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

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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.	6	0	2	0	0	0	0	0	0	1	0	1	0	5	0	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.	6	0	3	0	4	0	0	0	5	0	0	5	0	0	0	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.

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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	4.1
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@@ods (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, SrlO, 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' x Thatcher, gene Sr18 in a line from the cross Chinese Spring[3] x Hope, gene Sr22 from the cross Marquis' 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 11-47-26	0	; to 3
Frontana-K58-Newthatch 11-50-17	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	
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 axe 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.

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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 sraminis var. tritici. U.S. Dep. Agr., Agr. Res. Serv., Bull. E617 (Revised).