Stem rust of wheat, barley and rye in Canada in 1977[1]

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Susceptible wheat varieties in experimental plots in the eastern prairies were severely infected by ***Puccinia graminis tritici*** in 1977 but resistant commercial varieties in farm fields were nearly free from infection. Stem rust was also prevalent on ***Hordeum jubatum*** in Manitoba and eastern Saskatchewan but much of this rust was ***Puccinia graminis secalis.*** There was little stem rust in the rust nurseries excepting those located in Manitoba and eastern Saskatchewan. Twenty-seven races of wheat stem rust were identified. Race C33 (15B-1L) declined in prevalence and race C53 (15B-1L) replaced it as the main race. Races C25 (38) and C57 (32) are moderately virulent on seedlings of the resistant commercial varieties Neepawa and Sinton, but they were not found in farm fields of these varieties. There was a marked increase in the prevalence of races virulent on resistance gene ***Sr*** 17.

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Dans les provinces de l'est, les varietes de ble sensibles ont ete gravement atteintes de ***Puccinia graminis tritici*** en parcelles experimentales en 1977, mais en culture commerciale les varietes resistantes ont été pratiquement indemnes. La rouille de la tige a aussi attaque ***Hordeum jubatum*** au Manitoba et dans l'est de la Saskatchewan, mais en général elle appartenait au type ***Puccinia graminis secalis.*** Il y eu peu de rouille de la tige dans les pepinieres d'observation sauf dans celles du Manitoba et de l'est de la Saskatchewan. Vingt-sept races de rouille de la tige du ble ont été identifiées. La race C33 (15B-1L) a perdu de l'importance et a cede la premiere place a la race C53 (15B-1L). Les races C25 (38) et C57 (32) se sont montrees moyennement virulentes sur les plantules des varietes commerciales resistantes Neepawa et Sinton, mais en conditions de culture ordinaire a la ferme, on ne les a pas retrouvees. Il y en une nette recrudescence de la frequence des races virulentes sur les lignées portant le gene de resistance *Sr17*.

Prevalence and importance in western Canada

Early in the spring of 1977 infections of wheat stem rust (***Puccinia graminis*** Pers. f. sp. ***tritici*** Eriks. and E. Henn.) were heavy in the south-eastern United States but the rust developed slowly and infections in central and northern United States were light.

Urediospores produced in the south were carried into western Canada in early June. Stem rust was first observed on a susceptible wheat variety in experimental plots at Morden, Manitoba, on July 4. It developed rapidly on susceptible varieties and on August 8 the susceptible variety Klein Titan was severely infected (80%) at Brandon, Manitoba, and the plot was killed by stem rust as it turned color. On the same day at Indian Head, Saskatchewan, there was a 30% infection in a late plot of Klein Titan that, apparently, would become severely infected before maturity. There was abundant stem rust development on wild barley, Hordeum ***jubatum*** L., throughout Manitoba and in eastern Saskatchewan.

Despite favorable conditions for stem rust development resistant commercial varieties of wheat and barley were virtually free from stem rust.

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

Rust nurseries consisting of 15 varieties of wheat, 3 varieties of barley, one variety of rye, and one variety of triticale were planted by cooperators at 28 locations across Canada. The varieties grown (Tables 1 and 2) have been described in previous reports in this series. The cooperators harvested samples from the plots and sent them to the Winnipeg Research Station where rust assessments were made.

Wheat stem rust was present in nurseries from Creston, B.C., to La Pocatiere, Que., but heavy infections occurred only on the susceptible variety Red Bobs at locations in the eastern prairies (Table 1). Most rust occurred at Brandon where Red Bobs was heavily infected and Lee, Frontana, Thatcher[6] X Transfer, and Mindum had light infections. The resistant commercial varieties Neepawa, Napayo, Sinton, Glenlea, Wascana, Macoun, and Wakooma showed only traces of rust at a few locations.

Stem rust occurred on barley and rye at 7 scattered locations (Table 2). Infections were light except at Glenlea, Manitoba, where a moderate infection on Montcalm barley was, apparently, caused by wheat stem rust, and at Guelph, Ontario, where Prolific rye was heavily infected. The triticale variety Rosner was nearly free from infection at all locations.

Physiologic specialization

Physiologic races were identified using previously described methods and materials (1). During the 1977 survey some differentials were replaced by lines of wheat carrying the required resistance gene in a more

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Table 1. Percent infection of stem rust (*Puccinia graminis* f. sp. *tritici*) on 15 wheat varieties in uniform rust nurseries at 11 locations* in Canada in 1977

	Common Wheat											Durum Wheat			
Location	Red Bobs	Lee	Pitic 62	Neepawa	Napayo	Sinton	Kenya Farmer	Glenlea	Exchange	Frontana	Thatcher^{6} × Transfer	Mindum	Wascana	Macoun	Wakooma
Creston, B.C.	tr**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Indian Head, Sask.	60	10	tr	tr	tr	tr	tr	tr	tr	1	0	0	0	0	0
Durban, Man.	tr	tr	0	0	0	0	0	0	0	0	0	0	0	0	0
Brandon, Man.	60	5	1	tr	tr	tr	tr	1	tr	20	20	30	tr	tr	tr
Morden, Man.	70	tr	0	0	0	0	0	0	0	0	0	0	0	0	0
Glenlea, Man.	60	tr	tr	tr	tr	tr	tr	0	0	0	0	1	0	0	0
Thunder Bay, Ont.	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New Liskeard, Ont.	tr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Appleton, Ont.	tr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Normandin, Que.	tr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
La Pocatiere, Que.	1	0 1	0	0	0	0	0	0	0	0	0	0	0	0	0

*No rust was observed in nurseries at 17 locations: Agassiz, B.C.; Beaverlodge, Lacombe, Edmonton and Lethbridge, Alta.; Scott and Melfort, Sask.; Guelph, Vineland. Sunbury, Ottawa and Kapuskasing, Ont.; Macdonald College and Quebec, Que.; Fredericton, N.B.; Kentville and Truro, N.S.
**tr trace

Table 2. Percent infection of stem rust (*Puccinia graminis*) on 3 varieties of barley, one variety of rye, and one variety of triticale in uniform rust nurseries at 7 locations* in Canada in 1977

	Barley			Rye	Triticale
Location	Montcalm	Conquest	Wpg-702-M7118-13	Prolific	Rosner
Creston, B.C.	tr**	0	5	tr	0
Brandon, Man.	10	0	0	tr	tr
Morden, Man.	tr	0	tr	5	0
Glenlea, Man.	30	0	0	tr	tr
Guelph, Ont.	0	tr	tr	80	0
Sunbury, Ont.	tr	0	0	10	0
Appleton, Ont.	tr	tr	0	20	0

*No rust was observed in nurseries at 20 locations: Agassiz, B.C.; Beaverlodge, Lacombe, Edmonton and Lethbridge, Alta.; Scott, Melfort and Indian Head, Sask.; Durban, Man.: Thunder Bay, New Liskeard, Vineland, Ottawa and Kapuskasing, Ont.; Macdonald College, Normandin, Quebec and La Pocatiere, Que.; Fredericton, N.B.; Kentville, N.S.
** tr = trace

susceptible background. The parentage and source of the new differentials are:

Sr 9b - PRELUDE*4/2/MARQUIS*6/K117A
P.L. Dyck, Agriculture Canada Research Station, Winnipeg.

Sr 10 - MARQUIS*4/EGYPT NA95/2/W2691
R.A. McIntosh, University of Sydney, Australia.

Sr 73 - PRELUDE*4/2/MARQUIS*6/KHAPSTEIN
P.L. Dyck, Agriculture Canada Research Station, Winnipeg.

Table 3. Distribution by provinces of physiologic races of ***Puccinia graminis*** f. sp. ***tritici*** on wheat, barley, and grasses, and of ***Puccinia graminis*** f. sp. ***secalis*** on barley and grasses in 1977.

Virulence formula and (race number)	Virulence formula [1] (effective/ineffective host genes)	Number of isolates from:					Total number of isolates	Percent of total isolates
		P.Q.	Ont.	Man.	Sask.	B.C.		
C1 (17)	5,6,7a,9a,9b,9d,9e,10,11*,13,17,Tt2/8,14,15,Ttl			1			1	2
C10 (15B-1)	6,7a,8/5,9a,9b,9d,9e,10,11,13,14,15,17,Tt1,Tt2			4			4	6
C15 (11-32)	6,7a,9d,9e,10,13,17,Tt2/5,8,9a,9b,11,14,15,Tt1				1		1	2
C16 (39)	6,7a,8,9e,11,Tt2/5,9a,9b,10,13,14,15,17,Tt1			1			1	2
C17 (56)	6,8,9a,9b,9d,9e,11,13,17,Tt1,Tt2/5,7a,10,14,15	1					1	2
C18 (15B-1L)	6,8,9a,9b,13,15,17,Tt2/5,7a,9d,9e,10,11,14,Tt1			4			4	6
C25 (38)	9a,9d,9e,Tt1,Tt2/5,6,7a,8,9b,10,11,13,14,15,17	1		76	50	2	129	197
C33 (15B-1L)	6,9a,9b,13,15,17,Tt2/5,7a,8,9d,9e,10,11,14,Tt1	1		126	48		175	268
C33 (15B-1L)	6,9a,9b,13,15,17,Tt2/5,7a,8,9d,9e,10,11*,14,Tt1			5	4		9	13
C35 (32-113)	9d,9e,10,11.13.17,Tt2/5,6,7a,8,9a,9b,14,15,Tt1			1			1	2
C40 (32-113)	6,9d,9e,10,13,17,Tt2/5,7a,8,9a,9b,11,14,15,Tt1			1			1	2
C41 (32-113)	9d,9e,10,13,17,Tt2/5,6,7a,8,9a,9b,11,14,15,Tt1			4			4	6
C43 (32)	6,7a,8,9d,9e,11,Tt2/5,9a,9b,10,13,14,15,17,Tt1	1		9			10	15
C44 (15B-1L)	6,9a,9b,13,17,Tt2/5,7a,8,9d,9e,10,11,14,15,Tt1			1			1	2
C46 (15B-1L)	6,8,9a,9b,13,15,Tt2/5,7a,9d,9e,10,11,14,17,Tt1			1			1	2
C49 (15)	6,9a,9b,11,13,15,17,Tt2/5,7a,8,9d,9e,10,14,Tt1	1	1	33	26		61	93
C53 (15B-1L)	6,9a,9b,13,15,Tt2/5,7a,8,9d,9e,10,11,14,17,Tt1	1		158	38		197	301
C53 (15B-1L)	6,9a,9b,13,15,Tt2/5,7a,8,9d,9e,10,11*,14,17,Tt1			6			6	9
C56 (38-151)	6,7a,8,9b,9d,9e,10,11,Tt2/5,9a,13,14,15,17			1			1	2
C57 (32)	9a,9d,9e,Tt1,Tt2/5,6,7a,8,9b*,10,11,13*,14,15,17			12	1		13	19
C58 (29)	5,9a,9b,9d,9e,11,13,15,Tt1,Tt2/6,7a,8,10,14,17			1			1	2
C61 (38)	6,7a,9b,9d,9e,10,11,13,Tt2/5,8,9a,14,15,17,Tt1			6	3		9	13
C62 (39)	6,8,9b,9d,9e,11,13,Tt1,Tt2/5,7a,9a,10,14,15,17					2	2	3
C63 (32-113)	7a,9d,9e,10,11,13,17,Tt2/5,6,8,9a,9b,14,15,Tt1			1	1		2	3
C66 (15)	6,9a,9b,11,13,15,Tt2/5,7a,8,9d,9e,10,14,17,Tt1			12	4		16	24
C71 (172)	6,9a,9b,9d,9e,10,11,13,Tt1,Tt2/5,7a,8,14,15,17			1			1	2
C72 (39)	6,9a,9b,9d,9e,11,13,Tt1,Tt2/5,7a,8,10,14,15,17					1	1	2
Total wheat stem rust isolates		6	1	465	176	5	653	100
Rye stem rust isolates			2	177	113	1	293	

* Intermediate infection type

[1]/ All races were avirulent on resistance genes ***Sr22, Sr24, Sr26, Sr27, Sr29,*** and ***Sr30***

Sr 14 - W2691*2/KHAPSTEIN
R.A. McIntosh, University of Sydney, Australia.

Sr 15 - PRELUDE*2/NORKA
P.L. Dyck, Agriculture Canada Research Station, Winnipeg.

Sr 17 - PRELUDE/8*MARQUIS*2/2/ESP518
P.L. Dyck, Agriculture Canada Research Station, Winnipeg.

*Sr **Tt1*** - PRELUDE*4/MHLII.64.62.1.3.18
P.L. Dyck, Agriculture Canada Research Station, Winnipeg.

Three lines with resistance genes Sr ***27, Sr 29*** and ***Sr 30*** were used as differentials for the first time. The parentage and source of each line is:

Sr 27 - WHEAT-RYE-TRANSLOCATION-238-5
University of Minnesota

Sr 29 - PRELUDE/8*MARQUIS/2/ETOILE DE CHOISI
P.L. Dyck, Agriculture Canada, Research Station, Winnipeg.

Sr 30 - WEBSTER
P.L. Dyck, Agriculture Canada, Research Station, Winnipeg

A relatively large number of isolates (653) was identified but most of them were from Manitoba and Saskatchewan. Many of the collections from these two provinces (227 from Manitoba and 136 from Saskatchewan) were obtained from plots of the susceptible variety Klein Titan at Morden, Portage, and Brandon, Manitoba and at Indian Head and Regina, Saskatchewan. The other collections were mainly from wild barley. A few were from susceptible varieties in experimental plots. The absence of collections from Alberta confirms rust nursery results indicating that stem rust was scarce on the western prairies.

Table 4. Percent of total isolates and races avirulent on single identified resistance genes in 1977 and 1976

Resistance gene	Avirulent isolates % 1977 (1976)	Avirulent races % 1977 (1976)
Sr5	0.4 (0)	8 (0)
Sr6	76.9 (94.7)	76 (74)
Sr7a	4.1 (0.2)	24 (4)
Sr8	3.6 (4.1)	28 (30)
Sr9a	94.8 (94.4)	64 (65)
Sr9b	74.8 (93.4)	68 (52)
Sr9d	27.4 (5.2)	60 (26)
Sr9e	27.4 (6.3)	60 (52)
Sr10	3.2 (4.5)	32 (17)
Srll	16.5 (18.3)	52 (48)
Sr13	75.9 (98.2)	80 (61)
Sr14	0 (0)	0 (0)
Sr15	72.0 (93.0)	36 (40)
Sr17	40.0 (79.7)	44 (57)
SrTt1	22.9 (2.3)	28 (35)
SrTt2	99.4	96

Twenty-seven races were identified in 1977 (Table 3) including two new virulence combinations (C71 and C72). This is the fourth consecutive year that the stem rust population of western Canada has shown broad variability.

The trends in race prevalence noted in 1976 were continued in 1977. Race C33 (15B-1L) was displaced as the predominant race for the first time since 1970. It comprised 28.2% of the isolates and was displaced by race C53 (15B-1L) (31.1% of the isolates). Race C25 (38) increased to 19.8% of the isolates and race C49 comprised 9.3%. Other less prevalent but not uncommon races were C43 (32), C57 (32), C61 (38) and C66 (38) (Table 3). Race C53 resembles race C33 except that it is virulent on *Sr 17*, and race C49 resembles race C33 except that it is avirulent on *Sr 11*. The three races appear to be equally aggressive. Many collections contained both race C33 and race C53, and race C49 frequently occurred with them. The similarities of the three races and their chronological relationships suggest that races C53 and C49 are mutants of race C33. Race C25 is a different type of race as indicated by its formula and by its avirulence on resistance gene *Sr 7b* that is carried by Marquis. However, except for avirulence on gene *Sr 7b* it closely resembles race C57. They appear to be related and they are the most threatening of the races found in 1977. Both are moderately virulent on Manitou, Neepawa and Sinton. They were not found in farm fields of these varieties in 1977 nor did they attack adult plants of these varieties vigorously in a preliminary greenhouse test.

One of the most important results of the 1977 survey was the finding that the number and prevalence of races virulent on *Sr 17* had increased (Table 4). Canadian commercial varieties do not depend on *Sr 17* for their resistance and they are resistant to races virulent on *Sr 17*.

The use of plots of Klein Titan to trap wheat stem rust was a good method for determining the prevalence of the main races. However, four races were isolated from Klein Titan that were not isolated from wild barley and 9 races not found on Klein Titan were isolated from wild barley. These results are consistent with those of the past two years. They show that collections from plots of Klein Titan reliably indicate the main races present and their prevalence, but they do not reveal all of the minor races.

In total there were less than half as many rye stem rust isolates as wheat stem rust isolates, but when the collections from the wheat variety Klein Titan are ignored, there were 240 wheat stem rust isolates and 293 rye stem rust isolates. Many collections from *H. jubatum* contained both wheat stem rust and rye stem rust. Collections from *H. jubatum* made in October in central Saskatchewan were mostly rye stem rust. The ratio of rye stem rust to wheat stem rust in collections from wild barley was greater in 1977 than in 1976.

Evidently there are many constantly changing minor races in the stem rust population and many of them are never detected in the race survey. Fourteen of the races identified in 1977 were not found in 1976 and 7 of the races found in 1976 were not identified in 1977. It is uncertain whether such changes result from genetic variability or from inadequate survey methods, but it seems reasonable to believe that these minor races lack aggressiveness and do not threaten commercial varieties, although they may carry dangerous virulence combinations.

After several years of stability, the virulence of the population on some identified resistance genes changed in 1977. Although the proportion of races avirulent on resistance gene *Sr 6* was about the same, the prevalence of virulent races increased by about 18% (Table 4). The

Table 5. Adult plant reaction of five wheat varieties to six stem rust races collected in 1977

Race	Variety				
	Marquis	Sinton	Prelude-*Sr6*	Neepawa	Manitou
C25 (38)	MR*	MR	S	R	MS
C41 (32)	S	M	MR	R	MR
C43 (32)	S	R	MS	MR	R
C53 (15B-1L)	S	R	R	R	R
C57 (32)	S	R	S	MR	MR
C66 (15)	S	R	R	R	R

* S - susceptible; MS - moderately susceptible; M - mesothetic; MR - moderately resistant; R - resistant

precentage of races and isolates avirulent on genes Sr *9d* and Sr *9e* increased sharply. The greatest change was a 40% increase in the number of isolates and a 13% increase in the number of races virulent on resistance gene Sr 17.

A group of highly resistant varieties, essentially the same as those used in 1975 (2), were inoculated with composite collections of urediospores from each 1977 isolate. Varieties that were resistant to all bulked collections were: C.I. 8154 X Frocor[2], Waldron, Agatha, Tama, Romany, Esp 518/9, R.L. 5405, N.D. 499, N.D. 506, St 464, Coulter, Hercules, Wascana, Wakooma, and Macoun. The varieties Norquay and Glenlea were resistant to most bulk collections but occasionally they had type 3 infections that were presumed to result from high temperature. Varieties that had infections ranging from flecks to type 4 were: Mida-McMurachy-Exchange 11-47-26, Frontana-K58-Newthatch 11-50-17, Kenya Farmer, R.L. 4314, Chris, Era, and Bonny. Frontana-K58-Newthatch 11-50-17, Era, and Bonny were resistant to all bulk collections in 1976. Isolates from the type 4 infections on varieties in the last group were identified as race C25 (38). Evidently this race is one of the most threatening of those found in Canada in 1977.

Adult plant reactions

The adult plant reactions of the widely grown commercial varieties Sinton, Neepawa, and Manitou and the check varieties Marquis and Prelude-Sr *6* to races C25 (38), C41 (32), C43 (32), C53 (15B-1L), C57 (32) and C66 (15) were tested in a preliminary greenhouse trial.

The results (Table 5) indicate that Neepawa and Sinton are fairly resistant to the cultures used in the test. Manitou is resistant to all races except C25 (38) and this race is not fully virulent on it. The results indicate that the races used in the test do not seriously threaten the most widely grown Canadian stem rust resistant varieties. However, both adult plant and seedling reactions suggest that races such as C25 (38), C41 (32), and C57 (32) would not have to change much to attain virulence on one or more of these varieties.

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