STEM RUST OF WHEAT, BARLEY, AND RYE IN CANADA IN 1969

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Prevalence and importance in Western Canada

Wheat stem rust (Puccinia graminis Pers. f. sp. tritici Eriks. and E. Henn.) was scarce in Western Canada in 1969. It was first observed in plots of the susceptible variety Red Bobs on July 9 at Morden in southern Manitoba. Cool weather during July and the resistance of the widely used varieties delayed development. Despite warm weather in August, stem rust could not be found readily on susceptible wild barley (Hordeum jubatum L.) in much of Manitoba and south-eastern Saskatchewan until early October.

Infections on wild barley were heaviest in south-eastern Manitoba, decreasing to the north and west. They were difficult to find at Yorkton, Saskatchewan, in October but were easily found 100 miles to the south. Mere traces of stem rust were reported in central and western Saskatchewan. Much of the rust on wild barley was rye stem rust (P. graminis f. sp. secalis).

There was little or no damage to most commercial wheat varieties, but moderate infections of a new race developed late in the season in small plantings of the recently licensed variety 'Pitic 62'.

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

Wheat stem rust was observed in only 13 of the 35 rust nurseries grown at various locations across Canada. Infections of 50% or greater on the very susceptible variety 'Red Bobs' occurred at only eight locations (Table 1). 'Pitic 62' was infected at one location in Manitoba and at two locations in Ontario. These infections were caused by a

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Table 1. Percentage infection of stem rust (Puccinia graminis f. sp. tritici) on 15 wheat varieties in uniform rust nurseries at 13 locations* in Canada in 1969

	Common wheat									Durum wheat					
Location	Red Bobs	Lee	Selkirk	Manitou	Kenya Farmer	Thatcher x Transfer	Pitic 62	Exchange	Frontana	R. L. 540	R. L. 540	Mindum	Stewart 6	Hercules	D. T. 316
Creston, B. C.	50	0	0	0	0	0	0	0	tr**	0	0	0	0	0	0
Brandon, Man.	70	10	0	0	0	tr	0	5	0	0	5	0	4	0	0
Morden, Man.	70	30	0	0	0	20	0	5	tr	25	70	30	0	0	5
Glenlea, Man.	80	30	tr	0	0	5	5	tr	1	5	60	40	0	tr	10
Fort William, Ont.	100	15	0	0	0	5	0	tr	0	tr	90	10	0	0	0
Williamstown, Ont.	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Douglas, Ont.	80	20	tr	0	5	10	5	5	tr	10	60	40	0	0	0
Kapuskasing, Ont.	90	40	0	10	30	5	20	5	tr	10	80	25	0	0	0
Guelph, Ont.	5	tr	0	0	0	0	tr	0	tr	1	2	5	5	0	0
Morewood, Ont.	70	0	0	0	0	1	0	tr	0	tr	0	0	0	0	0
Normandin, Que.	0	0	0	0	0	0	0	0	0	tr	1	tr	0	0	0
La Pocatikre, Que.	tr	tr	0	0	0	0	0	0	0	0	tr	0	0	0	0
Lennoxville, Que.	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* No rust was observed in nurseries at 22 locations: Agassiz, B. C.; Edmonton, Beaverlodge, Lacombe, and Lethbridge, Alta.; Scott, Melfort, and Indian Head, Sask.; The Pas, Man.; Alfred, Kemptville, Ottawa, Appleton, and Vineland, Ont.; Macdonald College, Québec, and L'Assomption, Qué.; Kentville and Truro, N. S.; Charlottetown, P. E. I.; Doyles and St. John's, Nfld.

** tr = trace

new race which may also have caused the 10 percent infection on 'Manitou' at Kapuskasing, Ontario. 'Manitou' was free from infection at all other locations and 'Selkirk' had only traces of rust at two locations. 'Kenya Farmer' has been highly resistant in the nurseries for many years but it was infected at the two locations in Ontario where 'Pitic 62' was attacked. 'Lee' and 'Thatcher[6] X Transfer' are susceptible to race C18 (15B-1L), which predominated in 1969. They had moderate infections at most locations where 'Red Bobs' was severely attacked. 'R.L. 5404' and 'R.L. 5406' are hexaploid derivatives of Triticum monococcum L. with different degrees of resistance. The durum wheat varieties 'Stewart 63' and 'Hercules' were highly resistant at all locations.

Stem rust occurred on barley or rye at 16 of the 35 nursery locations (Table 2). The widespread infection of 'Prolific' rye demonstrates the prevalence of rye stem rust in 1969.

Distribution of physiologic races

Physiologic races were identified by the methods decribed in earlier reports in this annual series.

In 1969, 172 isolates of wheat stem rust were separated into nine virulence formulas corresponding to seven physiologic races (Table 3). Race C18 (15B-1L) (82% of the isolates) has predominated since 1964 and continued to predominate in 1969. The inclusion in the survey of 62 single pustule isolates from 'Red Bobs' at Morden may have exaggerated its prevalence. Race C18 does not attack the resistant varieties now grown in Western Canada. The second race in order of prevalence, C33 (15B-1L), resembles C18

Table 2. Percentage infection of stem rust (Puccinia graminis) on three varieties of barley and one variety of rye in uniform rust nurseries at 16 locations* in Canada in 1969

	Barley			Rye
Location	Montcalm	Parkland	C.I. 10644	Prolific
Agassiz, B. C.	0	0	0	20
Creston, B. C.	5	tr**	0	60
Brandon, Man.	20	0	0	30
Morden, Man.	0	0	0	10
Glenlea, Man.	0	0	0	30
Fort William, Ont.	tr	0	0	0
Williamstown, Ont.	0	0	0	30
Douglas, Ont.	10	0	0	15
Alfred, Ont.	0	0	0	10
Kapuskasing, Ont.	5	tr	0	0
Guelph, Ont.	0	0	0	tr
Vineland, Ont.	0	0	0	10
La Pocatière, Que.	tr	tr	0	40
Macdonald College, Que.	0	0	0	10
Lennoxville, Que.	0	0	0	tr
Kentville, N. S.	0	0	0	10

* No rust was observed in nurseries at 19 locations: Edmonton, Beaverlodge, Lacombe, and Lethbridge, Alta.; Scott, Melfort, and Indian Head, Sask.; The Pas, Man.; Kemptville, Ottawa, Appleton, and Morewood, Ont.; Quebec, L'Assomption, and Normandin, Que.; Truro, N. S.; Charlottetown, P. E. I.; Doyles and St. John's, Nfld.

** tr = trace

Table 3. Distribution by provinces of physiologic races of Puccinia graminis f. sp. tritici collected on wheat, barley, and grasses in 1969

Virulence formula number	Physiologic race number	Number of isolates from						Total number of isolates	Percent of total isolates
		P. E. I.	Que.	Ont.	Man.	Sask.	B. C.		
c9	15B-1L(Can.)	0	0	0	1	0	0	1	0.6
C17	56	0	0	0	0	0	1	1	0.6
C18	15B-1L(Can.)	2	2	19	107*	11	0	141	82.0
C20	11	0	0	3	2	0	0	5	2.9
C27	59	0	0	0	0	0	1	1	0.6
c33	15B-1L(Can.)	0	2	7	0	2	0	11	6.4
c35	32-113	0	2	5	2	0	0	9	5.2
C36	48	0	0	0	0	0	1	1	0.6
c37	15	0	2	0	0	0	0	2	1.1
Total wheat stem rust isolates		2	8	34	112	13	3	172	100.0
Rye stem rust isolates		0	1	2	62	28	1	94	

* Sixty-two isolates of C18 were from single pustules collected on the susceptible variety 'Red Bobs' at Morden, Man., on July 24.

except that it is virulent on Marquis-Sr8. A single culture was identified late in 1967 but it disappeared in 1968. Its reappearance at five locations in three provinces in 1969 (Table 4) indicates it is a potentially important race. The third race in order of prevalence is a new one, C35 (32–113). Infection types produced on the 'Marquis' backcross lines were clear (Table 5) but this race could not always be readily identified on the "standard" differential hosts. It was clearly in the 11–32–113 race group and could usually be separated from race 11 by the mesothetic reaction of 'Mindum' (race 11 is type 4). The infection type produced on 'Marquis' was unstable, varying from mesothetic (race 113) to 4– (race 32). Race C35 was collected mainly on the variety 'Pitic 62' and attacked seedlings of this variety in the greenhouse. It caused an infection of 60 percent in plots of 'Pitic 62' at Glenlea, Manitoba. It is moderately virulent on seedlings of 'Manitou' and 'Neepawa' but plots of 'Neepawa' near the rusted 'Pitic 62' were free from rust and it was not found in farm fields of 'Manitou', the predominant variety in the rust area of Western Canada. The seedling reactions of 'Selkirk' to different cultures of race C35 indicate at least two biotypes that cannot be separated using the backcross lines of 'Marquis' carrying identified resistance genes. Race C35 was found at five locations in three provinces (Table 4). Race C20 (11), fourth in order of prevalence, has been found each year since 1964 and may have been present before that time. It does not threaten the resistant varieties now grown. Race C17 (56) has declined steadily in prevalence since 1961 when it predominated

Table 4. Number of locations at which *two* potentially important new races were found in 1969

Virulence formula number	Province				Total number of locations
	Que.	Ont.	Man.	Sask.	
c33	1	2	0	2	5
c35	2	1	2	0	5

Table 5. Virulence formulas, formula numbers, and corresponding physiologic race numbers used from 1964 to 1969

Year found	Formula number	Virulence formula (Effective/Ineffective host genes)	Physiologic race
1964	C1	1, 5, 6, 7, 9a, 9b, 10, 11, 13/8, 14, 15, 16	17
	c2	5, 6, 7, 9a, 9b, 10, 13/8, 11, 14, 15, 16	17A
	c3	5, 6, 9a, 11/7, 8, 9b, 10	29-4(Can.)
	c4	5, 6, 11/7, 15, 16	23
	c5	5, 9a, 9b, 11/6, 7, 8, 10, GB	29-1(Can.)
	C6	5, 9a, 9b, 11, GB/6, 7, 8, 10	29-2(Can.)
	c7	5, 11, GB/6, 7	48
	C8	5, 11/6, 7, GB	48A
	c9	6, 7, 8, 9a, 9b, 10, 13, 15/1, 5, 11, 14, 16	15B-1L(Can.)
	C10	6, 7, 8, GB/1, 5, 9a, 9b, 10, 11, 13, 14, 15, 16	15B-1(Can.)
	C11	6, 7, 8/5, 9a, 9b, 10, 11, GB	15B-4(Can.)
	c12	6, 7, 9a. 9b, 10, 11/5, 8	11
	C13	1, 6, 7, 10, 11, 13/5, 8, 9a, 9b, 14, 15, 16	32,113
	C14	6, 7, 10, 11/5	14, 38
	c15	6, 7, 10/5, 8, 9a, 9b, 11	11, 32, 113
	C16	6, 7, 11/1, 5, 10, 15, 16	39
	C17	1, 6, 8, 9a, 9b. 11, 13/5, 7, 10, 15, 16	11, 56
	C18	6, 8, 9a, 9b, 13, 15/1, 5, 7, 10, 11, 14, 16	15B-1L(Can.)
	C19	1, 6, 10, 11/5, 7, 15, 16	10, 38
	c20	1, 7, 8, 11/5, 6, 9a, 9b, 10, 14, 15, 16	11, 87
	C21	9a, 11/5, 6, 7, 8, 9b, 10	32
	c22	1, 9a/5, 6, 7, 8, 9b, 10, 11, 14, 15	32
	c23	/5, 6, 7, 10, 15, 16	38

Table 5 (Continued)

Year found	Formula number	Virulence formula (Effective/Ineffective host genes)	Physiologic race
1965	C24	5, 7, 9a, 9b, 10/6, 8, 11	17
	C25	/5, 6, 7, 10, 11	38
	C26	6, 7, 8, 9b, 13, 15/1, 5, 9a, 10, 11, 14, 16	15B-4(Can.)
	C27	6, 11/5, 7, 10, 15, 16	33.59
	C28	1, 6, 8, 9b, 11/5, 7, 9a, 10	18, 54
	C29	1, 5, 6, 7, 9a, 10, 11/8, 9b	17
	C30	1, 9a, 9b/5, 6, 7, 8, 10, 11	29
1966	C31	5, 6, 7, 10, 11/	27
1967	C32	1, 9a, 9b, 11/5, 6, 7, 8, 10	32
1968	c33	6, 9a, 9b/1, 5, 7, 8, 10, 11	15B-1L(Can.)
	c34	1, 6, 7, 9a, 9b, 11/5, 8, 10, 13, 14, 15, 16	32
1969	c35	1, 10, 11, 13/5, 6, 7, 8, 9a, 9b, 14, 15, 16	32-113
	C36	5, 6, 7, 11/10, 15, 16	48
	c37	6, 8, 9a, 9b, 11, 13/1, 5, 7, 10, 14, 15, 16	15

(72.8 percent of the isolates). This well-known race has nearly disappeared as it did in the early 1950's when C10 (15B-1) predominated. The remaining races (Table 3) occurred in trace amounts and do not appear to be important.

Rye stem rust occurred widely in 1969 (Table 3) as it did in 1968. The prevalence of rye stem rust is probably exaggerated by the scarcity of wheat stem rust.

The race distribution shown by isolates from susceptible, non-selective varieties has been given in earlier years, but in 1969 nearly all rust collections were from susceptible varieties, excepting a few collections of race C35 (32-113) from 'Pitic 62'.

During 1969, wheat lines carrying resistance genes. Sr1, Sr13, Sr14, Sr15, and Sr16 were tested to cultures identified before these lines were available. The virulence formulas have been revised to include the results of these tests. The list of formulas now in use and equivalent physiologic race numbers appear in Table 5.

Most of the resistance genes (Sr1, Sr5, Sr6, Sr8, Sr9a, Sr9b, and Sr11) give clear infection types with all cultures; others (Sr10, Sr13, Sr14) give clear infection types with most cultures; and others (Sr7, Sr15, and Sr16) give variable infection types that are often difficult to interpret. Sr7 is noteworthy because it gave a reasonably clear resistant reaction to race C10, the original 15B, and to several other races such as C1 and C20. The best indication of its

Table 6. Percent of total isolates avirulent on single identified resistance genes and number of avirulent races in 1969

Resistance gene	Avirulent isolates (%)	Number of avirulent races
Sr1	8.7	3
Sr5	0.6	1
Sr6	91.9	7
Sr7	4.1	3
Sr8	87.2	5
Sr9a	90.7	5
Sr9b	90.7	5
Sr10	5.8	2
Sr11	11.0	6
Sr13	89.5	5
Sr14	0	0
Sr15	82.0	2
Sr16	0	0

resistant reaction was diffuse necrosis of the seedling leaves. This symptom is not present with most of the races encountered in recent years. Instead, various infection types and degrees of chlorosis occur. The effectiveness of Sr7 appears to have eroded instead of being lost by the one-step process observed with other genes. The variety 'Norka' is used to test for the effectiveness of Sr15. It is mesothetic to races C9 and C18 and susceptible to all other races. The mesothetic response is interpreted as a resistant reaction. A line carrying Sr16 derived from 'Thatcher' was suceptible to most cultures. Occasionally it showed type 3 infections but for practical purposes it was considered to be susceptible. The interpretation of the reaction of this line may require revision. It is recorded in the formulas only where the infections were clearly type 4.

The percentage of isolates avirulent on each identified resistance gene (Table 6) show that gene Sr6, Sr8, Sr9a, Sr9b, Sr13, and Sr15 conferred resistance to most isolates. These genes confer resistance to race C18, which constituted 82 percent of the rust population. Sr6 was effective against more races than any other gene (Table 6).

Composite collections of urediospores from all cultures studied in the survey were used to inoculate a group of highly resistant varieties. Race C35 was isolated from large pustules on the varieties 'Chris', 'Mida-McMurachy-Exchange 11-47-26', 'Frontana-K58-Newthatch II-50-17', 'C.T. 296' (Pembina^2 x Magnif Entrerriano), 'C.T. 299' (Lake x Selkirk), and 'Minn.II-58-14'. Race C33 was isolated from 'Chris' and race C20 from 'C.T. 296'. 'Minn.II-54-30' showed many susceptible pustules but no isolations were made. 'Wis. 261' was highly resistant to most composites but showed type 2 and 3+ infections in one test. 'Inia 66' showed type 2 infections in all tests. 'ND 264', 'St 464', 'C.I. 8155', 'Hercules', 'D.T. 316' (Lk^2 x Pelissier), 'D.T. 317' (Lk^2 x Pelissier), and a line of 'Manitou' with a translocation from rye were highly resistant to all composites.

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