STEM RUST OF WHEAT, BARLEY, AND RYE IN CANADA IN 1972[1]

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Prevalence and importance in Western Canada

Stem rust spores (Puccinia graminis Pers.) were found in spore traps in southern Manitoba and Saskatchewan during May and early June. Apparently the spores were carried into Western Canada earlier than usual because stem rust was more widespread in the United States than in the preceding 8 years. Despite the early presence of inoculum, stem rust was not found in Manitoba until July 17, about 2 weeks later than usual. Development was slow, but before the end of the growing season stem rust (P. graminis Pers. f. sp. tritici Eriks. and E. Henn.) was present on susceptible wheat varieties (Triticum aestivum L.) and wild barley (Hordeum jubatum L.) across Western Canada. However it was not observed on resistant commercial varieties that occupy most of the wheat acreage in the rust area, and losses were insignificant.

The bread wheat varieties Manitou, Neepawa, and Selkirk, the utility wheat variety Glenlea, and the durum wheats (T. durum Desf.) Stewart 63, Hercules, and Wascana continue to show good resistance. The Mexican variety Pitic 62, which was severely attacked by stem rust in 1970 and 1971, was moderately infected in test plots.

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

Uniform rust nurseries were planted by cooperators at 29 locations across Canada in 1972. The wheat varieties grown included the

Table 1. Percentage infection of stem rust *(Puccinia graminis* f. sp. *tritici)* on 18 wheat varieties in uniform rust nurseries at 16 locations* in Canada in 1972

	Common wheat															Durum wheat	
Location			Teric	Selkir	Manito	Neepawa		Napayo	Thatcher x Transf	Exchange	Frontana	R.L. 425	Glenlea	Mindum	Stewart	Hercules	Wascana	D.T. 316
Creston, B.C.	tr**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Edmonton, Alta.	10	tr	tr	0	0	0	0	0	tr	0	tr	1	0	0	0	tr	0	0
Lacombe, Alta.	10	1	0	0	0	0	0	0	0	0	0	0	0	tr	0	0	0	0
Scott, Sask.	tr	0	0	0	0	0	0	0	0	0	0	0	0	tr	0	0	0	0
Melfort, Sask.	1	tr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Indian Head, Sask.	30	50	0	0	0	0	0	0	tr	0	tr	0	0	tr	0	0	0	0
Brandon, Man.	50	tr	0	0	0	0	0	0	0	0	0	0	0	tr	0	0	0	0
Durban, Man.	40	10	5	0	0	0	0	0	5	5	tr	10	0	10	tr	0	0	0
Morden, Man.	40	5	1	0	0	0	0	0	50	1	tr	40	0	25	0	0	0	0
Glenlea, Man.	20	5	1	0	tr	tr	tr	tr	tr	tr	5	tr	tr	5	0	tr	0	0
Thunder Bay, Ont.	50	1	0	0	0	0	0	0	0	30	tr	0	0	0	0	0	0	0
New Liskeard, Ont.	50	0	0	0	0	0	tr	0	0	tr	5	0	0	tr	0	0	0	0
Guelph, Ont.	30	tr	5	0	0	0	0	0	tr	0	tr	5	0	tr	0	0	0	0
Appleton, Ont.	20	0	0	0	0	0	0	0	0	0	tr	0	0	0	0	0	0	0
Ottawa, Ont.	70	0	tr	0	0	0	0	0	tr	0	0	0	0	0	0	0	0	0
Kentville, N.S.	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* No rust was observed in nurseries at 13 locations: Agassiz, B.C.; Beaverlodge and Lethbridge, Alta.; Kemptville and Vineland, Ont.; La Pocatière, Quebec, Macdonald College and Normandin, Quebec; Truro, N.S.; Fredericton, N.B.; Charlottetown, P.E.I.; and St. John's West, Nfld.

** tr = trace.

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susceptible Red Bobs and Mindum; Lee, which is selective for all strains of the "standard" race 15B (C9, C10, C11, C18, C26, C33, C38, C44, C46, C47, C48, and C50); Pitic 62, which is selective for certain strains in the "standard" race group 11–32–113 (C35,

C41, C51, and C52); the resistant commercial varieties Selkirk, Manitou, Neepawa, Napayo, Glenlea, Stewart 63, Hercules, and Wascana; and the resistant test varieties Kenya Farmer and D.T. 316. The cooperators harvested the nurseries at an appropriate time and sent the sheaves to Winnipeg where rust infection was assessed and collections were made for race identification.

Wheat stem rust was more widespread and infections were more severe than in 1971. It was found in 16 nurseries in 1972 (Table 1) and in 10 in 1971. Evidently, severe infections would have developed in Western Canada if commercial varieties had been susceptible to the prevalent races.

The nurseries also included the barley (Hordeum vulgare L.) variety Montcalm, which is susceptible to wheat stem rust and rye stem rust (P. graminis Pers. f. sp. secalis Eriks. and E. Henn.); the barley varieties Parkland and C.I. 10644, and the rye (Secale cereale L.) variety Prolific, which are resistant to wheat stem rust and susceptible to rye stem rust. These differences in reaction and the early maturity of barley compared with rye, account for the different amounts of rust on the barley and rye in the nurseries (Table 2).

Table 2. Percentage infection of stem rust *(Puccinia graminis)* on three varieties of barley and one variety of rye in uniform rust nurseries at 11 locations* in Canada in 1972

	Barley			Rye
Location	Montcalm	Parkland	C.I. 10644	Prolific
Agassiz, B.C.	0	0	0**	20
Creston, B.C.	40	20	tr	80
Brandon, Man.	1	tr	tr	70
Durban, Man.	0	0	0	20
Morden, Man.	tr	tr	tr	60
Thunder Bay, Ont.	5	0	0	tr
Kemptville, Ont.	0	0	0	50
Guelph, Ont.	10	0	0	20
Appleton, Ont.	5	40	20	70
Ottawa, Ont.	0	0	0	40
Kentville, N.S.	0	0	0	tr

* No rust was observed in nurseries at 18 locations: Edmonton, Beaverlodge, Lacombe and Lethbridge, Alta.; Scott, Melfort and Indian Head, Sask.; Glenlea, Man.; New Liskeard and Vineland, Ont.; La Pocatière, Quebec, Macdonald College and Normandin, Que.; Truro, N.S.; Fredericton, N.B.; Charlottetown, P.E.I.; and St. John's West, Nfld.

** tr = trace.

Rye stem rust has become prevalent in recent years but it was less prevalent in 1972 (11 nurseries) than in 1971 (14 nurseries). It was present in all Manitoba nurseries but not in Saskatchewan nurseries. Presumably it was carried into Manitoba by southerly winds but developed too slowly to infect rye in Saskatchewan.

Physiologic races

Physiologic races were identified by six "standard" differential hosts (T. aestivum 'Marquis' and 'Reliance'; T. durum 'Arnautka' and 'Mindum'; T. monococcum L. 'Einkorn', and; T. dicoccum Schrank 'Vernal') and by the formula method. The formulas were determined using the identified resistance genes Sr5, Sr6, Sr7a, Sr8, Sr9a, Sr9b, Sr9d, Sr10, Sr11, Sr13, and Sr14 that had been backcrossed into lines of Marquis. Marquis is known to carry at least three resistance genes, the main one for Canadian races being Sr7b. The variety Norka carries Sr15, but there was evidence for a second gene in this variety. A line of Chinese Spring carrying Sr16 from Thatcher and a selection of Renown carrying Sr17 were also used. Both lines are believed to carry additional resistance genes. The additional genes complicate race identification but they do not appear to cause important errors.

Several cultures identified in earlier years were retested and the genes found in recent years were placed in their formulas (Table 3).

Eight new virulence combinations (C45 to C52) were described in 1972 (Table 3). Formula C45 is for the old race 56A that differs from race C17(56) by being virulent on Sr6. Formula C50 is for the old race 15B-5 (Can.) that is virulent on both Sr6 and Golden Ball. Races 56A and 15B-5 have not been found in the field for many years but they are used often in experimental work at Winnipeg. Five interesting new races (C46, C47, C48, C49, and C51) were discovered in 1972. Race C52(32-113), called C35"S" in 1971, is like C35 but is virulent on Renown (Sr17) and Selkirk.

Most of the resistance genes used are good differentials but Sr15 and Sr16 have serious disadvantages. Both are influenced greatly by temperature and possibly by other environmental factors. Their resistance breaks down completely at times making differentiation between certain races possible only when the environment is favorable. At Winnipeg, the difficulties occur mainly during late spring, summer, and early fall when, despite evaporative cooling, greenhouse temperatures may be high. The resistant reactions are usually distinct at temperatures about 21°C (70°F).

Norka (Sr15) produced infection type 2+ or 3- with cultures of race C14 (38) instead of the usual ; to 2 or X- that resemble the resistant reaction described by Watson

Table 3. Formula (physiologic race) numbers, virulence formulas, and infection types produced on four wheat varieties by stem rust races found in Canada to 1972

Formula and (race) number	Virulence formula		Infection type on			
	Effective genes	Ineffective genes	Sk	Mit	Np	Ptc62
C1(17)	5,6,7a,9a,9b,9d,10,11,13,17	8,14,15,16	;	0	;	;
C2(17A)	5,6,7a,9a,9b,10,13	8,11,14,15,16				
C3(29-4)	5,6,9a,11	7a,8,9b,10				
C4(23)	5,6,11,17	7a,15,16	;	;		
C5(29-1)	5,9a,9b,9d,11,16	6,7a,8,10,13,14,15,17,GB	3+	;	1	
C6(29-2)	5,9a,9b,11,GB	6,7a,8,10				
C7(48)	5,11,GB	6,7a				
C8(48A)	5,11,16	6,7a,15,GB				
C9(15B-1L)	6,7a,8,9a,9b,10,13,15	5,9d,11,14,16	;	;	;	2
C10(15B-1)	6,7a,8,GB	5,9a,9b,9d,10,11,13,14,15,16,17	;	;	;2	1
C11(15B-4)	6,7a,8	5,9a,9b,9d,10,11,13,14,15,16,17,GB	;	;	2	
C12(11)	6,7a,9a,9b,10,11	5,8				
C13(32,113)	6,7a,9d,10,11,13	5,8,9a,9b,14,15,16				
C14(14,38)	6,7a,10,11,15,16	5	;	;	;2	;
C15(11,32,113)	6,7a,10	5,8,9a,9b,11				
C16(39)	6,7a,11	5,10,15,16	;	;	;	;
C17(11,56)	6,8,9a,9b,9d,11,13,17	5,7a,10,14,15,16	;	;	;	;
C18(15B-1L)	6,8,9a,9b,13,15,17	5,7a,9d,10,11,14,16	;	;	;1	;
C19(10,38)	6,9d,10,11	5,7a,15,16				
C20(11,87)	7a,8,9d,11,13	5,6,9a,9b,10,14,15,16,17	3+	12	2	2
C21(32)	9a,11	5,6,7a,8,9b,10				
C22(32)	9a,9d,13,16	5,6,7a,8,9b,10,11,14,15,17	3+	23	12	2
C23(38)		5,6,7a,10,15,16				
C24(17)	5,7a,9a,9b,10	6,8,11				
C25(38)		5,6,7a,10,11,15	2	3+	3f	2
C26(15B-4)	6,7a,8,9b,13,15	5,9a,9d,10,11,14,16				
C27(33,59)	6,11,17	5,7a,10,15,16	;	;	1	1
C28(18,54)	6,8,9b,9d,11	5,7a,9a,10				
C29(17)	5,6,7a,9a,9d,10,11	8,9b				
C30(29)	9a,9b,9d	5,6,7a,8,10,11				
C31(27)	5,6,7a,10,11					
C32(32)	9a,9b,9d,11	5,6,7a,8,10				
C33(15B-1L)	6,9a,9b,13,15,17	5,7a,8,9d,10,11,14,16	;	;	;2	
C34(32)	6,7a,9a,9b,9d,11	5,8,10,13,14,15,16				
C35(32-113)	9d,10,11,13,17	5,6,7a,8,9a,9b,14,15,16	;	3±	3f	3+
C36(48)	5,6,7a,11,16	10,15	;	;		
C37(15)	6,8,9a,9b,11,13	5,7a,9d,10,14,15,16	;	;	1	
C38(15B-1L)	6,8,9a,9b,13,17	5,7a,9d,10,11,14,15,16	;	;		1
C39(32-113)	6,9d,10,13,17	5,7a,8,9a,9b,11,14,15	;	;		
C40(32-113)	6,9d,10,13,17	5,7a,8,9a,9b,11,14,15,16	;	;	2	2,;
C41(32-113)	9d,10,13,17	5,6,7a,8,9a,9b,11,14,15,16	;	3f	23	3+
C42(15)	6,8,9a,9b,11,13,15,17	5,7a,9d,10,14,16	;	;		

Table 3 (ctd.)

Formula and (race) number	Virulence formula		Infection type on			
	Effective genes	Ineffective genes	Sk*	Mit	Np	Ptc62
C43(32)	6,7a,8,9d,11,16	5,9a,9b,10,13,14,15	;	;		
C44(15B-1L)	6,9a,9b,13,17	5,7a,8,9d,10,11,14,15,16	;	;	2	
C45(56A)	8,9a,9b,9d,11,13,17	5,6,7a,10,14,15,16	;	;		
C46(15B-1L)	6,8,9a,9b,13,15	5,7a,9d,10,11,14,16,17	;	;	;2	
C47(15B-1L)	6,9a,9b,10,13,17	5,7a,8,9d,11,14,15,16	;	;	;1	
C48(15B-1L)	6,8,9a,9b,17	5,7a,9d,10,11,13,14,15,16	;	;	12	
C49(15)	6,9a,9b,11,13,15,17	5,7a,8,9d,10,14,16	;	;	;1	
C50(15B-5)	7a,8	5,6,9a,9b,9d,10,11,13,14,15,16,17	4	;1	x-	1+
C51(32-113)	9d,10,13	5,6,7a,8,9a,9b,11,14,15,16,17	3+	23	23	3+
C52(32-113)	9d,10,11,13	5,6,7a,8,9a,9b,14,15,16,17	3+	3f	3f	3+

* Sk = Selkirk, Mit = Manitou, Np = Neepawa, Ptc62 = Pitic 62, GB = Golden Ball.

and Luig (1). Norka seems to carry a resistance gene in addition to Sr15 that confers moderate resistance. When effective, Sr16 produces a 3- infection type.

The varieties Selkirk, Manitou, Neepawa, and Pitic 62 are important commercial varieties in Western Canada and their infection types with most races are recorded in Table 3. The variety Yuma is not shown although it has been a helpful differential. It is resistant to all races excepting cultures of race 15B designated 15B-IL. In recent years, its reaction to certain races has been obscure and variable. It is more resistant to the recently occurring strains of race 15B-IL than to earlier cultures.

The only races virulent on the important Thatcher derivatives Manitou and Neepawa (Table 3) are the rare race C25(38) and certain members of the "standard" race 11-32-113 complex (C20, C22, C35, C41, C51). They have not attacked these varieties in the field.

Seventeen races were identified in 1972, when rust was relatively prevalent, compared with 12 in 1971, when rust was not prevalent. There were no important changes in race distribution in 1972 (Table 4). Race C33

Table 4. Distribution by provinces of physrologic races of *Puccinia graminis* f. sp. **tritici** collected on wheat, barley, and **grasses** in 1972, 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
		P.E.I.	N.S.	Que.	Ont.	Man.	Sask.	Alta.	B.C.		
C14(38)	6,7 ,10,11,15,16/5	1	2		9	3	9		1	25	8.9
C17(56)	6,8,9a,9b,9d,11,13,17/5,7a,10,14,15,16		3							3	1.2
C18(15B-1LX)	6,8,9a,9b,13,15,17/5,7a,9d,10,11,14,16				1	9	17	4		31	11.0
C22(32)	9a,9d,13,16/5,6,7a,8,9b,10,11,14,15,17						1			1	0.3
C25(38)	15/5,6,7a,10,11				1		1			2	0.7
C33(15B-1L)	6,9a,9b,13,15,17/5,7a,8,9d,10,11,14,16				19	45	81	16		161	57.1
C35(32-113)	9d,10,11,13,17/5,6,7a,8,9a,9b,14,15,16			1	5	5	21	3		35	12.4
C36(48)	5,6,7a,11,16/10,15								1	1	0.3
C41(32-113)	9d,10,13,17/5,6,7a,8,9a,9b,11,14,15,16					2	1			3	1.2
C42(15)	6,8,9a,9b,11,13,15,17/5,7a,9d,10,14,16						1			1	0.3
C44(15B-1L)	6,9a,9b,13,17/5,7a,8,9d,10,11,14,15,16					3	2			5	1.8
C46(15B-1L)	6,8,9a,9b,13,15/5,7a,9d,10,11,14,16,17						5			5	1.8
C47(15B-1L)	6,9a,9b,10,13,17/5,7a,8,9d,11,14,15,16				1					1	0.3
C48(15B-1L)	6,8,9a,9b,17/5,7a,9d,10,11,13,14,15,16						1			1	0.3
C49(15)	6,9a,9b,11,13,15,17/5,7a,8,9d,10,14,16						1			1	0.3
C51(32-113)	9d,10,13/5,6,7a,8,9a,9b,11,14,15,16,17					1				1	0.3
C52(32-113)	9d,10,11,13/5,6,7a,8,9a,9b,14,15,16,17				2	1	2			5	1.8
Total wheat stem rust isolates		1	5	1	38	69	143	23	2	282	100.0
Rye stem rust isolates					3	60	37		2	102	

Table 5. Distribution by provinces of physiologic races of Puccinia *graminis* f. sp. tritici collected on susceptible varieties of wheat and susceptible wild grasses in 1972

Virulence formula (race) number	Virulence formula (effective/ineffective host genes)	Number of isolates from						Total number of isolates	Percent of total isolates
		N.S.	Ont.	Man.	Sask.	Alta.	B.C.		
C14 (38)	6,7a,10,11,15,16/5	1	3	2	7			14	7.7
C17 (56)	6,8,9a,9b,9d,11,13,17/5,7a,10,14,15,16	3						3	1.6
C18 (15B-1LX)	6,8,9a,9b,13,15,17/5,7a,9d,10,11,14,16		1	4	14	1		20	11.1
C33 (15B-1L)	6,9a,9b,13,15,17/5,7a,8,9d,10,11,14,16		8	34	66	3		111	61.7
C35 (32-113)	9d,10,11,13,17/5,6,7a,8,9a,9b,14,15,16		1		13			14	7.8
C36 (48)	5,6,7a,11,16/10,15						1	1	0.6
C41 (32-113)	9d,10,13,17/5,6,7a,8,9a,9b,11,14,15,16			1	1			2	1.1
C42 (15)	6,8,9a,9b,11,13,15,17/5,7a,9d,10,14,16				1			1	0.6
C44 (15B-1L)	6,9a,9b,13,17/5,7a,8,9d,10,11,14,15,16			2	1			3	1.6
C46 (15B-1L)	6,8,9a,9b,13,15/5,7a,9d,10,11,14,16,17				5			5	2.8
C48 (15B-1L)	6,8,9a,9b,17/5,7a,9d,10,11,13,14,15,16				1			1	0.6
C51 (32-113)	9d,10,13/5,6,7a,8,9a,9b,11,14,15,16,17			1				1	0.6
C52 (32-113)	9d,10,11,13/5,6,7a,8,9a,9b,14,15,16,17			2	2			4	2.2
Total isolates		4	13	46	111	4	2	180	100.0

(15B–IL) continued to predominate at about the same level as in 1971. It does not threaten the resistant varieties grown in Western Canada. Three races C14 (38), C18 (15B-ILX) and C35 (32–113) were moderately prevalent. Race C14 more than doubled its prevalence in 1971; race C18 recovered from near extinction in 1971; and race C35 was identified about half as many times as in 1971. Race C35 is virulent on Pitic 62 and moderately virulent on seedlings of Manitou and Neepawa. Reduced planting of Pitic 62 probably accounts for its reduced prevalence.

Fourteen other races occurred in trace amounts and some are worthy of note. The old and well-known race C17 (56) was found three times in Nova Scotia. It had not been identified in 1971, for the first time since 1931, but apparently it has persisted in the east although not in Western Canada. The new races (C46, C47, C48, C49, C51, and C52) are variants in the "standard" race complexes 15B-IL and 11–32–113.

The distributions of races isolated from all sources (Table 4) and from susceptible, non–selective, hosts (Table 5) are similar. A few rare races (C22, C25, C47, and C49) were obtained only from selective hosts.

Changes in the percentage of isolates avirulent on the identified resistance genes were small (Table 6). The avirulence of the rust population on Sr8 had decreased sharply in 1971, but genes Sr6, Sr9a, Sr9b, Sr13, Sr15, and Sr17 continue to provide resistance to most isolates.

All cultures were bulked to make 10 composite collections which were used to inoculate 26 highly resistant varieties. Varieties resistant to all composite collections were: C.I. 8155, St464, WRT 240 (Manitou with rye translocation), Agent, Tama, Esp. 518/9, Inia 66, Saric 70, Era, D.T. 332, D.T. 350, D.T. 317, Stewart[8] x R.L. 5244, and Marquis[8] x (Stewart[8] x R.L. 5244). The last two have resistance from T. monococcum at the tetraploid and hexaploid levels, respectively. Important varieties showing susceptible or moderately susceptible type pustules were: Mida-McMurachy-Exchange 11–47–26, Frontana-K58-Newthatch 11–50–17, Chris, Glenlea, Kenya Farmer, C.T. 615, and Timgalen. C.T. indicates a variety from the Western Canadian Cooperative Test; D.T.

Table 6. Percent of total isolates avirulent on single identified resistance genes and number of avirulent races in 1971 and 1972

Resistance gene	Avirulent isolates (%) 1972 (1971)	Number of avirulent races 1972 (1971)
Sr 5	0.3 (1.6)	1 (2)
Sr 6	83.2 (68.8)	11 (7)
Sr 7a	9.2 (0.8)	2 (1)
Sr 7b	9.2	2
Sr 8	14.5 (3.2)	5 (2)
Sr 9a	74.3 (65.6)	10 (4)
Sr 9b	74.0 (65.6)	9 (4)
Sr 9d	17.2 (31.2)	6 (3)
Sr 10	25.0 (32.0)	6 (4)
Sr 11	25.2 (30.4)	7 (5)
Sr 13	89.8 (96.8)	13 (7)
Sr 14	0.0 (*0.0*)	*0* (0)
Sr 15	79.4 (59.2)	6 (2)
Sr 16	9.5 (0.0)	3 (0)
Sr 17	87.7	11

indicates a variety from the Durum Test. No new races were isolated from the susceptible pustules.

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Literature cited

1. Watson, I. A. and N. H. Luig. 1966. Sr15--a new gene for use in the classification of Puccinia graminis var. tritici. Euphytica 15:239-250.