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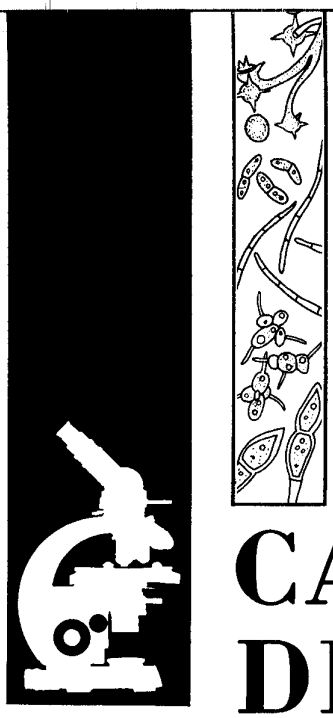
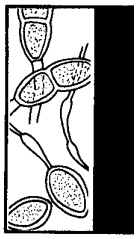


CANADIAN PLANT DISEASE SURVEY



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CANADIAN PLANT DISEASE SURVEY

RESEARCH BRANCH CANADA DEPARTMENT OF AGRICULTURE

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."

BARLEY DISEASES IN SOUTH AND CENTRAL ALBERTA IN 1971: DISTRIBUTION, SEVERITY, AND YIELD LOSSES

F.R. Harper and L.J. Piening[1]

Abstract

The distribution and severity of barley diseases and estimates of yield losses associated with them were determined in south and central Alberta by standardized methods of field survey and disease assessment. In 1971 common root rot (Cochliobolus sativus and Fusarium spp.) caused an estimated loss of 6.0%, scald (Rhynchosporium secalis) 1.1%, net blotch (Pyrenophora teres) 0.5%, and loose smut (Ustilago nuda) 0.5%. The loss in yield from these diseases was estimated at 20.3 million bu, leaving an estimated harvest of 216 million bu. Spot blotch (Cochliobolus sativus), speckled leaf blotch (Septoria spp.), and bacterial blight (Xanthomonas translucens) were found occasionally but caused little damage.

Introduction

The occurrence of diseases in the western Canadian barley crop has been reported annually for over 40 years (3). However, there are few reports on the quantitative distribution of diseases and even fewer that attempt to estimate the losses in yield that occurred (7, 8, 10). This study was undertaken as part of a program to determine the severity of barley diseases in south and central Alberta and to assess the losses they cause.

Materials and methods

The province was stratified for survey purposes into Census Divisions (CD) as these were the smallest areas for which crop acreage and yield statistics were available (1). The acreage sown to barley in each CD in 1971 was estimated before the survey started, as follows:

$$\text{Acreage 1971} = A \times \frac{\text{Total Alberta acreage 1971}}{\text{Total Alberta acreage 1970}}$$

where A is the acreage sown to barley in the CD in 1970. A preliminary estimate was needed because the acreage estimates for intraprovincial subdivisions were available only several weeks after the growing season was completed. The number of barley fields chosen for examination in each CD was based on a sampling target of one field for each 48,000 acres sown. The approximate location for each field to be sampled was marked on a map before the survey started (Fig. 1). These locations were chosen to coincide with acreage concentrations of barley within each CD. There were too few acres of barley in CD 9 and CD 14 to warrant sampling and time was not available to assess the barley crop in northern Alberta (CD 15).

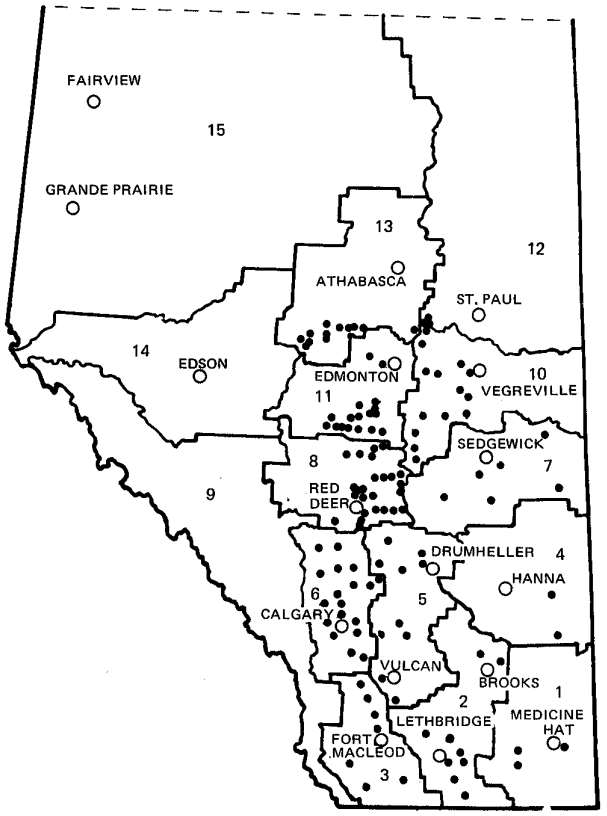

Figure 1: Map of Alberta, showing Census Divisions and locations of fields sampled for barley diseases.

Each field examined was within a 5-mile radius of the preselected approximate location and was the first one encountered in which the plants were at Growth Stage 10.5 (all spikes emerged from sheath) (4). Variety was not a criterion in field selection, either 2-rowed or 6-rowed varieties were examined. We avoided sampling fields that bordered major highways. In each

[1] Agriculture Canada Research Station, Lethbridge, Alberta T1J 4B1 and Agriculture Canada Research Station, Lacombe, Alberta T0C 1S0, respectively.

Table 1. Barley production and number of fields assessed for diseases in Alberta, 1971

Census Division*	Acres sown ('000) 1970	Acres sown ('000) 1971	Yield, 1971† Bu/acre	Yield, 1971† Total bu ('000)	Fields assessed
1	111	198	35.4	7,018	4
2	363	517	46.5	24,060	10
3	240	316	42.5	13,434	7
4	87	173	30.9	5,345	2
5	467	666	48.4	32,214	10
6	473	569	45.8	26,080	18
7	259	366	42.1	15,410	6
8	616	650	35.1	22,842	24
10	490	666	39.2	26,094	14
11	444	544	40.3	21,918	17
12	120	178	32.1	5,715	3
13	416	507	26.8	13,567	12
15	614	750	35.0	26,280	0
Total	4,700	6,100	39.3	240,000	127

* Production in Census Divisions 9 and 14 was grouped with that of 6 and 13, respectively.

† See reference 1.

field surveyed, five plants were chosen at each of 10 sites situated 50 paces apart on an "inverted V". The first site was 50 paces from the edge of the field with six sites on the entry arm and four on the exit arm. The plants selected were those nearest the toe of the forward shoe at the end of the 50th pace.

The rating for each disease on each plant was recorded on a standard form to allow analysis by computer. Disease severities were assessed as follows: Common root rot, 0 = clean, 1 = slight, 2 = moderate, 3 = severe (6); Smuts, 0 = no smut, 1 = smutted plant; Virus diseases, 0 = no symptoms, 1 = leaf symptoms, 2 = stunted plant (2); Leaf diseases, mean percentage of leaf area affected on the flag and penultimate leaves of the main tiller (4). In addition, notes were made on diseases present in the field but not recorded from the 50 plants sampled.

Yield losses from root rot were estimated using the method of Ledingham (6); for loose smut by percent smutted plants = percent yield loss (9, 11); for leaf diseases by percent yield loss = 0.5 x mean area affected by the disease on the flag and penultimate leaves based on the principle of James et al. (5). Loss values for CD's represent the means for all fields sampled within the CD. Yield losses in bu were estimated separately for each CD by:

$$[100 \times B/(100 - \%\ \text{loss})] - B$$

where B = total bu produced.

Weighted percent loss from a disease for the surveyed area was $100[A/(A + B)]$, where A = estimated loss in bu from the disease in CD's 1 to 13, and B = total bu harvested in CD's 1 to 13 (1).

Results

The most serious disease encountered on barley in Alberta in 1971 was common root rot caused by Cochliobolus sativus (Ito & Kurib.) Drechsl. ex Dastur and Fusarium spp. The disease was found in almost every field examined and caused an estimated loss of 6.0% in the surveyed area (Table 2). The disease was most severe in CD 4 and 13 and was least severe in CD's 3, 6, and 12. Several leaf diseases were widespread in the surveyed area. The scald pathogen Rhynchosporium secalis (Oud.) Davis was widely distributed on the basal leaves of barley (Table 3), occurring on 95% of the 127 fields examined. In the southern region (CD's 1 to 6), there was little spread to the upper leaves and yield loss was low. In the central region (CD's 7 to 13), scald was more frequently found on the flag and penultimate leaves and yield loss was greater. Yield loss from scald in one field reached 25.7% with the average loss being 1.1%. Net blotch

Table 2. Severity and yield loss from common root rot of barley in south and central Alberta, 1971

Census Division	Severity*	Yield loss %	Yield loss bu ('000)
1	0.64	6.9	520
2	0.68	7.0	1,811
3	0.34	3.5	487
4	1.03	10.4	620
5	0.53	5.4	1,839
6	0.34	3.5	946
7	0.85	9.1	1,543
8	0.60	6.0	1,458
10	0.56	5.7	1,577
11	0.82	8.4	2,010
12	0.33	3.3	195
13	1.29	15.0	2,394
Total		6.0	15,400

* Scale of 0 (least) to 3 (most).

Table 3. Barley fields with symptoms, leaf area affected, and yield loss from scald (*Rhynchosporium secalis*) in south and central Alberta, 1971

Census Division	% fields with symptoms: Basal leaves	% fields with symptoms: Upper leaves	% leaf area affected*	Yield loss %	Yield loss bu ('000)
1	100	50	0.02	<0.1	1
2	100	90	0.12	<0.1	14
3	100	57	0.03	<0.1	2
4	50	0	0.00	0	0
5	90	60	0.09	<0.1	15
6	94	83	1.02	0.5	134
7	100	67	1.84	0.9	143
8	96	67	3.83	1.9	446
10	86	86	3.65	1.8	485
11	100	65	6.22	3.1	704
12	67	0	0.00	0	0
13	100	92	9.87	4.9	704
Total				1.1	2,648

* Mean area of flag and penultimate leaves affected by the disease.

[Pyrenophora teres (Died.) Dreschsl.] was present on the lower leaves of most barley crops in the southern part of the province (Table 4). In the central region, incidence of this disease was lower. Damage to the upper leaves was generally light, resulting in an estimated yield loss of 0.5%. Loose smut [Ustilago nuda (Jens.) Rostr.] was noted in 42% of the 127 fields examined. However, infection levels were generally low (Table 5). The greatest infection level recorded in an individual field was 6%. Mean yield loss due to smut was 0.5%. Bacterial blight [Xanthomonas translucens (Jones, Johns, & Reddy) Dowson] occurred in 23 of the 127 fields examined. Damage to the upper leaves was as high as 4.8% of the leaf area in individual fields. Mean loss for the surveyed area was 0.1% with CD's 5 and 8 having the greatest loss, 0.3 and 0.2%, respectively. Spot blotch (Cochliobolus sativus) symptoms were noted on the lower leaves in many fields in the southern part of Alberta and in a few fields in the area south of Edmonton in CD 11. The disease was rare on the upper leaves and loss was considered negligible. Speckled leaf blotch (Septoria spp.) was rare in Alberta in 1971, occurring in only two fields in the southwestern part of CD 10.

No symptoms of barley yellow dwarf were encountered in the surveyed fields although in CD 3 moderate damage was found in barley and oats that were sown in late-July for use as fall pasture and examined for the disease in mid-September (T. G. Atkinson, personal communication). Stem rust (Puccinia graminis Pers.), leaf rust (Puccinia recondita Rob. ex Desm.), ergot [Claviceps purpurea (Fr.) Tul.], covered smut [Ustilago hordei (Pers.) Lagerh.], and false loose smut (Ustilago nigra Tapke) were not encountered in any of the 127 barley fields examined in the 1971 survey.

There was a marked regional difference in the distribution of 2-rowed and 6-rowed barleys in this survey. In the south, 6-rowed barleys occurred in only 35% of the fields sampled whereas, in the central part of the province, they were found in 92%.

An allocation-of-resources analysis (12) was used with selected root rot, scald and net blotch data to determine where future changes in the sampling procedures could best be made. Relative costs were estimated as plants = 1, sites = 2, and fields = 60. The analysis suggested a reduction in the number of sites per field and an increase in the number of fields sampled.

Discussion

The incidence and severity of common root rot in Alberta was determined at Growth Stage 10.5 in this study. The loss was estimated using Ledingham's (6) equation which was

Table 4. Barley fields with symptoms, leaf area affected, and yield loss from net blotch (*Pyrenophora teres*) in south and central Alberta, 1971

Census Division	% fields with symptoms: Basal leaves	% fields with symptoms: Upper leaves	% leaf area affected*	Yield loss: %	Yield loss: bu ('000)
1	100	25	0.02	<0.1	1
2	100	80	0.40	0.2	48
3	86	86	0.13	<0.1	9
4	100	100	0.50	0.3	13
5	100	100	1.14	0.6	185
6	94	89	0.22	0.1	29
7	100	100	1.24	0.6	96
8	54	38	4.03	2.0	470
10	64	64	0.65	0.3	85
11	53	24	0.11	<0.1	12
12	100	33	2.93	1.5	85
13	67	58	1.07	0.5	73
Total				0.5	1,106

* Mean area of flag and penultimate leaves affected by the disease.

Table 5. Barley fields affected and yield loss from loose smut (*Ustilago nuda*) in south and central Alberta, 1971

Census Division	% fields with smut: Trace*	% fields with smut: ≥2%	Yield loss: %	Yield loss: bu ('000)
1	0	25	0.5	35
2	20	20	0.8	194
3	43	14	0.6	81
4	0	0	0	0
5	30	0	0	0
6	33	17	0.4	105
7	17	50	1.0	156
8	29	8	0.4	92
10	21	21	0.9	237
11	18	18	0.8	177
12	67	0	0	0
13	33	8	0.4	54
Total			0.5	1,131

* Trace = <2% of heads affected.

developed to relate root rot severity in wheat at Growth Stage 11.3 (hard dough) to the yield loss. Ledingham's equation may have to be modified to obtain an accurate estimate of loss from root rot in barley, especially when the disease is assessed before the hard dough stage.

Yield loss estimates as determined for scald by James et al. (5) have not been experimentally proven to apply for other barley leaf diseases. However, the relationship will serve as a reasonable approximation for assessing the losses from other leaf diseases until more accurate equations are derived.

The loss from scald, and presumably other leaf diseases of barley, is related primarily to the degree of damage sustained by the flag and penultimate leaves (5). In 1971, estimated losses from scald and net bloth in Alberta were low because the upper leaves escaped serious infection even though the lower leaves were often severely diseased. Hot, dry weather during late July and early August, when the upper leaves were susceptible, appeared to have arrested the spread of the diseases at this critical period and prevented more serious losses.

The number of fields sampled in each CD in 1971 was based on the relative distribution of barley acreage in 1970 (see Table 1). In 1971, there was a large (30%) increase in barley acreage and also a change in its relative distribution. This resulted in higher than average ratios of fields sampled/acres sown in CD's 4, 5, 7, and 12. However, it is unlikely that the high ratios in these four CD's had a major effect on the accuracy of the loss estimates obtained in this study as the acreage involved was less than 20% of the total.

We found that 6-rowed varieties occupied 35% of the fields in the south and 92% of those in the central region. These values agree with the proportions reported by the Brewing and Malting Barley Research Institute, Winnipeg, Manitoba. From this, it may be inferred that our method of selecting fields also selected individual varieties in relation to the acreage they occupied. The eleven barley varieties commonly grown in Alberta in 1971 varied somewhat in resistance to certain diseases that caused measurable losses. However, if, as we suggest above, our field selection technique was unbiased, the lower losses occasioned by the use of resistant varieties should be accurately accounted for in the severity and loss estimates.

Loss assessment studies of the type described provide an estimate of the relative economic impact of the diseases in a crop within an agricultural region. In addition, they provide a "benchmark" from which to determine whether certain diseases are increasing or decreasing in prevalence and

severity. Bacterial blight, for example, was restricted in distribution in 1971 but caused moderate damage in certain fields. Further monitoring of incidence and severity will enable accurate prediction of the potential threat of this disease to barley production in Alberta.

Literature cited

1. Alberta Dep. Agr. 1971. Agricultural statistics. November estimate of production of principal crops, Alberta, 1971. Field Crops 4, Nov. 23, 1971. 2 pp.

2. Atkinson, T. G., and M. N. Grant. 1967. An evaluation of streak mosaic losses in winter wheat. Phytopathology 57:188-192.

3. Conners, I. L. 1967. An annotated index of plant diseases in Canada. Can. Dep. Agr. Publ. 1251. 381 pp.

4 James, W. C. 1971. An illustrated series of assessment keys for plant diseases, their preparation and usage. Can. Plant Dis. Surv. 51:39-65.

5. James, W. C., J. E. E. Jenkins, and J. L. Jennet. 1968. The relationship between leaf blotch caused by Rhynchosporium secalis and losses in grain yield of spring barley. Ann. Appl. Biol. 62:273-288.

6. Ledingham, R. J. 1970. Host: Triticum vulgare (wheat) Organism: Cochliobolus sativus (common root rot). In L. Chiarappa, ed. Crop loss assessment methods. F.A.O., Rome.

7. McDonald, W. C., J. W. Martens, G. J. Green, D. J. Samborski, G. Fleischmann, and C. C. Gill. 1969. Losses from cereal diseases and value of disease resistance in Manitoba in 1969. Can. Plant Dis. Surv. 49:114-121.

8. McDonald, W. C., J. W. Martens, J. Nielsen, G. J. Green, D. J. Samborski, G. Fleischmann, C. C. Gill, A. W. Chiko, and R. J. Baker. 1971. Losses from cereal diseases and value of disease resistance in Manitoba and eastern and northern Saskatchewan in 1970. Can. Plant Dis. Surv. 51:105-110.

9. Morton, D. J. 1961. Percentage yield loss as related to percentage loose smut in barley. Plant Dis. Rep. 45:348-350.

10. Piening, L. J. 1971. A disease survey of cereals in central and northern Alberta, 1970. Can. Plant Dis. Surv. 51:101-104.

11. Semeniuk, W., and J. G. Foss. 1942. Relation of loose smut to yield of barley. Can. J. Res., C, 20:491-500.

12. Snedecor, G. W. 1956. Statistical methods, 5th ed. Iowa State Coll. Press, Ames. 534 pp.

AIR-BORNE RUST INOCULUM OVER WESTERN CANADA IN 1973[1]

G. J. Green

An estimate of the amount of air-borne cereal rust inoculum over Western Canada in 1973 was obtained by exposing vaseline-coated microscope slides, held at 45° from the vertical, in spore traps, as reported in previous issues of the Canadian Plant Disease Survey. Slides were exposed at Winnipeg, Morden, and Brandon, Manitoba, and at Indian Head, Regina, and Saskatoon, Saskatchewan (Table 1). The slides exposed at all spore trap locations except Saskatoon were prepared at Winnipeg and, after exposure, were returned to Winnipeg where the number of urediospores on each slide was counted using a microscope. Slides exposed at Saskatoon were prepared and examined by the staff of the Agriculture Canada Research Station, Saskatoon, Saskatchewan.

Despite widespread but light infections of stem rust (Puccinia graminis Pers. f. sp. tritici Eriks. and E. Henn.) in the winter wheat area in the southern United States, few stem rust spores were carried into Western Canada during the critical period in May and June. It was early August before they appeared regularly on the slides and mid-August before an appreciable increase in their numbers occurred. The total number of stem rust spores counted on the slides was less than in 1972 and less than the average for the last 10 years (Table 1).

Wheat stem rust was scarce in Western Canada in 1973 and oat stem rust (P. graminis f. sp. avenae) did not develop on susceptible wild and cultivated oats until after August 7. It is likely that wheat stem rust, oat stem rust, and rye stem rust (P. graminis f. sp. secalis), which occurred commonly on Hordeum jubatum L., contributed about equally to the spore counts.

The number of leaf rust spores counted was similar to 1972 and generally much above the 10 year average. Leaf rust spores were carried into Western Canada in late May and during June. Their numbers increased rapidly during July and reached a peak about mid-August (Table 1). Wheat leaf rust (P.

Table 1. Number of urediospores of stem rust and leaf rust per square inch observed on vaseline-coated slides exposed for 48-hour periods at three locations in Manitoba and three locations in Saskatchewan in 1973

Date	Winnipeg		Morden		Brandon		Indian Head		Regina		Saskatoon	
	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust
May 22-23	0	0	0	0	0	0	0	0	0	0	0	0
24-25	0	0	0	0	0	0	0	0	0	0	0	0
26-27	0	0	0	0	0	0	0	0	0	0	0	0
28-29	1	1	0	0	0	0	0	1	0	0	0	0
30-31	0	0	0	0	0	0	0	4	0	5	0	0
May Total	1	1	0	0	0	0	0	5	0	5	0	0
June 1- 2	0	136	0	31	0	32	0	1	0	1	0	0
3- 4	0	4	0	0	0	10	0	1	0	2	0	0
5- 6	0	1	1	1	0	2	0	1	0	4	0	0
7- 8	0	0	0	6	0	1	0	1	0	1	0	0
9-10	0	1	0	0	0	1	0	1	0	1	0	0
11-12	0	0	1	0	0	0	0	1	0	1	0	0
13-14	0	56	0	172	0	8	0	57	0	50	0	0
15-16	0	41	0	84	0	48	0	19	0	11	0	0
17-18	0	4	0	0	0	1	0	0	0	2	0	0
19-20	0	2	0	2	0	2	0	2	0	2	0	7
21-22	0	0	0	2	1	2	0	4	0	2	0	13
23-24	0	4	0	0	3	12	0	20	0	91	0	45
25-26	0	19	0	19	0	21	0	13	0	18	0	9
27-28	1	7	0	30	0	1	0	8	0	2	0	12
29-30	0	5	0	1	0	0	1	17	0	17	0	2
June Total	1	280	2	348	4	141	1	146	0	205	0	88

[1] Contribution No. 599, Research Station, Agriculture Canada, Winnipeg, Manitoba R3T 2M9.

Table 1 (ctd.)

Date	Winnipeg		Morden		Brandon		Indian Head		Regina		Saskatoon	
	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust
July 1- 2	0	35	0	106	0	28	0	8	1	29	0	3
3- 4	0	5	0	7	0	1	0	20	0	11	0	10
5- 6	0	62	0	42	0	9	0	12	0	8	0	20
7- 8	0	36	0	1*	0	19	0	11	0	6	0	11
9-10	0	16	0	29	0	9	2	64	0	72	0	56
11-12	0	252	0	262	0	236	0	80	0	60	0	27
13-14	0	34	0	79	0	70	0	36	0	13	0	12
15-16	0	157	0	1*	0	110	0	100	0	52	0	170
17-18	0	62	0	47	0	184	0	88	0	13	0	7
19-20	0	21	0	91	0	16	0	81	0	106	0	45
21-22	0	29	0	9	0	127	2	1,133	0	178	5	98
23-24	0	16	0	304	0	192	0	34	0	3	0	69
25-26	5	242	0	80	0	170	0	35	0	19	0	71
27-28	0	101	0	141	0	218	0	223	0	115	1	45
29-30	0	174	0	2*	0	403	2	191	0	178	1	74
31- 1	0	45	11	246	0	241	2	573	0	422	1	86
July Total	5	1,287	11	1,447	0	2,033	8	2,689	1	1,285	8	804
Aug. 2- 3	19	249	66	1,100	6	612	7	1,742	7	2,477	3	472
4- 5	7	725	2	6*	0	1,014	21	3,844	7	3,919	122	1,504
6- 7	0	189	0	1*	0	86	0	537	0	2,038	6	274
8- 9	40	751	16	290	9	870	0	388	2	825	1	121
10-11	39	456	5	259	0	178	0	1,810	2	4,953	9	244
12-13	4	33	0	4*	0	58	2	2,441	19	5,665	1	110
14-15	246	2,039	2	31*	12	724	9	1,008	0	12,162	13	595
16-17	185	969	120	558	28	607	80	1,198	53	22,961	20	766
18-19	139	1,403	157	1,808	148	2,308	18	1,404	12	1,747	1	204
20-21	54	104	25	152	13	170	47	447	201	40,194	3	271
22-23	72	168	84	322	142	246	104	797	246	70,327	47	618
24-25	194	447	239	772	15	180	106	1,344	428	5,866	8	119
26-27	533	1,031	260	460	251	5,663	81	593	453	11,217	3	79
28-29	181	340	162	304	262	821	60	266	393	7,838	6	94
30-31	427	718	692	1,880	438	739	171	708	631	10,379	7	84
Aug. Total	2,140	9,622	1,830	7,947	1,324	14,276	706	18,527	2,454	202,568	250	5,555
1973 Total	2,147	11,190	1,843	9,742	1,328	16,450	715	21,367	2,455	204,063	258	6,447
1963-72 Average	3,874	11,199	4,261	16,752	2,696	10,093	2,150	19,627	5,209	65,905	927	22,289

* Slide incorrectly exposed.

recondita Rob. ex Desm.) was observed in the field on June 14 and developed rapidly in Manitoba and southeastern Saskatchewan, diminishing to the north and west. The heavy infections and the large numbers of leaf rust spores on the slides were caused mainly by the susceptibility of the commercial varieties Manitou and Neepawa. The low total spore count at Morden was caused by some slides being improperly exposed. The spore trap results show that leaf rust was carried into Western Canada during late May and early June, caused primary infections that appeared about mid-June, and developed rapidly during July and early August.

Oat crown rust (P. coronata Cda. f. sp. avenae Eriks.) was observed early in July but did not develop rapidly until early August. It probably contributed to the leaf rust spore counts in Manitoba but its contribution was small compared with that of wheat leaf rust.

LEAF RUST OF WHEAT IN CANADA IN 1973[1]

D.J. Samborski

Disease development and crop losses in Western Canada

Wheat leaf rust caused by Puccinia recondita Rob. ex Desm. was first found in Manitoba on June 14. By mid-July, leaf rust was widespread in Manitoba and eastern Saskatchewan. Moderate to severe infections were present on 'Manitou' and 'Neepawa' wheats in early August from the Red River valley to Estevan and Yorkton in eastern Saskatchewan. Farther west the amount of leaf rust diminished, and damage to wheat was restricted to the heavily infected eastern area. It was estimated from field observations that leaf rust caused yield losses of 5 to 10% in this area.

Leaf rust in the nurseries

Ratings of leaf intensity on 18 wheat (Triticum aestivum L.) varieties grown at nurseries across Canada are shown in Table I. The utility wheat, Glenlea, was highly resistant at all locations. This variety possesses gene Lr1 and additional genes conditioning adult-plant resistance to leaf rust. R.L. 4255 is a 'Manitou' backcross line containing genes Lr1, Lr2a, Lr12, Lr13 and Lr18 for resistance to leaf rust. It was highly resistant in the rust nurseries but has not been licensed for commercial production because of inferior quality.

Physiologic specialization

In 1973, as in previous years, field collections of leaf rust were established on 'Little Club' wheat in the greenhouse and one single-pustule isolate was taken from each collection. Most of the collections in Manitoba and Saskatchewan were obtained from commercial fields of 'Manitou' or 'Neepawa'. These varieties do not possess any seedling genes for leaf rust resistance. However, in 1973, 'Selkirk' comprised 12.6% of the bread wheat acreage in Manitoba and 3.8% of the bread wheat acreage in Saskatchewan. This

Table 1. Percentage infection by *Puccinia recondita* on 17 wheat varieties in uniform rust nurseries at 21 locations in Canada in 1973

Location	Lee	Pitic 62	Napayo	Red Bobs	C.I. 8154 × Frocor[2]	Neepawa	Kenya Farmer	Marquis[6] × (Stewart[3] × R.L. 5244)	Hercules	Mindum	D.T. 332	Wascana	Exchange	Frontana	Thatcher[6] × Transfer	R.L. 4255	Glenlea
Creston, B.C.	0	10	5	35	tr*	5	0	15	5	tr	30	5	0	0	0	0	0
Edmonton, Alta.	tr	10	5	45	tr	10	10	30	5	tr	tr	10	0	0	0	0	tr
Lacombe, Alta.	15	15	20	40	15	40	25	30	20	0	25	15	0	tr	0	0	0
Indian Head, Sask.	45	50	25	80	5	30	50	50	20	5	35	30	0	10	0	0	tr
Scott, Sask.	0	tr	tr	tr	0	0	tr	tr	0	0	tr	0	0	0	0	0	0
Melfort, Sask.	3	10	5	30	15	5	1	20	3	0	3	3	0	0	0	0	0
Brandon, Man.	70	60	70	80	60	70	50	70	20	0	15	30	tr	tr	0	0	0
Durban, Man.	15	25	20	60	5	15	25	50	20	0	25	20	0	0	0	0	0
Morden, Man.	50	30	60	80	10	50	50	70	1	tr	1	tr	tr	tr	0	tr	tr
Glenlea, Man.	15	10	30	70	tr	30	5	70	5	tr	5	3	tr	tr	0	0	0
Kemptville, Ont.	0	0	0	35	0	0	0	35	0	tr	tr	tr	0	0	0	0	0
Thunder Bay, Ont.	10	5	15	35	tr	tr	5	35	0	0	0	0	0	0	0	0	0
Guelph, Ont.	35	20	tr	60	15	15	15	30	25	20	40	40	tr	0	0	0	tr
Ottawa, Ont.	20	10	10	75	10	5	5	60	30	tr	40	45	0	0	0	0	0
Appleton, Ont.	10	5	5	35	5	0	tr	30	20	tr	25	10	0	0	0	0	0
Vineland, Ont.	10	5	20	60	tr	5	20	60	10	0	10	15	0	0	0	0	0
La Pocatière, Qué.	0	tr	0	tr	0	0	0	tr	0	0	0	0	0	0	0	0	0
Macdonald College, Qué.	0	15	0	60	10	0	tr	40	40	20	35	30	0	0	0	0	0
Normandin, Qué.	tr	0	1	10	0	0	tr	10	5	0	tr	tr	0	0	0	0	0
Fredericton, N.B.	10	10	3	20	20	2	5	10	3	0	3	3	0	0	0	0	0
Charlottetown, P.E.I.	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0

* tr = trace.

[1] Contribution No. 601, Research Station, Agriculture Canada, Winnipeg, Manitoba R3T 2M9.

Table 2. Virulence of isolates of *Puccinia recondita* on backcross lines containing single genes for resistance to leaf rust in Canada in 1973

Resistance genes	No. of virulent isolates from:					Total no. of virulent isolates	% total isolates
	Qué.	Ont.	Man.	Sask.	Alta. & B.C.		
Lr 1	1	1	0	0	0	2	1.2
Lr 2a	1	0	0	1	0	2	1.2
Lr 2d	7	11	0	1	7	26	15.8
Lr 3	11	8	56	66	12	153	93.3
Lr 3ka	1	3	0	0	0	4	2.4
Lr 10	7	9	33	33	10	92	56.1
Lr 16	2	0	8	2	2	14	8.5
Lr 17	0	0	0	0	7	7	4.3
Lr 18	9	12	15	18	2	56	34.2

Table 3. Virulence combinations of *Puccinia recondita* isolates on backcross lines containing single genes for resistance to leaf rust in Canada in 1973

Avirulence/virulence formula	No. of isolates from:					Total no. of isolates
	Qué.	Ont.	Man.	Sask.	Alta. & B.C.	
1,2a,2d,3ka,10,16,17,18/3	2	0	15	23	1	41
1,2a,2d,3ka,16,17,18/3,10	2	1	19	23	2	47
1,2a,2d,3ka,10,16,17/3,18	0	0	8	10	1	19
1,2a,3,3ka,10,16,17/2d,18	4	5	0	0	0	9
1,2a,2d,10,16,17,18/3,3ka	1	0	0	0	0	1
1,2a,2d,3ka,17,18/3,10,16	2	0	7	1	0	10
1,2a,2d,3ka,16,17/3,10,18	2	1	6	8	0	17
1,2a,3ka,10,16,17/2d,3,18	1	1	0	0	0	2
1,2a,3,3ka,16,17/2d,10,18	1	2	0	0	0	3
2a,2d,3ka,16,17,18/1,3,10	0	1	0	0	0	1
1,2a,3ka,16,18/2d,3,10,17	0	0	0	0	6	6
1,2a,2d,3ka,17/3,10,16,18	0	0	1	0	1	2
1,3ka,17,18/2a,2d,3,10,16	0	0	0	1	0	1
1,2a,3ka,18/2d,3,10,16,17	0	0	0	0	1	1
1,2a,16,17/2d,3,3ka,10,18	0	3	0	0	0	3
3ka,10,16,17/1,2a,2d,3,18	1	0	0	0	0	1

variety possesses genes Lr10 and Lr16. Some collections of leaf rust must have been taken from Selkirk but the exact number is not known.

Nine single-gene backcross lines were used to study physiologic specialization in leaf rust (1,2,3,4,5). The distribution of virulence on the individual single-gene lines (Table 2) is essentially similar to the distribution obtained in 1972 (6). Few isolates are virulent on Lr1 and Lr2a, and most isolates are virulent on Lr3. Virulence to genes Lr1 and Lr2 is present in the leaf rust population and virulent cultures can readily be obtained by inoculating varieties possessing gene Lr1 with bulked collections of urediospores. However, for a number of years, approximately 1% of the isolates from Manitoba and Saskatchewan have been virulent on genes Lr1 and Lr2a. Gene Lr3ka was obtained from 'Klein Aniversario' and is allelic to Lr3 from 'Democrat'. Only a few isolates from Eastern Canada were virulent on this gene. Virulence to Lr17 was observed only in collections from Lethbridge, Alberta, and Creston, B.C. Collections of leaf rust from these two areas show very similar patterns of virulence while collections of leaf rust from central and northern Alberta have virulence patterns identical to those shown by collections from Manitoba and Saskatchewan. It is obvious that Alberta receives inoculum from two different ecological areas.

Sixteen virulence combinations were obtained in 1973 (Table 3). Four combinations showing virulence on Lr3, Lr10 and Lr18 comprised the majority of the isolates.

Composite collections of leaf rust were used to inoculate a number of highly resistant varieties of wheat. This study showed that there was in the rust population a low frequency of virulence on Lr1 and Lr2a and an even lower frequency of virulence on 'Agent'. No susceptible-type pustules were observed on 'Agatha', 'Transfer', 'Aniversario', 'El Gaucho', 'Terenzio', 'Tobari 66', and 'Waldron'.

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Literature cited

1. Dyck, P. L., and D. J. Samborski. 1968. Genetics of resistance to leaf rust in the common wheat varieties Webster, Loros, Brevit, Carina, Malakof and Centenario. Can. J. Genet. Cytol. 10:7-17.

2. Samborski, D. J., and P.L. Dyck. 1968. Inheritance of virulence in wheat leaf rust on the standard differential wheat varieties. Can. J. Genet. Cytol. 10:24-32.

3. Dyck, P.L., and D. J. Samborski. 1968. Host-parasite interactions involving two genes for leaf rust resistance in wheat. Pages 245-250 in Proc. 3rd Intern. Wheat Genet. Symp. (Canberra) 1968, Australia.

4. Haggag, M. E. A., and P. L. Dyck. 1973. The inheritance of leaf rust resistance in four common wheat varieties possessing genes at or near the Lr3 locus. Can. J. Genet. Cytol. 15:127-134.

5. Haggag, M. E. A., D. J. Samborski, and P. L. Dyck. 1973. Genetics of pathogenicity in three races of leaf rust on four wheat varieties. Can. J. Genet. Cytol. 15:78-82.

6. Samborski, D.J. 1972. Leaf rust of wheat in Canada in 1972. Can. Plant Dis. Surv. 52:168-170.

STEM RUST OF WHEAT, BARLEY, AND RYE IN CANADA IN 1973[1]

G.J. Green

Prevalence and importance in Western Canada

Wheat stem rust (*Puccinia graminis* Pers. f. sp. *tritici* Eriks. and E. Henn.) was widespread in the winter wheat region of the United States in 1973 but infections were light. Few urediospores were carried into Western Canada by the wind, and rust developed slowly. Infections on susceptible varieties in experimental plots and on the susceptible grass *Hordeum jubatum* L. were not observed until mid-August. There was no stem rust on resistant commercial varieties.

The amount of wheat stem rust in the rust area of Western Canada has decreased greatly since the release of *Triticum aestivum* L. 'Selkirk' in 1954. Selkirk has been succeeded by Manitou (1965) and Neepawa (1969). Recently, Napayo, a variety with resistance from Manitou; Glenlea, a resistant utility wheat; and *T. durum* Desf. 'Hercules' and 'Wascana' have been released. These varieties are highly resistant in the field and no rust has been found on them in recent years. In the United States highly resistant varieties are grown in the spring wheat region and in the northern part of the winter wheat region as well. The combined effect of these resistant varieties has been to so delay and restrict the development and extent of wheat stem rust in Western Canada that it is usually difficult to find until late in the season.

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

Uniform rust nurseries were planted by cooperators at 30 locations across Canada in 1973 (Table 1). The nurseries included: the stem rust susceptible varieties Red Bobs and Mindum; Lee, a variety selective for all strains of "standard" race 15B; Pitic 62, a variety selective for several strains of the "standard" race group 11-32-113; the stem rust resistant commercial varieties Neepawa, Napayo, Glenlea, Hercules, and Wascana; the stem rust resistant test varieties Kenya Farmer, C.I. 8154 x Frocor[2], Marquis[6] x (Stewart[3] x R.L. 5244), and D.T. 322. The cooperators harvested the plots at an appropriate time and sent small sheaves of the material to Winnipeg where the percentages of stem rust were recorded and collections were made for race identification.

Table 1. Percent infection of stem rust (*Puccinia graminis* f. sp. *tritici*) on 17 wheat varieties in uniform rust nurseries at 9 locations* in Canada in 1973

	Common wheat													Durum wheat			
Location	Red Bobs	Lee	Pitic 62	Neepawa	Napayo	Kenya Farmer	Glenlea	Exchange	Frontana	Thatcher[6] x Transfer	R.L. 4255	C.I. 8154 x Frocor[2]	Marquis[6] x (Stewart[3] x R.L. 5244)	Hercules	Mindum	Wascana	D.T. 332
Brandon, Man.	tr**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Durban, Man.	5	tr	tr	0	0	0	0	0	tr	0	0	0	0	0	tr	0	0
Glenlea, Man.	60	10	tr	0	tr	tr	tr	tr	tr	tr	tr	0	10	0	tr	tr	tr
New Liskeard, Ont.	60	20	0	0	0	0	0	10	10	5	0	0	0	0	90	0	0
Vineland, Ont.	30	tr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Guelph, Ont.	30	tr	10	0	1	tr	0	0	10	5	tr	0	0	0	1	0	0
Ottawa, Ont.	50	tr	0	0	0	0	0	0	0	5	tr	0	0	0	tr	0	0
Sunbury, Ont.	60	30	40	0	0	5	0	0	5	0	0	0	10	0	30	0	0
Macdonald College, Qué.	70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* No rust was observed in nurseries at 21 locations: Agassiz and Creston, B.C.; Edmonton, Beaverlodge, Lacombe, and Lethbridge, Alta.; Scott, Melfort, and Indian Head, Sask.; Morden, Man.; Thunder Bay, Kemptville, and Appleton, Ont.; La Pocatière, Québec, and Normandin, Qué.; Truro and Kentville, N.S.; Fredericton, N.B.; Charlottetown, P.E.I.; and St. John's West, Nfld.

** tr = trace.

[1] Contribution No. 600, Research Station, Agriculture Canada, Winnipeg, Manitoba, R3T 2M9.

Table 2. Percent infection of stem rust (*Puccinia graminis*) on three varieties of barley and one variety of rye in uniform rust nurseries at 14 locations* in Canada in 1973

Location	Barley			Rye
	Montcalm	Parkland	C.I. 10644	Prolific
Agassiz, B.C.	0	0	0	tr
Indian Head, Sask.	tr	tr	0	0
Brandon, Man.	0	0	0	10
Glenlea, Man.	5	tr	tr	30
Kemptville, Ont.	0	0	0	30
Guelph, Ont.	0	0	0	40
Ottawa, Ont.	5	10	1	80
Appleton, Ont.	20	20	25	90
Sunbury, Ont.	20	40	10	80
Vineland, Ont.	0	0	0	tr
La Pocatière, Qué.	tr	0	0	50
Macdonald College, Qué.	0	0	0	40
Kentville, N.S.	0	0	0	80
Fredericton, N.B.	0	0	0	40

* No rust was observed in nurseries at 16 locations: Creston, B.C.; Edmonton, Beaverlodge, Lacombe, and Lethbridge, Alta.; Scott and Melfort, Sask.; Durban and Morden, Man.; Thunder Bay and New Liskeard, Ont.; Québec and Normandin, Qué.; Truro, N.S.; Charlottetown, P.E.I.; and St. John's West, Nfld.

Table 3. Distribution by provinces of physiologic races of *Puccinia graminis* f. sp. *tritici* collected on wheat, barley, and grasses in 1973, and frequency of isolation of *P. graminis* f. sp. *secalis* from barley and wild grasses

Virulence formula (race) number	Virulence formula (effective/ineffective host genes)	Number of isolates from:				Total number of isolates	Percent of total isolates
		Qué.	Ont.	Man.	Sask.		
C10(15B-1)	6,7a,8,GB/5,9a,9b,9d,10,11,13,14,15,16,17			1		1	0.9
C14(14,38)	6,7a,10,11,15,16/5		4	1		5	4.7
C18(15B-1L)	6,8,9a,9b,13,15,17/5,7a,9d,10,11,14,16	1	3	8		12	11.3
C33(15B-1L)	6,9a,9b,13,15,17/5,7a,8,9d,10,11,14,16	3	19	35	11	68	69.2
C35(32-113)	9d,10,11,13,17/5,6,7a,8,9a,9b,14,15,16		3	3		6	5.7
C38(15B-1L)	6,8,9a,9b,13,17/5,7a,9d,10,11,14,15,16			1		1	0.9
C41(32-113)	9d,10,13,17/5,6,7a,8,9a,9b,11,14,15,16			1		1	0.9
C46(15B-1L)	6,8,9a,9b,13,15/5,7a,9d,10,11,14,16,17				1	1	0.9
C52(32-113)	9d,10,11,13/5,6,7a,8,9a,9b,14,15,16,17		4	1		5	4.7
C53(15B-1L)	6,9a,9b,13,15/5,7a,8,9d,10,11,14,16,17			1		1	0.9
C54(38)	6,7a,10,11,16,17/5,8,12,15		4	1		5	4.7
Total wheat stem rust isolates		4	37	53	12	106	100
Rye stem rust isolates		0	6	146	116	268	

Stem rust was found in only 9 of the 30 nurseries and infections were light except for moderate infections on the very susceptible variety Red Bobs at 5 locations and a heavy infection on Mindum at 1 location (Table 1). In Western Canada rust occurred only in Manitoba. Infections were light except at Glenlea in the vicinity of a large inoculated rust nursery. It is clear that there was not much wheat stem rust in Western Canada in 1973. In Eastern Canada most rust occurred in nurseries in eastern Ontario where stem rust resistant wheat varieties are not commonly grown. In Quebec, stem rust occurred only at Macdonald College and there was no rust eastwards to Newfoundland.

The nurseries also included three varieties of barley (Hordeum vulgare L.) and one of rye (Secale cereale L.) (Table 2). The barley variety Montcalm is susceptible to wheat stem rust and rye stem rust, whereas Parkland and C.I. 10644 are resistant to wheat stem rust and susceptible to rye stem rust. Stem rust was observed on barley or rye at 14 of the 30 locations (Table 2). Rye stem rust occurred at 13 locations and at all but one of these locations infection was moderate to severe. The rusting of all three barley varieties at several locations indicates that rye stem rust was probably the cause. Stem rust seems to have developed at some locations on rye after barley had matured. Evidently rye stem rust was more prevalent than wheat stem rust, but like wheat stem rust it developed late in the season.

Physiologic races

Physiologic races were identified by the "formula" and "standard" methods (1, 5) used in previous years. The "standard" differential hosts were reduced from six to four (T. aestivum 'Marquis', T. durum 'Mindum', T. monococcum L. 'Einkorn', and T. dicoccum Schrank. 'Vernal'). The resistance genes used in the "formula" method were: Sr5, Sr6, Sr7a, , Sr7b, Sr8, Sr9a, Sr9b, Sr9d, Sr9e, Sr10, Sr11, Sr12, Sr13, Sr14, Sr15, Sr16, Sr17, Sr18, Sr22, and SrTt2. The genes Sr7a, Sr9b, Sr9d, Sr10, Sr13, and Sr14 were used in backcross lines of Marquis. To avoid the Marquis resistance which, with some races, is epistatic to some of the genes, Sr5 and Sr6 were used in backcross lines of the susceptible variety Prelude. Sr8, Sr9a, Sr11, and Sr16 were used in lines of susceptible Chinese Spring. Sr15 is in the variety Norka and Sr17 is in Renown. Both varieties have more resistance genes than the single one mentioned. Hosts used for the first time include gene Sr9e in the variety Vernstein, gene Sr7b from Hope in a line of Chinese Spring, gene Sr12 in a line from the cross Chinese Spring[5] x Thatcher, gene Sr18 in a line from the cross Chinese Spring[3] x Hope, gene Sr22 from the cross Marquis[5] x (Stewart[3] x R.L. 5244), and gene SrTt2 in Sydney University Line W3563. The wheat lines were obtained from a variety of sources.

Genes Sr12, Sr16, and Sr18 are poor differentials for the Canadian stem rust population. They are susceptible or moderately susceptible to all races. The lowest infection type observed on them was not sufficiently distinct and stable to differentiate races reliably.

Genes Sr9e, Sr22, and SrTt2 are promising differentials. When effective, Sr9e produces infection type 1+ or 2-, Sr22 type 2, and SrTt2 type ;1. Gene Sr9e, like Vernal, confers resistance to all races found in 1973 except to the "standard" race 15 group. Sr22 confers resistance to all races against which it has been tested. SrTt2 confers resistance to all 1973 races except C10 (15B-1). They will not be added to the formulas until a second years experience confirms their usefulness.

The Chinese Spring line carrying Sr7b produced infection type 2 to 3 or 3± with some cultures that produced type 3+ or 4- on Marquis, which also carries Sr7b. The reason for the lower infection type was not established. A second interesting reaction was a mesothetic or 2 to 3+ infection type on the Chinese Spring-Sr11 line with some cultures of races C18(15B-1L) and C33(15B-1L) that normally produce type 3+ or 4. The partial loss of virulence on Sr11 may be comparable to increased virulence on gene Sr7a resulting from what appeared to be an "erosion" of resistance (3). Previous changes in virulence on Sr11 have been from avirulence to virulence, or vice versa. There is evidence that virulence on Sr11 is controlled by a single recessive gene (2). Consequently, heterozygosity would not be expected to cause a mesothetic reaction, although in some genotypes avirulence may be only partially dominant. The recent observation of intermediates suggests that rust strains may lose or acquire virulence by more than one kind of genetic change.

The absence of stem rust on commercial wheat varieties in Western Canada restricted collections to a few susceptible experimental plots and to wild barley, which was the main source. Although a large number of collections were made late in the season, only 106 isolates of wheat stem rust were obtained. The other collections were rye stem rust (Table 3). The small amount of wheat stem rust was accompanied by a reduction of the number of races identified from 17 in 1972 to 11 in 1973.

There was no change in the main races. Race C33(15B-1L) predominated, and races C18(15B-1L), C35(32-113), and C14(38) occurred commonly. Race C52(32-113), which resembles race C35(32-113) but is avirulent on gene Sr17, increased from 1.8% of the isolates in 1972 to 4.7%, and the new race C54(38), which resembles C14(38) except for virulence on gene Sr15, also comprised 4.7% of the population. A second new race, C53(15B-1L), was identified rarely. Race C10(15B-1), the original race 15B, was identified for the first time since 1964. The formulas for the races found in 1973, including the two new races C53(15B-1L) and C54(38), appear in Table 3. The formulas for races C1 to C52 were given in 1972 (4).

The new races found in 1973 do not seriously threaten resistant commercial varieties, nor do the prevalent races. The only race that causes concern is C52(32-113) which increased slightly over 1972. It is one of the most recent and virulent members of the "standard" race 11-32-113 group that has steadily evolved greater virulence on Thatcher derivatives such as Manitou and Neepawa. Race C52(32-113) probably could not seriously damage these varieties but it

Table 4. Percent of total isolates avirulent on single identified resistance genes and number of avirulent races in 1972 and 1973*

Resistance gene	Avirulent isolates (%) 1973 (1972)	Number of avirulent races 1973 (1972)
Sr 5	0 (0.3)	0 (1)
Sr 6	88.7 (83.2)	8 (11)
Sr 7a	10.3 (9.2)	3 (2)
Sr 7b	9.4 (9.2)	2 (2)
Sr 8	14.1 (14.5)	4 (5)
Sr 9a	78.4 (74.3)	5 (10)
Sr 9b	78.4 (74.0)	5 (9)
Sr 9d	11.3 (17.2)	3 (6)
Sr 10	20.7 (25.0)	5 (6)
Sr 11	19.8 (25.2)	4 (7)
Sr 13	89.7 (89.8)	8 (13)
Sr 14	0 (0)	0 (0)
Sr 15	82.2 (79.4)	5 (6)
Sr 16	9.4 (9.5)	2 (3)
Sr 17	87.9 (87.7)	6 (11)

* 1973 - 11 races; 1972 - 17 races.

appears to be another step along an evolutionary pathway of gradually increasing virulence on Thatcher and some of its derivatives.

The percentages of the isolates avirulent on 15 resistance genes were similar to 1972 although 17 races were identified in 1972 and 11 in 1973. The data in Table 4 are incomplete because races C14(38) and C54(38) are avirulent on Marquis and have not been included in the percentage for the genes to which Marquis resistance is epistatic. The results indicate that resistance genes Sr6, Sr9a, Sr9b, Sr13, Sr15, and Sr17 act against most of the Canadian rust population.

Six composite collections were made from urediospores from the initial increase of the 106 isolates of wheat stem rust. Each composite collection was used to inoculate a group of highly resistant varieties. Five of the six composite collections produced similar results (Table 5). Only Chris and C.T. 436 showed susceptible infections. Composite No. 1, however, produced type 3 infections on Mida-McMurachy-Exchange 11-47-26, 2± on Frontana-K58-Newthatch II-50-17, and 2 on Glenlea. The races causing the higher infection types have not yet been identified but these reactions are not surprising because races found in earlier years were virulent on these varieties. Apparently there were no new combinations of virulence affecting these varieties.

Table 5. Infection types produced on 24 resistant varieties by six composite collections of urediospores from 106 isolates of wheat stem rust collected in 1973

Variety	Composites 2,3,4,5,6	Composite 1
Mida-McMurachy-Exchange II-47-26	0	; to 3
Frontana-K58-Newthatch II-50-17	0	2±
Chris	; to 4	; to 4
Era	;	;
Glenlea	;	2
Agent	2	2
Agatha	2	2
St 464	1	1
WRT 240 (Manitou with rye translocation)	;	;
Bonny	0 or ;	;
Kenya Farmer	2	2
Webster	2 or 2 to 3	2 to 3
Hercules	1	1
C.I. 8154 × Frocor[2]	;1	;1
Esp 518/9	0 or ;	;
Tama	0 or ;	;
Romany	0 or ;	;
Saric 70	2	2
C.T. 436	; to 4	; to 4
ND 499	;	;
D.T. 317	1	1
D.T. 411	;	;
Etoile de Choisi	2	2
R.L. 5405 (resistance from *Aegilops squarrosa*)	2	2

The large number of rye stem rust isolates (Table 3) may have been caused by the reduction in the amount of wheat stem rust rather than an increase in the amount of rye stem rust. However, an attempt was made to determine whether there were strains of rye stem rust with pathogenicity on wheat, rye, or triticale that might help explain the large number of rye stem rust isolates. Thirty-six of the isolates were used separately to inoculate the wheat stem rust susceptible wheat varieties Prelude and W2691; the wheat stem rust and rye stem rust susceptible wheat variety W3498; the rye stem rust susceptible rye variety Rosen; the winter wheat varieties Scout 66, Scoutland, Eagle, Gage, Lancer, Bronze, and Agent; selections from the rye varieties P.I. 168186, P.I. 168205, and P.I. 168215 selected in the field for susceptibility to wheat stem rust; and the Mexican triticale lines S532, S534, S535, and S537 that are susceptible to wheat stem rust.

Prelude and W2691 were highly resistant to all cultures of rye stem rust; W3498 was moderately susceptible; Rosen rye was susceptible; the winter wheat varieties were immune; the rye selections segregated and were variable in reaction; and the triticale lines were immune or highly resistant. There was little or no variability in the rye stem rust isolates on these varieties, nor did the reactions suggest why rye stem rust was collected so frequently in 1973.

Acknowledgments

I am grateful to the cooperators at rust nursery locations who made this project possible, and to those who sent rust samples for identification. Mr. J. H. Campbell was responsible for the technical aspects of the survey and for recording rust intensities in the nurseries.

Literature cited

1. Green, G. J. 1965. Stem rust of wheat, rye, and barley in Canada in 1964. Can. Plant Dis. Surv. 45:23-29.

2. Green, G. J. 1966. Selfing studies with races 10 and 11 of wheat stem rust. Can. J. Bot. 44:1250-1260.

3. Green, G. J. 1969. Stem rust of wheat, barley, and rye in Canada in 1969. Can. Plant Dis. Surv. 49:83-87.

4. Green, G. J. 1972. Stem rust of wheat, barley, and rye in Canada in 1972. Can. Plant Dis. Surv. 52:162-167.

5. Stakman, E. C., D. M. Stewart, and W. Q. Loegering. 1962. Identification of physiologic races of Puccinia graminis var. tritici. U.S. Dep. Agr., Agr. Res. Serv., Bull. E617 (Revised).

CROWN RUST OF OATS IN CANADA IN 1973[1]

D.E. Harder and R.I.H. McKenzie

Occurrence in western Canada

Oat crown rust caused by Puccinia coronata Cda. f. sp. avenae Eriks. was general but light throughout Manitoba and southeastern Saskatchewan. There was moderate damage in late-sown fields. Well developed crown rust pustules were found on oats adjacent to buckthorn (Rhamnus cathartica L.) thickets near Morden, Manitoba, on June 26, 2 weeks earlier than the first observation of crown rust in farm fields distant from buckthorn.

Uniform rust nurseries

Ratings of crown rust intensity on 10 oat (Avena sativa L.) cultivars in nurseries grown across Canada are given in Table 1. Locations at which no crown rust was detectable or from which leaves could not be scored are omitted from the table. There was a slight increase in virulence on R.L. 2924 (a line with gene Pc38) in 1973 as compared to other years (1, 2). The line R.L. 2925, carrying gene Pc39, has remained resistant.

The cultivar Hudson has been recently licensed for commercial production, and it is expected that Hudson will be grown mainly in Western Canada. There were significant levels of infection on Hudson at all locations, with the highest levels occurring in Eastern Canada. Some isolates of races 229, 264, 275, 284, 295, 324, 326, 330, and 333 obtained in the present survey were virulent on this cultivar. Most isolates could attack the commercial oat cultivars Harmon and Random (Table 4).

Physiologic specialization

The incidence and distribution of physiologic races of crown rust in Canada are given in Table 2. The 73 isolates from Eastern Canada comprised 22 "standard" races, giving a race/isolate ratio of 0.30. As in 1972 (2) race 210 predominated, comprising 26% of the isolates. Races 284 and 330 were also common.

In Western Canada 104 isolates comprised 18 races, for a race/isolate ratio of 0.17. As in recent years (1,2), races 295 and 326 were the most common.

All crown rust collections were tested on a series of backcross lines of Avena sativa L. cv. Pendek containing single genes for crown rust resistance derived from Avena

Table 1. Percentage infection of crown rust on 10 oat cultivars at 10 locations* in Canada in 1973

Location	Hudson	C.I. 9139	C.I. 4023	C.I. 3034	Rodney	R.L. 2924	R.L. 2925	R.L. 2926	R.L. 2970	Harmon
Brandon, Man.	40	65	80	60	65	0	0	65	65	80
Morden, Man.	20	10	20	5	20	tr†	0	40	20	30
Durban, Man.	30	10	40	65	60	0	0	40	50	60
Kemptville, Ont.	90	40	90	60	90	tr	0	90	80	80
Guelph, Ont.	50	30	50	20	60	0	0	10	20	50
La Pocatière, Qué.	5	tr	20	10	25	tr	0	10	5	15
Macdonald College, Qué.	50	0	50	80	80	0	0	50	70	20
Truro, N.S.	5	0	10	0	tr	0	0	tr	tr	tr
Kentville, N.S.	25	0	25	15	25	0	0	20	20	25
Charlottetown, P.E.I.	tr	0	10	tr	10	0	0	5	tr	5

* Crown rust was not detected or was not rated in nurseries at the following locations: Agassiz and Creston, B.C.; Edmonton, Beaverlodge, and Lacombe, Alta.; Indian Head, Scott, and Melfort, Sask.; New Liskeard, Thunder Bay, Ottawa, Appleton, Sudbury, and Vineland, Ont.; Québec City, Lennoxville, and Normandin, Qué.; Fredericton, N.B.; St. John's West, Nfld.

† tr = trace.

[1] Contribution No. 602, Research Station, Agriculture Canada, Winnipeg, Manitoba R3T 2M9.

Table 2. Distribution of physiologic races of crown rust in Canada in 1973

Physiologic race	East		West	
	No. of isolates	% of isolates	No. of isolates	% of isolates
203	2	2.7	4	3.8
210	19	26.0		
211	1	1.4		
212	1	1.4		
216			1	1.0
226	1	1.4		
228	6	8.2		
229	2	2.7		
230	2	2.7		
231	1	1.4		
239	2	2.7		
241	1	1.4		
275	3	4.1		
283	2	2.7		
284	10	13.7	6	5.8
290	2	2.7	2	1.9
295			50	48.0
299	2	2.7		
320			1	1.0
322	1	1.4		
324			1	1.0
326			22	21.0
330	8	10.9	1	1.0
333			2	1.9
335			3	2.9
336			1	1.0
337			2	1.9
341	3	4.1	1	1.0
350			1	1.0
360			1	1.0
367			1	1.0
409	1	1.4		
416	2	2.7		
427	1	1.4	4	3.9

sterilis L. There was limited virulence on the single gene lines (Table 3). There were only 10 virulence combinations in 1973 as compared to 21 in 1972 (2). About 48% of the isolates were avirulent on the single gene lines, and, as in 1972, virulence on lines with genes Pc35 and Pc50 predominated (Table 4). The virulence combination/isolate ratios for Eastern and Western Canada were 0.11 and 0.042 respectively, following a pattern similar to the standard race/isolate ratios.

Crown rust isolates were also obtained from plots at Glenlea and Greenacres (Winnipeg), Manitoba. These plots contain a wide range of genetic material, and plots at Greenacres were artificially inoculated with a mixture of crown rust races. Races isolated in addition to those found in the general survey were 264, 281, 285, 293, and 392. Also, single isolates were found with virulence combinations 39, 40, 45, 46, 47, 48, 50/35, 38, and 35, 38, 39, 45, 46, 47, 48/40, 50. Genes Pc38 and Pc39 are expected to constitute the major resistance to crown rust in Western Canada in the near future. The resistance provided by these genes in combination has remained effective.

At present there is little being done in Canada to control buckthorn, the alternate host of crown rust. In Manitoba, there are several areas with fairly extensive growths of buckthorn, while in Eastern Canada the shrub is common. The higher crown rust race/isolate ratio in Eastern Canada may be a reflection of this. The presence of buckthorn in oat growing areas is a matter of concern because of the acceleration given to epiphytotics in such areas and because the opportunity for sexual recombination in P. coronata increases the probability of a race appearing that is capable of attacking cultivars in which the resistance genes Pc38 and Pc39 are combined.

Table 3. Virulence combinations of *Puccinia coronato* on backcross lines containing single (*Pc*) genes for resistance to crown rust

Virulence formula (effective/ineffective host genes)	East		West	
	No. of isolates	% of isolates	No. of isolates	% of isolates
35,38,39,40,45,46,47,48,50/	37	43.5	88	52.7
38,39,40,45,46,47,48,50/35	35	41.2	40	23.9
35,39,40,45,46,47,48,50/38	1	1.2	2	1.2
35,38,39,45,46,47,48,50/40	1	1.2	4	2.4
35,38,39,40,46,47,48,50/45	3	3.5		
35,38,39,40,45,46,47,48/50	4	4.7	25	14.9
38,39,45,46,47,48,50/35,40			3	1.9
38,39,40,46,47,48,50/35,45	2	2.4		
38,39,40,45,46,47,48/35,50	1	1.2	5	3.0
39,45,46,47,48,50/35,38,40	1	1.2		

Table 4. Distribution of virulence of isolates of *Puccinia coronata* in 1973 on the standard differential cultivars, on backcross lines carrying single crown rust resistant genes, and on several commercial oat varieties

Cultivar or resistance gene	Eastern Canada		Western Canada	
	No. of virulent isolates	% of isolates	No. of virulent isolates	% of isolates
Anthony	25	34.2	97	93.3
Victoria	7	9.6	28	26.9
Appler	15	20.5	85	81.7
Bond	51	69.9	95	91.3
Landhafer	7	9.6	81	77.9
Santa Fe	5	6.8	76	73.1
Ukraine	67	91.8	96	92.3
Trispernia				
Bondvic				
Saia	14	19.2	4	3.8
Pc35	38	44.7	48	28.7
Pc38	2	2.4	3	1.2
Pc39				
Pc40	1	1.2	7	4.2
Pc45	5	5.9		
Pc46				
Pc47				
Pc48				
Pc50	5	5.9	30	18.0
Hudson	11	12.9	11	6.6
Harmon	83	97.6	166	99.4
Random	49	57.6	157	94.0

Acknowledgments

The cooperators who cared for nurseries and submitted rust collections from the various locations in Canada are thanked. Mr. W. L. Timlick carried out all technical operations.

Literature cited

1. Fleischmann, G. 1972. Crown rust of oats in Canada in 1971. Can. Plant Dis. Surv. 52:15-16.

2. Samborski, D. J., and R. I. H. McKenzie. 1972. Crown rust of oats in Canada in 1972. Can. Plant Dis. Surv. 52:173-174.

STEM RUST OF OATS IN CANADA IN 1973[1]

J.W. Martens

Prevalence and crop losses in Western Canada

Stem rust of oats caused by Puccinia graminis Pers. f. sp. avenae Eriks. and E. Henn. was first found in southern Manitoba on August 7. Light infections developed throughout most of Manitoba and eastern Saskatchewan as far west as Regina, but the disease caused almost no crop losses.

Uniform rust nurseries

Rust nurseries comprising the cultivars Harmon, Hudson, and Rodney, and the lines CI 3034, CI 4023, CI 9139, RL 2924, RL 2925, RL 2926, and RL 2970 were grown at 28 locations across Canada. Rust was observed in trace amounts at only six locations, Charlottetown, P.E.I., Kentville, N.S., and Brandon, Durban, Glenlea, and Morden, Man. No rust was observed in nurseries grown at St. John's West, Nfld.; Fredericton, N.B.; Truro, N.S.; Normandin, Québec, and La Pocatière, Qué.; Appleton, Guelph, Kemptville, New Liskeard, Ottawa, Sudbury, Thunder Bay, and Vineland, Ont.; Indian Head, Melfort, and Scott, Sask.; Beaverlodge, Edmonton, Lacombe, and Lethbridge, Alta.; and Agassiz and Creston, B.C.

Identification and distribution of physiologic races

Physiologic races were identified by the infection types produced on seedlings of the cultivars Richland (rust resistance gene Pg 2), Rodney (Pg 4), Minrus (Pg 1), Jostrain (Pg 3), Eagle[2] x C.I. 4023 (pg 8), and C.I. 5844-1 (pg 9). Adequate stocks of single gene lines in the 'Rodney 0' background have now been produced and it is anticipated that these will be used for race identification in the future. A supplementary set comprising the cultivars C.I. 9139 (unknown genotype) and R.L. 2926 (pg 13), (2) was used. All 153 cultures were avirulent on the supplementary set. The race distribution in Western Canada (Table 1) has remained almost unchanged from 1972 with two races, C10 and C23, comprising over 98% of the population; however the

Table 1. Distribution of physiologic races of oat stem rust in Canada in 1973

Race no.	Virulence formula (effective/ineffective Pg host genes)	No. of isolates from: N.S. & Qué.	Ont.	Man.	Sask.	Total isolates	Percentage of total isolates
	A. Combined isolates from all hosts						
C 5	4,9/1,2,3,8			2		2	1.3
C 9	8/1,2,3,4,9	2	3			5	3.3
C 10	9/1,2,3,4,8		2	58	37	97	63.4
C 23	2,4,9/1,3,8			20	29	49	32.0
Total						153	
	B. Isolates from cultivars with some stem rust resistance						
C 5				2		2	3.2
C 9			3			3	4.8
C 10			2	38	14	54	85.7
C 23				4		4	6.3
Total						63	
	C. Isolates from wild oats and cultivars with no stem rust resistance						
C 9		2				2	2.2
C 10				20	23	43	47.8
C 23				16	29	45	50.0
Total						90	

[1] Contribution No. 598, Research Station, Agriculture Canada, Winnipeg, Manitoba, R3T 2M9.

Table 2. Frequency of virulence in the oat stem rust population on various types of resistance in western Canada in 1973

Percentage of isolates virulent on cultivars with the following genes for resistance							Total no. isolates	Mean virulence capability*
Pg 1	*Pg 2*	*Pg 3*	*Pg 4*	*pg 8*	*pg 9*	*pg 13*		
100.0	66.4	100.0	65.1	100.0	1.4	0.0	146	4.32

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

prevalence of C23 decreased slightly in 1973, the first such decrease since 1969 (1). Since race C23 is avirulent on most commercial cultivars (most have Pg 2 and Pg 4) the collections from host plants with no known resistance (Table 1, C) most accurately reflect field populations. If the present race distribution is maintained, the newly licensed cultivar Hudson, which combines resistance genes Pg 2, Pg 4 and pg 9, should provide adequate protection. The distribution of virulence on the lines carrying single resistance genes (Table 2) has not changed significantly from that of 1972. Very high levels of virulence on lines with Pg 1, Pg 3, and pg 8 resistance are being maintained even though these genes do not occur in the host population of Western Canada.

In an effort to detect new virulence combinations on breeding material a large number of small pustules were isolated from resistant lines in the breeding nursery near Winnipeg. Races C1 (1,2,3,4,8/9), C2 (1,2,4,8/3,9), and C24 (1,2,8/3,4,9), all with virulence on pg 13, were isolated. A new avirulent race (1,2,3,4,8,9,13/) was also found.

Another new virulence combination (1,8,9,13/2,3,4) was isolated by Dr. G. J. Green from barberry (Berberis vulgaris L.) infected by means of teliospores from Hordeum jubatum L. collected near Altamont, Manitoba. We do not know of any previous record of P. graminis avenae being isolated from H. jubatum. Greenhouse contamination seems unlikely because it is a new virulence combination. However, the urediospores of this culture did not reinfect H. jubatum in two attempts in the greenhouse.

Acknowledgments

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

Literature cited

1. Martens, J. W. 1972. Stem rust of oats in Canada in 1972. Can. Plant Dis. Surv. 52:171-172.

2. McKenzie, R. I. H., J. W. Martens, and T. Rajhathy. 1970. Inheritance of oat stem rust resistance in a Tunesian strain of Avena sterilis. Can. J. Genet. Cytol. 12:501-505.

BARLEY STRIPE MOSAIC IN MANITOBA IN 1973[1]

Arthur W. Chiko

A survey for barley stripe mosaic (BSM) in fields of 2-row barley (Hordeum distichum L. emend. Lam.) and 6-row barley (H. vulgare L. emend. Lam.) was conducted in southeastern Manitoba from June 25 to July 4, 1973, at which time these crops were in the early tillering to watery ripe stage. The region surveyed, methods of conducting the survey, and procedures used to identify barley stripe mosaic virus (BSMV) were outlined previously (2). BSM incidence was estimated by counting the number of diseased plants in a row of 100 plants within a representative portion of a field. In fields with trace infections (fewer than 1% of the plants with BSM), an arbitrary incidence of 0.1% was assigned.

BSM was detected in 18 of 130 (13.8%) fields of 2-row barley and in 4 of 34 (11.8%) fields of 6-row barley surveyed in 1973. The incidence of diseased plants was a trace in 4 fields of 6-row barley, whereas in fields of 2-row barley the incidence was a trace in 10 fields, 2-10% in 5 fields and 15-30% in 3 fields.

Increased planting of 'Fergus' barley and decreased planting of 'Herta' barley was associated with a marked decrease in the proportion of 2-row barley fields with BSM in Manitoba in 1972 compared to 1971 (3). In 1973, the acreage of 'Herta' in Manitoba was approximately the same as in 1972, while the acreage of 'Fergus' increased by about 6% (1). This small change probably accounts for the slight decrease in the proportion of 2-row barley fields in which BSM was detected in 1973 compared to 1972.

Although the proportion of 2-row barley fields with BSM has decreased annually in Manitoba since 1971, the average incidence of diseased plants in surveyed fields of this crop has increased (0.3% in 1971, 0.5% in 1972, 0.7% in 1973). This increase, presumably due to an increase in the amount of infected seed in some seed-lots, would probably have been considerably greater if the acreage of 'Herta' barley had not been substantially reduced in 1972.

The proportion of fields of 6-row barley in which BSM was detected in Manitoba in 1973 was considerably greater than in the previous 2 years (2, 3). However, because of the relatively small numbers of fields of this type of barley examined, only future surveys will reveal if BSM is increasing significantly in this crop.

Efforts to reduce the intensity and distribution of BSM in Manitoba and elsewhere in Canada are being continued. Currently, major emphasis is being placed on the benefits of planting pedigreed seed of recommended barley varieties, most lots of which are believed to be completely or nearly free of BSMV (3).

Literature cited

1. Brewing and Malting Barley Research Institute. 1973. Barley variety survey 1973. Barley Briefs. Winnipeg, Manitoba.

2. Chiko, A. W. 1971. Barley stripe mosaic virus in Manitoba in 1971. Can. Plant Dis. Surv. 51:159-160.

3. Chiko, A. W. 1973. Barley stripe mosaic in the Canadian prairies in 1972. Can. Plant Dis. Surv. 53:107-111.

[1] Contribution No. 585, Research Station, Agriculture Canada, Winnipeg, Manitoba R3T 2M9.

SCREENING OF POTATO FUNGICIDES IN 1973[1]

L.C. Callbeck [2]

Introduction

In Prince Edward Island weather conditions during July 1973 were generally favorable to the potato late blight fungus Phytophthora infestans (Mont.) de Bary, and at the end of that month a few cases of field infections were observed in the province. At mid-August the weather became much less conducive to the development and spread of the disease and growers were able to contain the epidemic.

This paper describes the procedures used and presents the results obtained in the 1973 screening of nine fungicidal mixtures for their relative efficacies in controlling late blight disease.

Materials and methods

In the list of fungicides given below, the description of each is arranged in order of trade name or code number, guaranteed active ingredient (except for three products that must be treated confidentially), source, and dosage rate per acre in terms of formulated product.

1. Bravo 7.2F. 7.2 lb/Imp. gal. tetrachloroisophthalonitrile. Diamond Shamrock Canada Ltd., Willowdale, Ontario, Canada. (a) 0.4 pints first three sprays, 0.75 pints remaining four sprays; (b) 0.75 pints at each spray.

2. CGF 2660. Confidential formulation. Ciba-Geigy Canada Ltd., Etobicoke, Ontario, Canada. 1.5 lb.

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

4. DPX 740. Confidential formulation. E. I. DuPont de Nemours and Company (Inc.), Wilmington, Delaware, U. S. A. 6.0 oz.

5. Du-Ter 20 WP. 20% triphenyltin hydroxide. Ciba-Geigy Canada Limited, Etobicoke, Ontario, Canada. 1.5 lb.

6. Liro-Matin 45.5 WP. 34% maneb, 11.5% triphenyltin acetate. Ciba-Geigy Canada Limited, Etobicoke, Ontario, Canada. 1.8 lb.

7. Polyram 80W. Zinc activated polyethylene thiuram disulfide. Niagara Brand Chemicals (now Agricultural Chemicals Division, FMC of Canada Ltd.), Burlington, Ontario, Canada. 1.5 lb.

8. RHC-365. Confidential formulation. Rohm and Haas Company of Canada Limited, West Hill, Ontario, Canada. 48 fl. oz.

Table 1. Percent defoliation caused by late blight

Treatment	Aug. 23	Aug. 30	Sept. 4	Sept. 13
Bravo 7.2F 0.4 - 0.75 pt	8	18	20	29
Bravo 7.2F 0.75 pt	3	10	12	22
CGF 2660	2	4	5	8
Dithane M-45	1	4	5	9
DPX 740	15	25	28	33
Du-Ter	6	12	16	26
Liro Matin	2	5	8	14
Polyram	3	6	8	16
RHC-365	2	4	5	6
Check	47	63	70	97
LSD 0.05	2.0	3.2	3.2	5.0
LSD 0.01	2.7	4.3	4.3	6.7

The plots were set out on land that had been in potatoes in 1972, manured in the autumn, and given a broadcast application of 10-20-20 fertilizer at the rate of 1,000 lb/acre before planting. Each plot was 4 rows wide by 50 ft long and exactly 50 seed pieces of the cultivar Green Mountain were dropped in each row. Single rows of the same cultivar were planted as buffers between plots and along each lateral side of the block. The 10 treatments were randomized and replicated in five consecutive ranges, separated from one another by 20-ft driveways. All data were taken from the two center rows of the plots.

The entire experiment was sprayed with endosulfan when it was necessary to control insect pests.

The fungicides were applied on July 16, 26; August 7, 15, 23, 30; and September 5, the mean interval being 8.5 days.

[1] Contribution No. 296, Research Station, Research Branch, Canada Department of Agriculture, Charlottetown, Prince Edward Island.

[2] Plant Pathologist.

Table 2. Effects of treatments on yield and rot

Treatment	Total (bu/acre)	Rot (bu/acre)	No. 1 (bu/acre)
Bravo 7.2F 0.4 - 0.75 pt	432.5	0.7	298.3
Bravo 7.2F 0.75 pt	454.7	0.4	323.6
CGF 2660	466.0	1.8	335.7
Dithane M-45	470.4	0.7	335.5
DPX 740	398.0	2.9	257.8
Du-Ter	460.0	2.4	339.2
Liro-Matin	477.0	0.9	344.5
Polyram	452.7	0.4	321.4
RHC-365	478.0	0.4	360.8
Check	341.9	0.9	207.7
LSD 0.05	37.7		43.6
LSD 0.01	50.6		58.5

The unsprayed buffer and border rows were inoculated by sprinkling a few plants in each of them with a water suspension of late blight spores during a light mist in the late afternooon of July 19. A second inoculation was performed when the dew was falling in the evening of July 26. The first lesions in these rows were observed on July 24.

After the disease had become well established in the untreated check plots and had begun to appear in the treated plots, defoliation estimates, based on the British Mycological Society's late blight key, were made at regular intervals. The estimates for four dates are shown in Table 1.

The test was terminated by spraying the plants with a top killer (diquat) on September 14, which was 105 days after planting. The plots were harvested on October 2 and 3. Yield data are given in Table 2.

Results and discussion

Under the conditions of late blight activity that existed in the 1973 season, the new test products of RHC-365 and CGF 2660 and the standard product Dithane M-45 gave the best control of the disease on the foliage. Another new entrant, DPX 740, gave poor control and, consequently, the plots sprayed with it gave the lowest yield among the nine fungicidal mixtures.

Du-Ter 20WP did not produce any visible deleterious effects on the foliage of potato plants in 1973. In some previous years in which the test sample contained 50 percent triphenyltin hydroxide, phytotoxicity was expressed as bronze leaf spots and as a brittleness of the leaves, the latter condition resulting in the detachment of leaves during high winds and heavy rains. These symptoms were likely to occur even when the dosage rate had been set as low as 10 oz per acre per application.

Bravo 7.2 F gave only mediocre control at the dosage rates at which it was tested in 1973. In 1971 and 1972 (1, 2) the dosages per acre per application of the active ingredient had been 0.9375 lb and 0.75 lb, respectively. In these two years Bravo flowable had been a leading fungicide in the screening tests. In 1973 the 0.4 and 0.75 pints of Bravo 7.2 F provided active ingredient dosages of 0.36 lb and 0.675 lb, respectively. In the treatment in which it was used at 0.4 pints per acre for the first three applications and at 0.75 pints per acre for the remaining four applications it ranked eighth among the nine treatments in controlling late blight in the foliage. The product ranked sixth when it was used at 0.75 pints per acre for all seven applications.

Conclusions

Previous experience and current results suggest that further testing of Du-Ter is required to determine if this fungicide is likely to be phytotoxic under certain meteorological conditions or when applied at more than the recommended rate. Similarly, it is suggested that further studies on dosage rates for Bravo 7.2 F should be made.

Literature cited

1. Callbeck, L. C. 1972. Screening of potato fungicides in 1971. Can. Plant Dis. Surv. 52:30-31.

2. Callbeck, L. C. 1972. Screening of potato fungicides in 1972. Can. Plant Dis. Surv. 52:151-152.

REDUCTION OF PRIMARY INFECTION OF TOMATO EARLY BLIGHT BY FALL FUMIGATION OF SOIL WITH VORLEX[1]

P. K. Basu

Abstract

Field plots infested with Alternaria porri f. sp. solani were treated with Vorlex at rates of 25, 50, and 75 gal/acre after a severely infected tomato crop was ploughed under in the fall of 1971. The following spring the percentage of tomato transplants showing symptoms of primary infection was reduced in those plots by 58%, 74%, and 78%, respectively, as compared with untreated control plots.

Résumé

Après l'enfouissement dans le sol par labourage d'une récolte de plants de tomates sévèrement infectés de l'Alternaria porri f. sp. solani au cours de l'automne 1971, les champs furent traités au Vorlex au taux de 25, 50, et 75 gallons l'acre. Le printemps suivant, le pourcentage des plants de tomates repiqués dans ces champs, ayant des symptômes d'infection primaire, baissa à 58%, 74%, et 78%, respectivement, par rapport aux champs non traités au Vorlex.

Introduction

Propagules of Alternaria porri (Ellis) Cif. f. sp. solani (Ell. & Mart.) Neerg., the causal fungus of early blight of tomato (Lycopersicon esculentum Mill.), potato (Solanum tuberosum L.), and related crops, can overwinter in soil with diseased plant debris (1, 6). Crop rotation has been suggested (6, 7) to avoid this pathogen but soil fumigation has not been employed as a control measure primarily because of its high cost and the possibility of soil pollution or ill effects on the crop. However, volatile soil fumigants, such as chloropicrin (3) and Vorlex (5), have been used without permanent harmful effects on tomatoes, peas, and many other vegetable crops (2, 3, 5). The long-term residual effects of Vorlex are not clearly known but lettuce (Lactuca sativa L.) seedlings can tolerate 1 ppm methyl isothiocyanate, the active ingredient of Vorlex, in outdoor soils (4). Objectionable levels of Vorlex in field soil are usually determined by odor and by the failure of lettuce seeds to germinate (personal communication, Morton Chemical Co., Woodstock, Ill., U.S.A.).

The main objective of the present work was to determine the effects of a fall application of Vorlex to field soil heavily infested with debris of early blight affected tomato plants in reducing the amount of primary infection of a tomato crop the following spring.

Materials and methods

Vorlex (methylisothiocyanate 20%, and 1, 3-dichloropropane and related chlorinated hydrocarbons 80%, Morton Chemical Co.) was applied to soil with a tractor driven soil fumigator (Pfizer Co., Ltd., Sarnia, Ontario) according to the manufacturer's instructions, after a tomato crop heavily infected by A. porri f. sp. solani was ploughed under in the fall of 1971. The rates of application were 0, 25, 50, and 75 gallons of the formulation per acre in plots of 7 x 126 ft dimension with four replications. Each plot was surrounded by a 7-ft-wide zone treated with Vorlex at 75 gal/acre to avoid contamination of plots by diseased plant tissues. In early June 1972, 10 seedlings of each of three tomato cultivars (Fireball VR, Jet Star, and Geneva John Baer) were transplanted in a row in each plot (28 ft/cultivar). Each plant was carefully observed for initial symptoms of early blight until the end of June. During that time the appearance of disease symptoms on lower leaves, especially those in contact with soil, was indicative of primary infection (1, 7).

Results and discussion

The lower leaves of all tomato plants in the nontreated plots showed typical leaf spots of early blight by the end of June 1972 (Table 1). The absence of leaf spots on the middle and top leaves indicated that secondary infections had not started during the period of observation. At that time in

[1] Contribution No. 382, Ottawa Research Station, Agriculture Canada, Ottawa, Ontario K1A 0C6

Table 1. Effect of fall application* of Vorlex to infested field soil on the incidence of primary infection of early blight on three tomato cultivars the following spring

Vorlex conc. (gal/acre)	Average** number of infected plants			% infected plants of all cultivars	% reduction of primary infection
	Fireball VR	Jet Star	John Baer		
0	10	10	10	100.0	0.0
25	5.2(±0.7)	3.5(±0.9)	3.8(±0.9)	41.7	58.3
50	2.0(±0.7)	3.0(±0.7)	2.8(±0.8)	25.8	74.2
75	3.5(±0.6)	1.5(±0.9)	1.5(±0.6)	21.7	78.3

* Soil treated October 1971; tomato seedlings transplanted to field June 3, and disease assessed June 15-30, 1972.

** Average of 4 replications of 10 plants; figures in parentheses indicate standard error.

the Vorlex-treated plots, the overall percentages of infected plants were 41.7, 25.8, and 21.7, respectively, for the 25, 50, and 75 gal/acre treatments. In the treated plots Fireball VR showed slightly greater numbers of infected plants than John Baer or Jet Star, indicating that Fireball VR would be more efficient in detecting the primary inoculum in soil than the other two cultivars. The variability in the numbers of infected plants in each treatment was reasonably low as indicated by the range of standard error values (0.6 to 0.9).

The results clearly show that the primary infection of tomato plants by A. porri f. sp. solani can be considerably reduced by soil fumigation with Vorlex; a reduction of 74% occurred when the treatment was at the rate of 50 gal/acre. Little added advantage was obtained by using 75 gal/acre. It was significant to note later in the season that even at this high initial dosage of Vorlex in soil, the growth and yield of tomato plants remained unaffected. Results also suggest that a reduction in the number of infected plants early in the season should lower the amount of inoculum (conidia) for secondary infections (6, 7).

Acknowledgment

The author wishes to thank S.I. Wong for technical assistance.

Literature cited

1. Basu, P.K. 1971. Existence of chlamydospores of Alternaria porri f. sp. solani as overwintering propagules in soil. Phytopathology 61:1347-1350.

2. Ebbels, D.L. 1967. Effect of soil fumigants on Fusarium wilt and nodulation of peas (Pisum sativum L.). Ann. Appl. Biol. 60:391-398.

3. Howard, F.L., and F.K. Crandall. 1939. Response of field grown tomatoes to soil fumigation with chloropicrin. Proc. Amer. Soc. Hort. Sci. 37:939-941.

4. Lloyd, G.A. 1962. The elimination of methyl isothiocyanate from soil after treatment with metham-sodium. J. Sci. Food Agr. 13:309-315.

5. McKeen, C.D., and R.M. Sayre. 1964. Control of Verticillium dahliae and Meloidogyne incognita in greenhouse tomatoes by soil fumigation. Can. J. Plant Sci. 44:466-470.

6. Rands, R.D. 1917. Early blight of potato and related plants. Wis. Agr. Exp. Sta. Res. Bull. 42:1-48.

7. Walker, J.C. 1952. Disease of vegetable crops. McGraw-Hill Book Co. 529 p.

CORRECTIONS

OCCURRENCE AND POPULATION DENSITIES OF NEMATODES ASSOCIATED WITH FORAGE CROPS IN EASTERN CANADA

J.L. Townshend, C.B. Willis, J.W. Potter, and J. Santerre

Volume 53, No. 3, September 1973, p. 131-136

Page 131, column 2, line 23, "inpression" should read "impression".

Page 132, column 2, para. 6, line 3, "lession" should read "lesion".

Page 134, column 1, lines 4-5, sentence should read:

The needle (Longidorus) nematode was found in a single sample from P.E.I. The ring nematode occurred in 69% of the fields sampled in N.B.

PUBLICATION NOTICE: *FUNGI CANADENSES*

The first fascicle (Nos. 1-10) of Fungi Canadenses was issued November 29th, 1973. The purpose of this new publication is to make available illustrations and more or less standardized accounts of fungi that have been collected in Canada. The format of loose-leaf sheets closely resembles that of CMI Descriptions of Pathogenic Fungi and Bacteria. This continuing publication will be issued at intervals in fascicles of 10 or more sheets, and sent free of charge to institutions where fungi are being actively studied. Exchange publications for Fungi Canadenses will be welcome.

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S. J. Hughes
Editor
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