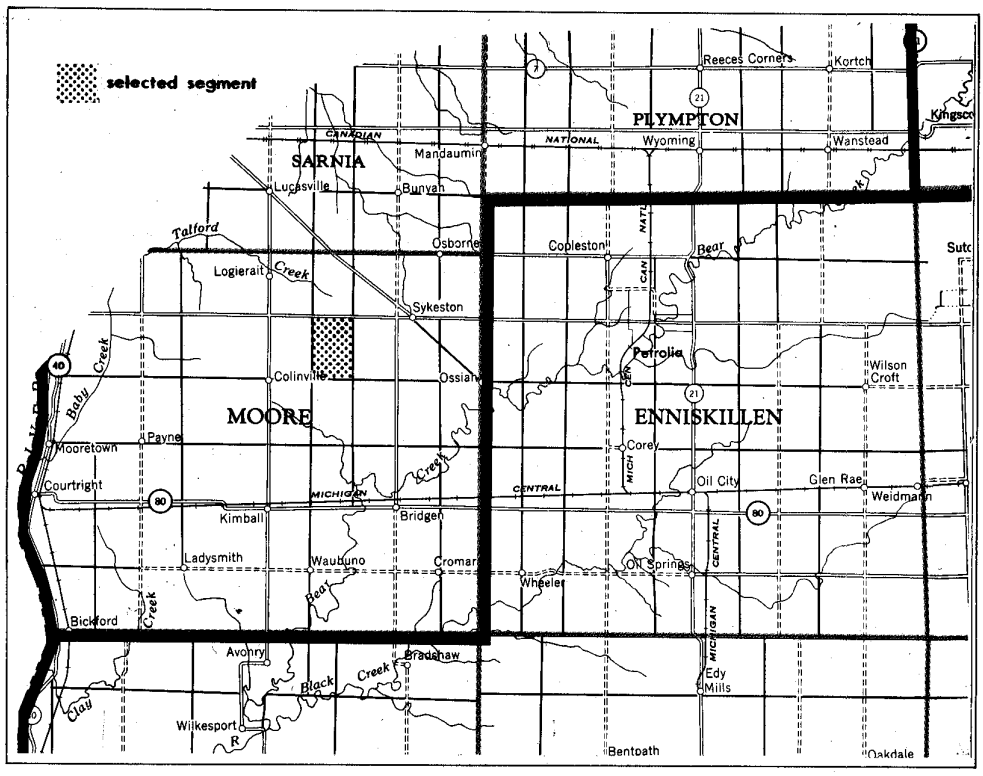

Figure 2. Detailed map showing position of a segment selected in Lambton County.

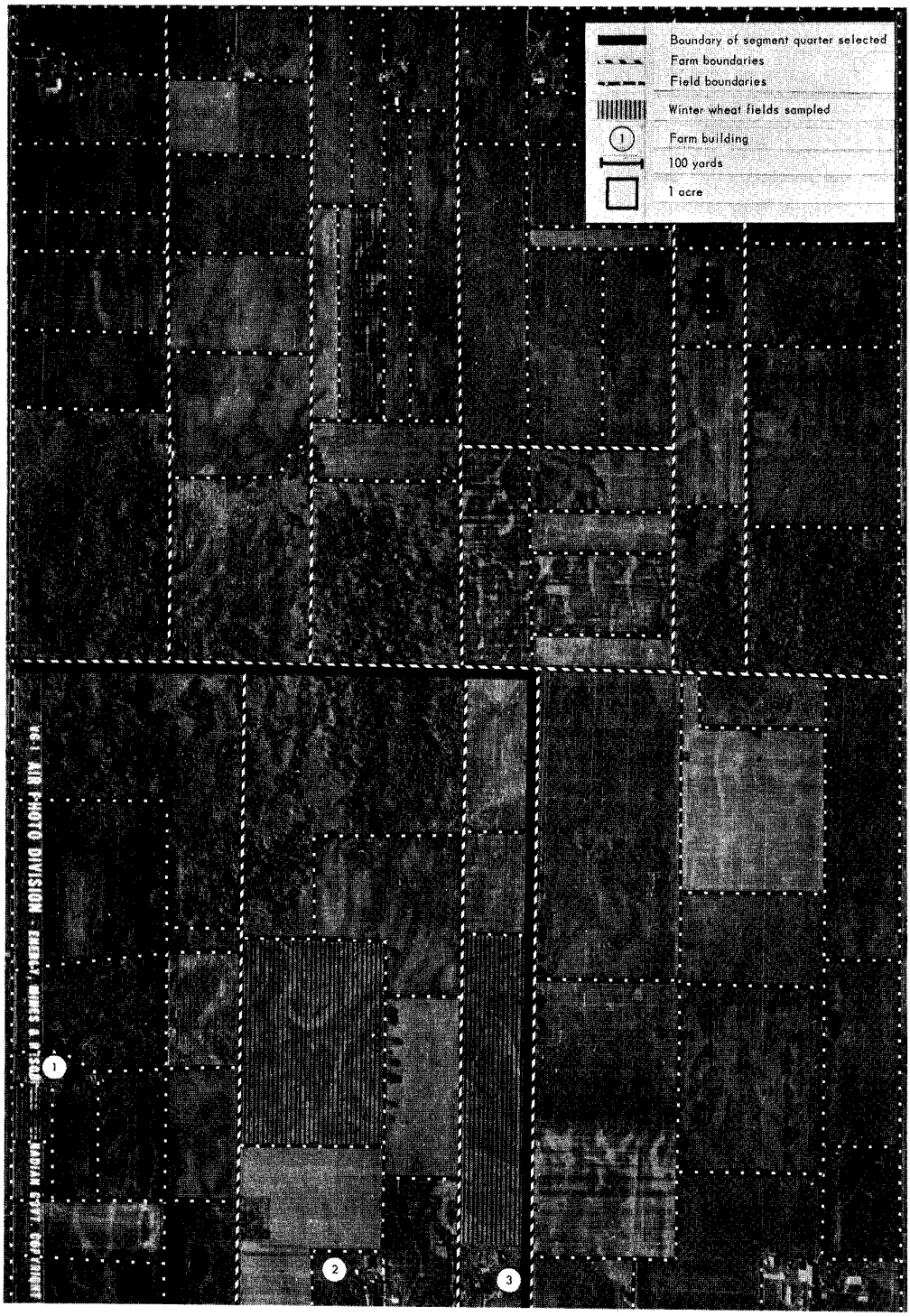

Figure 3. Aerial photograph of the segment shown in Figure 2, showing superimposed boundaries of farms and fields and the position of winter wheat fields sampled with the segment quarter selected.

Table 1. Percentage of leaves affected by disease

Disease	Leaf no.†	Date of assessment May 1969	June 1969	June 1970
Powdery mildew	1	0	12	49
	2	5	16	53
	3	25		
	4	49		
Spindle streak mosaic	1	4		
	2	24		
	3	35		
	4	40		
Leaf rust	1	0	25	86
	2	1	25	79
	3	2		
	4	5		
Septoria spp.	1			13
	2			29

† Top or flag leaf = 1.

reached the logarithmic phase of development in the period between May and June. The figures for leaf rust and for mildew in June 1970 were higher than the corresponding percentages for 1969, and this suggests that the weather during 1970 was more favorable for the development of both diseases.

Wheat spindle streak mosaic virus was first reported on winter wheat in southwestern Ontario in 1957 (15), and since then (5,15) checks on the distribution of the pathogen have been made annually. Slykhuis (15) reported that 65% of the 96 fields inspected in 1968 contained plants infected with the virus, and Gates (5) reported that 74% of the 90 fields examined were infected; the mean percentages of plants infected were 47.4% and 44.2% respectively. Further work by Slykhuis and Polak (16) in 1969 showed that 58% of 107 fields examined contained infected plants, with a mean infection of 38%. In the May 1969 survey reported in this paper, 49% of the 63 fields contained infected plants and 33% of all plants examined were affected with spindle streak mosaic symptoms. These results are in close agreement with those quoted above (16). However, it should be noted that each of the surveys referred to were conducted in a different way. The survey reported here differs from the others because it allows for distribution of winter wheat acreage and uses a strictly defined sampling technique capable of repetition by other research workers.

Two other foliage diseases, leaf stripe incited by Cephalosporium gramineum Nisikado & Itaka and stem rust caused by Puccinia graminis Pers. f. sp. tritici Erikss. & Henn. were seen occasionally, but were not observed in any of the subsamples.

Table 2. Mean percentage leaf area affected by disease

Disease	Leaf no.†	Date of assessment May 1969	June 1969	June 1970
Powdery mildew	1	0.00	0.23	1.47
	2	0.05	0.56	3.27
	3	0.41		
	4	1.14		
Avg for 4 leaves		0.40		
Leaf rust	1	0.00	0.46	3.12
	2	0.01	1.08	3.53
	3	0.03		
	4	0.06		
Avg for 4 leaves		0.03		
Spindle streak mosaic	1	0.08		
	2	0.68		
	3	1.75		
	4	3.07		
Avg for 4 leaves		1.39		
Total diseases	1	0.08	0.69	4.59
	2	0.73	1.65	6.80
	3	2.18		
	4	4.27		
Avg for 4 leaves		1.82		
Green tissue remaining	1		78.98	92.07
	2		37.46	34.95
Dead tissue	1		20.33	3.34
	2		60.90	58.25

† Top or flag leaf = 1.

Severity of infection - All the diseases were assessed in a similar manner by assessing the percentage leaf area (lamina) damaged by disease. The mean infections in Table 2 relate to the top four leaves for the May 1969 assessment and to the top two leaves for the June 1969 and 1970 assessments. For convenience the arithmetic means of the percentage area affected by disease on the top four leaves (where applicable) have been calculated so that one value can be used as a reference.

In May 1969 mildew covered a larger leaf area than rust, but by June this situation was reversed in considering the area occupied by disease on the top two leaves in June; reasons for this changeover have already been

discussed. For the May 1969 assessment the ratio of infection on leaves 4:2, 3:2, and 4:3 for mildew were 22.6, 8.2, and 2.8; whereas the corresponding ratios for rust were 6.0, 3.0, and 2.0. The mildew had higher ratios than rust, although the absolute level of mildew was higher than rust. This indicates that the two diseases differ epidemiologically and points to the earlier and more severe mildew infection on the lower leaves compared with the later infection on the upper leaves with leaf rust. The same phenomenon was noted in England and Wales for mildew and leaf rust of barley (7), although the values of the ratio for barley differed from those reported here. Leaf rust and mildew increased between May and June 1969 (Table 2), but the levels of disease on both occasions were quite low.

The data on spindle streak mosaic refer only to the 1969 May assessment because in June it was difficult to diagnose the disease satisfactorily. Consequently, it was not possible to estimate the increase in virus disease, if any, in the period between May and June 1969; and it also precluded an assessment in June 1970. The assessments reported here were the best possible considering the difficulty in visually assessing a mosaic symptom; a disease assessment key was used for this purpose. However, there was a definite trend for the lower leaves to exhibit more symptoms than the top leaves, but this may or may not represent the total effects of the disease. Other workers (5,15,16) have used the percentage of plants infected as the sole indicator of disease level, whereas the method reported here incorporates an extra measurement of the severity of the disease by assessing the percentage leaf area visibly affected by the disease.

The assessments for glume blotch incited by Septoria nodorum Berk., speckled leaf blotch caused by Septoria tritici Rob. ex Desm., and lesions caused by Septoria avenae Frank f. sp. triticea T. Johnson (stat perf. Leptosphaeria avenaria Weber f. sp. triticea T. Johnson) are qualitative and should not be regarded as a measure of the effect of these diseases on the winter wheat crop. In 1969 several lesions typical of Septoria, but without pycnidia, were noted and assessed in the field. Samples were cultured under varying conditions in the laboratory, but no Septoria spp. were isolated. During the 1970 survey, well defined lesions were assessed in the field, but only a few contained pycnidia. Sample lesions were examined in the laboratory and efforts were made to isolate and identify the pathogens involved. In all cases where pycnidia had been observed in the field a Septoria sp. was positively identified as the pathogen. Some of the lesions which had no pycnidia in the field produced pycnidia in the laboratory and were identified as Septoria sp., but other similar lesions did not produce pycnidia and no other pathogens were isolated. A similar situation was observed for extensive dead areas on the leaves. Furthermore, three species of Septoria, viz. nodorum, tritici and avenae f. sp. triticea, were isolated and it was not possible to correlate a lesion type with any of these species; this has also been noted by other workers (9). The assessment of Septoria is problematic because no typical symptoms can be used as a reliable guide in the field, except when pycnidia are observed. However, since most of the lesions which produced Septoria pycnidia in the laboratory did not contain pycnidia in the field, the only way to check the presence of the pathogen is to sample the individual lesions. The logistics involved in checking a meaningful and reliable sample from any large-scale survey makes the task impractical. Furthermore, if the species of the pathogen is to be identified, a sample of the pycnidiospores must be measured. In this survey Septoria nodorum was isolated more frequently than the other species. It is for the above reasons that it is felt that the data presented in this paper on Septoria species is strictly qualitative.

A large percentage of the leaf area was dead (Table 2), particularly of the flag leaf in 1969. Dead tissue may be due to several factors, including senescence, disease, and soil and nutritive effects.

Differences in disease level between counties or groups of counties were not detected and since the variety Genesee comprised 67% of the crops sampled, it was not possible to make any meaningful varietal comparison concerning disease susceptibility. The varieties Talbot and Yorkstar constituted 19% and 2% of the sample respectively, and in 12% of the fields it was not possible to verify the name of the variety.

Effect of diseases on yield - Usually one of the primary reasons for conducting any survey on plant diseases is to establish the approximate losses in yield caused by the individual diseases and also the total loss caused by all the diseases. However, in order to be able to compute the above losses, a knowledge of the relationship between disease and yield loss is imperative. This relationship may differ under varying environmental conditions and therefore methods developed for a particular region or country may not be applicable elsewhere. Because of lack of knowledge in this sphere of plant pathology, it is usually difficult to derive accurate estimates of losses in yield. Consequently, some degree of extrapolation has to be resorted to in most cases; and this should be noted whenever the estimates of loss are used.

A prediction method has been reported (11,12) for estimating the loss in yield in winter wheat due to mildew, using an assessment key which accounted for the percentage of leaf area affected by mildew on the top four leaves at growth stage 10.5

(11,12). Using this key, yield losses were calculated using the formula 2 x $\sqrt{\text{mildew \%}}$. This method was shown to be consistent and reliable over a period of 3 years in Great Britain. In the survey reported here, two visits were made to the same fields in 1969 so that information was available on the progress of the disease between growth stages 8-9 and 10.5.4-11.1. The 10.5 growth stage used in the prediction method probably occurred, on average, at the midpoint between the two assessments. It is estimated that the average mildew level in 1969 was less than 1% at growth stage 10.5 (according to the Large and Doling key [11]). The loss in grain yield would therefore be equivalent to less than 1%. The corresponding figures for mildew in 1970 are estimated at between 2% and 3% mildew, representing an average loss in yield of between 1% and 2%. Even allowing for considerable error in estimating the losses using this method, which has not been proven in Ontario, it is almost certain that losses due to mildew in winter wheat in Ontario are negligible. The magnitude of the loss could warrant a disease control programme only through breeding efforts and cultural practice rather than control by fungicides.

The level of leaf rust in 1969 and 1970 was very low. Greaney (6) established that the yield loss due to stem rust and leaf rust was equivalent to approximately half the percentage of rust (according to the Cobb Scale) recorded just before ripening. On this basis the loss due to leaf rust in winter wheat in Ontario in 1969 and 1970 is estimated at approximately 1%.

Gates (5) estimated the yield losses due to spindle streak mosaic and suggested that the yield loss was equivalent to 10% when all the plants were infected, however this estimate did not take into account the severity of infection on the individual plants. In the survey reported here 33% of all the plants examined were infected; and on this basis the yield loss in 1969 is estimated at 3%. Because most of the fields affected had approximately 100% plant infected there was no need to extrapolate for lower levels of infection.

Losses in yield due to Septoria spp. have been reported by several workers. In Australia, Shipton (14) showed that they can be as high as 29%, and this was probably an underestimate because the disease was not completely controlled in the fungicide sprayed plots. In the U.S.A., estimates of loss from Septoria diseases ranged from 10.5 to 27.6% (2); and in Switzerland where artificial inoculum was applied, losses of up to 65% were recorded (1). More recently, in the United Kingdom (9), a mixed infection with S. nodorum and S. tritici caused a yield loss of 26%, and an effort was also made to relate the amount of infection to yield loss, but no prediction method was proposed. Because the results for Septoria on winter wheat in Ontario are considered qualitative, it is not possible to estimate yield loss. However, the above losses show that the decrease in yield can be considerable when severe attacks of Septoria occur.

No estimate of the loss due to dead tissue can be made because there is no published method to transform percentage dead tissue to loss in yield. However the losses were probably higher in 1969 than in 1970, because of the higher percentage dead tissue on the flag leaves.

The effect of barley yellow dwarf virus on yield of winter wheat in Ontario in 1969 has been discussed elsewhere (8). It is not possible to predict the losses due to this disease, but it may well be that the virus diseases spindle streak mosaic and barley yellow dwarf represent the most important diseases affecting winter wheat in Ontario.

In 1969 the average yield/acre was 39.8 bushels, and this sold at an average price of $1.71/bushel, giving an average price per acre of $68.00 (13). Using the extrapolated methods discussed above, the total loss in yield caused by mildew, leaf rust, and spindle streak mosaic virus during 1969 and 1970 was approximately 5% per year, which represents an average loss of 2 bushels/acre, worth $3.40. For the total acreage of 350,000 acres, this represented a loss of $1.25 million per annum. In conclusion it can be said that fungal leaf pathogens are probably not important enough on winter wheat to warrant the development of control measures other than the introduction of resistant varieties through breeding programs already in existence.

Acknowledgment

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SOUTHERN LEAF BLIGHT OF CORN IN ONTARIO IN 1970

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Abstract

Southern leaf blight of corn (Zea mays) caused by Helminthosporium maydis became widespread in 1970 through weather conditions that were exceptionally favorable for the development and rapid spread of a new race of the pathogen. Most of the corn grown in the U.S.A. and in Ontario contained the Texas (T) male-sterile cytoplasmic factor and was therefore susceptible to the new race.

Most fields that were examined in Essex, Kent, and Lambton Counties contained diseased plants. The disease occurred as far north as Bruce and Grey Counties, and as far east as Northumberland and Prince Edward Counties and in the Ottawa area. In most of the fields that were examined in Essex, Kent, and Lambton the disease was confined to the lower leaves. In most fields yield loss from blight was assessed at less than 1%; only in occasional fields would assessed losses have exceeded about 5%. Seed crops were often blighted, resulting in a proportion of diseased kernels.

Because of the extensive use in seed production in 1970 of lines which contain Texas (T) male-sterile cytoplasm, 70 - 75% of the 1971 Canadian crop will be susceptible to the disease.

Introduction

Southern leaf blight of corn (Zea mays L.), caused by Helminthosporium maydis Nisikado & Miyake (Bipolaris maydis (Nisikado) Shoem. stat perf. Cochliobolus heterostrophus Drechs.), has until recently occurred mainly in the southern areas of the United States, extending occasionally into southern parts of the corn belt (12). In 1969 many seed crops and some grain crops in Illinois and Iowa (3, 5, 8) were damaged by a race of H. maydis that was distinguished by its virulence on corn genotypes containing the Texas (T) cytoplasmic factor for male sterility and by its avirulence on corresponding genotypes with normal cytoplasm (5, 8). Hooker et al. (5) and Smith et al. (9) concluded that a new 'biotype' of H. maydis had become established in the USA, because in earlier years local races of the fungus had not differentiated between the two cytoplasmic types, and cultures collected in 1963 did not do so in 1969.

In recent years, corn genotypes with Texas (T) male-sterile cytoplasm have been widely used to save the cost of labor for detasselling female parents in corn seed production. About 80% of the corn grown in 1970 in the United States and in Ontario contained this cytoplasmic factor. With unusual weather and with most of the acreage planted with susceptible corn, the new race of H. maydis was widespread in the U.S. corn belt in 1970, and extended into parts of Ontario. This report summarizes its occurrence in 1970 and its possible implications for corn production in Ontario.

Occurrence of the disease

The disease was first identified in Ontario in mid-August, at which time samples were received from Essex, Lambton, and Oxford counties. A cooperative survey of the disease was made by staff of the Research Station, Harrow, the Ontario Department of Agriculture and Food, and the University of Guelph.

In Essex and Kent counties between Aug. 25 and 28, the disease was found in 69 of 80 randomly selected fields (Table 1). In 57 fields the disease was essentially confined to leaves at or below ear level and its prevalence was sufficiently light (less than about 50 spots per leaf) as to cause very little loss (Table 1, classes 1 and 2). In 11 fields in Essex Co. and one in Kent Co., all within 5 miles of Lake Erie, leaves located at and below ear level were blighted to the extent of 1/4 to 1/2 of the leaf area (Table 1, class 3); spots were also present on the upper leaves, but in only 3 fields was the damage to these leaves extensive. Estimates of probable yield losses at these

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Table 1. Assessment of southern leaf blight of corn in southern and eastern Ontario in 1970

County	Date	No. of fields examined	Disease class† 0	1	2	3
Essex	late August	50	6	9	24	11
Kent	late August	30	5	8	16	1
Elgin	late August	9	2	3	4	0
Lambton	late August & late September	14	3	5	6	0
Middlesex	late August	12	3	7	2	0
Perth	late August	4				
Oxford	late August	4				
Waterloo	late August	2				
Wellington	late August	14	Identified on diseased corn leaves but not assessed.			
Lincoln	late August	8				
Wentworth	late August	3				
Bruce	early September	2				
Grey	early September	2				
Ontario	early September	3				
Durham	early September	5				
Prince Edward	mid-September	2				
Carleton, Russell, Grenville, Dundas	mid-September to mid-October	Up to 20% infected plants in 7 out of 17 fields examined.				

† Where 0 = disease not detected;
1 = disease incidence very light;
2 = less than about 50 spots per leaf at ear level and below; estimated yield loss <1%;
3 = spots damaging 1/4 to 1/2 of leaf area at and below ear level, light spotting above. Estimated yield loss 5 to 8%; in 3 cases with heavy spotting of upper leaves, about 15%.

levels of disease incidence are discussed below. Even in fields where there were many leaf spots, only a small proportion (<1%) of the ears became infected, generally through the tips.

The disease was widespread in Lambton, Middlesex, and Elgin counties, but no cases of appreciable loss were encountered. In Lambton Co. on September 23 the disease had spread to the tops of many infected plants, although its incidence was still light. Southern leaf blight was identified on diseased corn leaves collected in many other areas of southern Ontario (Table 1). By mid-September the disease had spread as far north as Bruce and Grey counties and as far east as Northumberland and Prince Edward counties.

Between September 15 and October 15, 17 corn fields were examined in the Ottawa valley in the counties of Carleton, Russell, Grenville, and Dundas. Symptoms of southern leaf blight were observed in 7 fields, and H. maydis was isolated in each case. In one field several ears were rotted at the tips and H. maydis was isolated from the blackened areas of the husks. The seeds under the severely affected husks were discolored, but isolations from these failed to yield the southern leaf blight fungus.

In Lambton Co. and in counties to the east, spots on leaf specimens were commonly found to be those of yellow leaf blight, caused by Phyllosticta sp., indicating that this disease was also widespread in Ontario in 1970. Symptoms of eyespot, caused by Kabatiella sp., appeared on some specimens from Middlesex, Waterloo, Wellington, Ontario, and Durham counties.

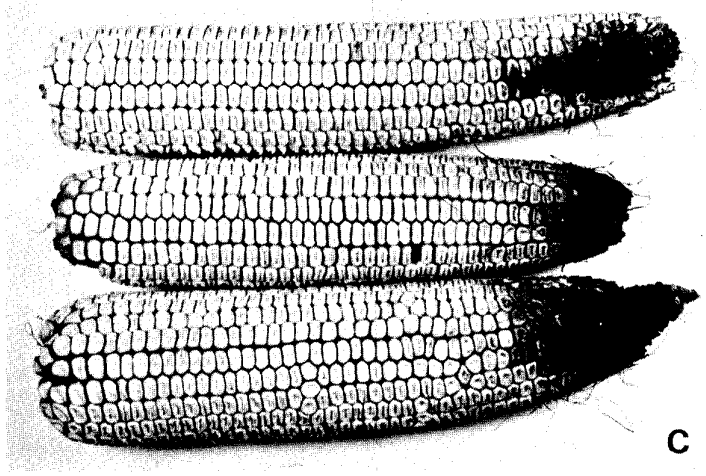

Figure 1. Symptoms of southern leaf blight of corn. A. Infected field crop, showing lesions on leaves, sheaths and ears. B. Lesions on leaf. C. Ears with black mycelial weft between tip kernels.

Symptoms and fungal characteristics

Leaf spots caused by H. maydis are fawn colored, sometimes with a grayish tinge and a dark border, and range in size up to about 2-3 cm x 0.4-0.8 cm (Figure 1A,B). Usually the spots are not distinguishable from those of yellow leaf blight (4, 10) unless the causal fungus can be identified on them. Leaf spot symptoms on the upper leaves are more likely to be those of southern leaf blight, which may affect upper, middle, and lower leaves, than of yellow leaf blight, which in Ontario tends to affect only the lower and middle leaves, especially before mid-August. Northern leaf blight lesions caused by Helminthosporium turcicum Pass. are usually much larger (about 5-10 cm x 0.5-1.5 cm) and are of a more regular, elliptical shape than are those of southern leaf blight.

On the leaf sheaths and husks, small dark brown spots develop and expand into fawn-colored lesions surrounded by brown or purple areas; lesions on the husks tend to be more rounded than those on leaf sheaths (Fig. 1A). The fungus may penetrate the husk layers and sometimes reaches the ear. Ear invasion may also take place through the tip of the ear; this can be recognized in the field by blackening of the tips of the husks, which tend to remain tightly closed. The mycelium progresses between the kernels and may mass into a dark grey or black weft between the tip kernels (Fig. 1C). Conidia are scarce in the region of the black weft, but can more readily be found on the husk tips and between the kernels further down the ear.

The range in size of conidia formed on the leaves or husks from 4 fields was 43 - 116μ x 11 - 16μ , with 3 - 10 septa (Fig. 2). Most were 58 - 93 x 12.8 - 16.0μ , with 5 - 9 septa; and the average measurements of 41 conidia were 75 x 14.2μ , with 6.3 septa. These averages are somewhat smaller than those given by others (listed in 1, 6), which are about 90 x 15 with 8 septa, but they are similar to those found by Burton (1) for H. maydis on ears of sweet corn from Florida. Most spores were boomerang-shaped, both sides of the spore being well curved. With Helminthosporium carbonum Ullstrup one side of the spore is usually more or less straight (11). Conidia of H. turcicum average 105 x 20μ ; and the hilum of an H. turcicum conidium is raised on a small prominence, whereas that of an H. maydis conidium is continuous with the rounded end of the spore (12).

Yield loss

Through leaf damage.--Experiments at Harrow (unpublished) indicate that about 10% of yield is lost if the two leaves below the ear leaf are removed at 2 to 3 weeks after mid-silk; and that the additional removal of all the leaves below these reduces yield by a further 5%. Removal of the ear leaf and all leaves above it at 2 to 3 weeks after mid-silk lowers yield by about 45%.

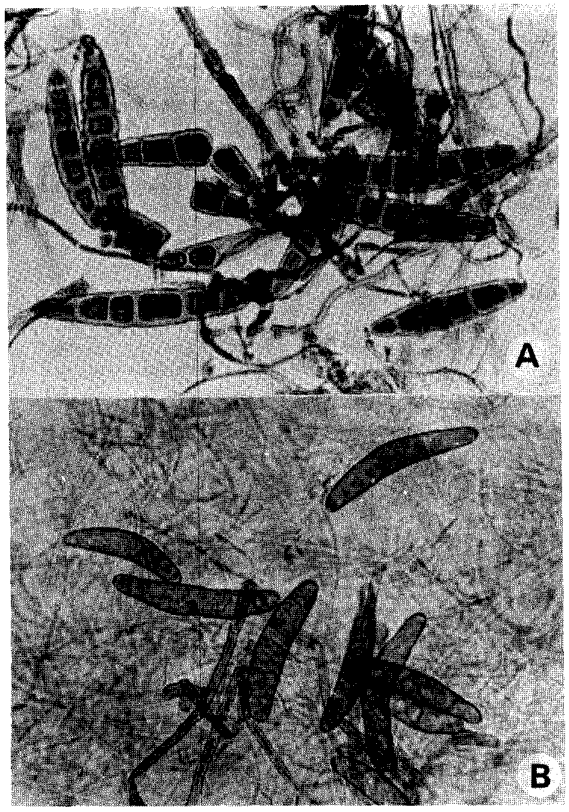

Figure 2. Conidia of *Helminthosporium maydis*, x310.
A. From field leaves.
B. From culture on potato-dextrose agar.

The blight became established in southern Ontario about 1 month after mid-silk, and after this time the leaves below the ear would normally make only a minor contribution to yield. In the great majority of fields in the area, leaf spots involved only a very small proportion of the area of these leaves, and thus their effect on yield would be well under 1%.

In the fields where about 1/4 to 1/2 of the area of the leaves at or below ear level was affected, yield losses of the order of 5 - 8% would be expected. In the three fields where, in addition to severe damage at and below ear level, about 10% of the overall area of the upper leaves was also diseased, the loss is estimated at about 15%.

In general, blight caused very minor loss in Essex and Kent counties in 1970 compared with the losses from severe late drought.

Through ear infection.--In several seed production fields the leaves of inbred lines containing the Texas (T) cytoplasmic factor

were severely blighted by the end of August. In a few of the fields, the fungus had invaded the apical one-third of a large proportion of the ears, but did not progress much further as the ears dried. Some seed crops were discarded, while in others much seed was lost in removing infected ears and diseased kernels. The damage to the ears in the seed fields was much greater than was seen in fields of heavily blighted grain corn.

Epidemiology

The simultaneous appearance of blight in several southern Ontario counties during August indicates that the disease may have been initiated after spore deposition from widespread spore showers blown in from the south in late July and early August. The Canadian Weather Review (2) describes, as an outstanding feature of the weather for July, a sustained flow of moist and warm tropical air during the last week of the month, bringing humid and wet weather and unusually warm nights to much of Ontario. Such conditions probably favored the establishment and development of blight. At Guelph in late August, leaves that were not visibly affected initially were observed to develop average-sized lesions in about 4-8 days in the field.

Development of the disease was retarded in much of southwestern Ontario during late August and September when dry weather prevailed. However, the disease became increasingly severe, especially on the upper leaves, in some of the fields located within a few miles of Lake Erie, where periods of high humidity were far more prolonged than futher inland.

Where comparisons were possible, only those hybrid and inbred corn lines with Texas male-sterile cytoplasm became heavily lesioned. Their counterparts with normal cytoplasm showed a few relatively small lesions. The presence of fertility restorer genes in genotypes with male sterile cytoplasm did not reduce their greater susceptibility to the blight as noted also by Scheifele et al. (8).

Discussion

The conclusion seems inescapable that the outbreak of the southern leaf blight in Ontario was caused by the newly recognized race of H. maydis that is virulent on corn carrying the Texas (T) male-sterile cytoplasm. A return to the use of seed containing normal cytoplasm will greatly restrict the development of the race of H. maydis that was prevalent in 1970. By 1972, most seed corn will carry normal cytoplasm, and some may contain male-sterile cytoplasm of types other than the Texas (T) type. However, because of the extensive use in seed production in 1970 of lines containing Texas (T) male-sterile cytoplasm, 70 - 75% of the 1971 Canadian crop will be susceptible to the disease. At a joint meeting of the Ontario Corn Committee and the Seed Corn Dealers' Association in September 1970, the seed corn companies voluntarily agreed to label all seed corn sold in Ontario in 1971, specifying the method used in its production and thus indicating its reaction to the race of H. maydis prevalent in 1970.

Because susceptible corn will be planted widely in Ontario in 1971, any serious and widespread outbreak of the blight will depend upon establishment of infection and weather conditions favorable to blight development. Temperatures close to the fungal optimum (85F[29.4C]) (1) and prolonged humid and wet periods occur frequently in southern Ontario in June and July, and would favor early and rapid disease development if the fungus is established at that time. Early infections from overwintered sources of inoculum may be highly significant in initiating a blight outbreak and increasing the extent of the damage caused. Complete ploughing under of corn crop residues is indicated. Seed transmission of the fungus even by a very small proportion of seed would also be important in view of the very rapid spread of the disease once established. Late-season infections produced from inoculum blown in from the south would probably result in relatively little disease, as was experienced in 1970.

Enhanced susceptibility both to southern leaf blight (5,8,9) and to yellow leaf blight (7) is associated with Texas (T) male-sterile cytoplasm. The rapid spread of a relatively new race of a pathogen previously of localized importance, and the much increased incidence of a formerly very minor pathogen, emphasize the risk involved in using plants of similar biological types over wide areas.

NOMENCLATOR

The scientific names currently used for the three diseases of corn referred to in this article are as follows:

Cochliobolus heterostrophus (Drechsler) Drechsler. Phytopathology 24:973. 1934.
st. conid. Bipolaris maydis (Nisikado) Shoemaker. Can. J. Bot. 37:882. 1959.
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Trichometasphaeria turcica Luttrell. Phytopathology 48:282. 1958.
st. conid. Bipolaris turcica (Pass.) Shoemaker. Can. J. Bot. 37:884. 1959.
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st. conid. Bipolaris zeicola (Stout) Shoemaker. Can. J. Bot. 37:885. 1959.
≡ Helminthosporium carbonum Ullstrup. Phytopathology 34:219. 1944.

Acknowledgments

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