STEM RUST OF WHEAT, BARLEY, AND RYE IN CANADA IN 1967[1]

G.J. Green[2]

Prevalence and importance in Western Canada

In 1967, wheat stem rust caused by Puccinia graminis Pers. f. sp. tritici Erikss. and Henn. was first found in Western Canada at Winnipeg, Manitoba. A few pustules were observed in experimental plots of winter wheat on July 11, but the disease could not be found on the susceptible spring wheat varieties 'Marquis' and 'Red Bobs' in experimental plots at Morden on July 13. Stem rust was not found on the resistant varieties grown in the rust area, although observations were made continuously during the growing season. Trace amounts could not be found readily on susceptible wild barley (Hordeum jubatum L.) throughout the rust area until August 3. Stem rust developed late in August in late-sown plots of susceptible varieties in rust nurseries located in the rust area. On August 15 there was only 1% stem rust on the very susceptible 'Red Bobs' at Brandon, Manitoba, but on August 30 40% of the plants of this variety were infected at The Pas, Manitoba. At Regina, Saskatchewan on July 24, stem rust could not be found on the susceptible spring wheat varieties 'Red Fife', 'Marquis', and 'Saunders' or on the susceptible winter wheat variety 'Kharkov'. On August 3, it was found in trace amounts at Fleming, Saskatchewan, on the Manitoba border, but it was not found at Alameda, Arcola, Aylesbury, Kelliher, Torquay, Radville, Viceroy, Langenburg, and Yorkton. The weather was dry at all locations except Fleming and Langenburg. Not a single pustule could be found at Swift Current in western Saskatchewan on August 7.

Probably the main factor limiting rust development was the extremely dry season. Average precipitation from April 1 to September 11 was 8.97 inches normal 12.25) in Manitoba, 4.55 inches (normal 9.80) in Saskatchewan, and 7.29 inches (normal 10.57) in Alberta. The development of stem rust on susceptible varieties late in the season in Manitoba indicated that rust development was limited, by the resistance of the cultivated varieties and by the small amount of primary inoculum carried into Western Canada.

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

The amount of stem rust in the Western Canadian nurseries was much less than usual. No rust developed on wheat in nurseries in Saskatchewan, Alberta, or British Columbia. At Brandon in western Manitoba stem rust infection was 1% on 'Red Bobs' on August 15 (Table 1). The rustnurseries at The Pas, Morden, and Glenlea, Manitoba, were examined in late August and early September, but rust development was heavy only at Morden. Rust occurred in all nurseries in Ontario but the intensities varied greatly. Barberry may have contributed to rust development in some areas. Rust was less common in Quebec than in Ontario, and none was found in nurseries east of Quebec.

The reaction of the varieties at locations where rust developed followed the pattern of former years. The susceptible varieties 'Red Bobs' and 'Marquis' were most heavily rusted; the varieties 'Lee' and 'Thatcher', which are susceptible to subraces of 15B but resistant to many other races, were lightly rusted at most locations: and the resistant varieties 'Selkirk', 'Manitou', 'Kenya Farmer', 'Stewart 63', and 'D.T. 184' had little or no infection.

Stem rust on barley and rye was also light. 'Prolific' rye was infected at only 10 of the 36 nurseries (Table 2), and apparently rye stem rust (Puccinia graminis Pers. f. sp. secalis Erikss. and Henn.) developed too late to infect the barley varieties. 'Montcalm' barley is susceptible to both wheat stem rust and rye stem rust, but it is evident that wheat stem rust was the cause of most of the infection on it because 'Parkland' and 'C.I. 106441, which are resistant to wheat stem rust but susceptible to rye stem rust, were not attacked.

Distribution of physiologic races

In 1967 the isolates of wheat stem rust obtained in Canada were classified into 9 virulence formulas or 6 physiologic races. The virulence formula system (2) has been used since 1965, and the physiologic races were identified by the methods described by Stakman et al. (3), except that only the varieties 'Marquis', 'Reliance', 'Arnautka', 'Mindum', 'Einkorn' and 'Vernal' were used as differential hosts.

The virulence formulas now in use (Table 3) differ from those listed earlier (2) mainly in that Srl has been added to some of the formulas. Several years ago Dr. Knott of the University of Saskatchewan provided seed of a backcross line of 'Marquis' (Marquis[6] x H-24-44) carrying a gene from 'H-44-24' presumed to be Srl that had been named many years ago (1). This line has been used regularly in the physiologic race survey for 3 years and considerable data is now available on its performance. It seems advisable to accept this gene as Srl, although it confers seedling resistance to a

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[1] Contribution No. 297, Research Station, Canada Department of Agriculture, Winnipeg, Manitoba.

[2] Plant Pathologist

Table 1. Percent infection of stem rust of wheat (Puccinia graminis f. sp. tritici) on 14 wheat varieties in uniform rust nurseries at 19 locations* in Canada in 1967

Locality	Common wheat										Durum wheat			
	Red Bobs	Marquis	Lee	Thatcher	Selkirk	Manitou	Kenya Farmer	McMurachy	Exchange	Frontana	Mindum	Ramsey	Stewart 63	D.T. 184
Brandon, Man.	1	tr**	tr	0	0	0	0	0	0	0	0	0	0	0
The Pas, Man.	40	10	tr	10	tr	0	0	0	tr	0	tr	0	0	0
Morden, Man.	80	70	20	20	0	0	0	0	1	tr	3	0	0	0
Glenlea, Man.	30	30	1	1	tr	tr	tr	0	1	1	10	tr	0	tr
Fort William, Ont.	70	40	5	tr	0	0	tr	0	tr	0	0	0	0	0
Kapuskasing, Ont.	5	tr	tr	tr	0	0	0	0	0	0	0	0	0	0
St. Catharines, Ont.	20	1	0	0	0	0	0	0	0	0	1	0	0	0
Guelph, Ont.	90	80	50	20	0	0	0	10	25	tr	50	0	0	0
Kemptville, Ont.	50	30	5	tr	0	0	0	0	tr	0	10	0	0	0
Appleton, Ont.	50	25	1	tr	0	0	tr	0	tr	0	5	0	0	0
Williamstown, Ont.	50	15	25	10	1	0	0	0	0	0	5	0	0	0
Alfred, Ont.	10	5	5	10	0	0	0	tr	0	0	tr	0	0	0
Verner, Ont.	40	5	0	0	0	0	0	)	tr	0	0	0	0	0
Douglas, Ont.	70	70	25	1	0	0	0	1	1	1	0	25	5	0
Ottawa, Ont.	35	40	30	5	0	0	0	10	20	tr	20	0	0	0
Macdonald College, Que.	50	20	1	tr	0	0	0	0	0	tr	15	0	0	0
Lennoxville, Que.	1	tr	0	1	0	0	0	0	0	0	tr	0	0	0
La Pocatikre, Que.	25	10	20	20	0	0	1	0	0	tr	tr	0	0	0
L'Assomption, Que.	25	5	0	0	0	0	0	0	0	0	0	0	0	0

* No rust was observed in nurseries at 17 other locations: Saanichton, Agassiz and Creston, B. C.; Edmonton, Beaverlodge, Lacombe and Lethbridge, Alta.; Scott, Melfort and Indian Head, Sask.; Ouebec and Normandin, Que.; Kentville and Truro, N. S.; Fredericton, N. B.; Charlottetown, P. E. I.; and St. John's, Nfld.

** tr = trace

number of races, whereas Srl was originally identified by a study of the inheritance of adult plant resistance. Some formulas that do not have g were written before the Marquis-Srl line became available and have not been found since. Other formulas such as C1, C2, and C24 do not contain Srl because this gene appeared to differentiate between cultures of these formulas, and supporting evidence is needed before new formulas can be written. Two cultures of C1 (17) were identified in 1967, but isolates with the other two formulas were not found. Cultures with these formulas do not appear to be important, and it does not seem worthwhile to carry out a special study to demonstrate that they include cultures virulent or avirulent on Srl. One new formula, C32, was differentiated in 1967.

The number of isolates identified in 1967 is smaller than usual because of the scarcity of rust in Canada. The prevalence of race C18 (15B-IL) (Table 4) increased from 68.1% in 1966 to 77.3% in 1967, while race C17 (56) decreased from 5.5% in 1966 to 2.4% in 1967. These changes follow a trend that began in 1964. Races C18 (15B-IL) and C17 (56) have no practical importance in Canada because all varieties produced for commercial use are resistant to them. The most virulent race found in 1967, C20 (11), increased from 2.5% of the isolates in 1966 to 13.0%. It can attack seedlings of 'Selkirk' and it is moderately avirulent on 'Manitou' (infection type; to 2CN). However, it is not as virulent as the races C22 (32) and C25 (38) Lhat were present in 1965 and 1966 and that have now disappeared from Western Canada. Race C20 (11) does not appear to threaten the varieties now grown in the rust area of Western Canada. Races C14 (38), C19 (38), C29 (17) and C32 (32) wete found rarely in Ontario, and may have 'originated on barberry. Race C1 (17) was found once in Manitoba and once in Saskatchewan. Only races C18 (15B-IL), C17 (56), and C20 (11) were found in both Eastern and Western Canada. Nearly all rust collections were obtained from susceptible varieties or susceptible wild grasses.

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 1966

Locality	Barley			Rye
	Montcalm	Parkland	C. I. 10644	Prolific
Creston, B. C.	0	0	0	20
The Pas, Man.	5	0	0	0
Morden, Man.	30	0	0	0
Glenlea, Man.	2	0	0	0
Guelph, Ont.	0	0	0	30
Kemptville, Ont.	0	0	0	1
Appleton, Ont.	tr	0	0	30
Williamstown, Ont.	0	0	0	5
Alfred, Ont.	0	0	0	25
Verner, Ont.	tr	0	0	tr
Douglas, Ont.	5	tr	0	0
Ottawa, Ont.	tr	0	0	10
Macdonald College, Que.	0	0	0	15
Kentville, N. S.	0	0	0	20

* No rust was observed at 22 other locations: Saanichton and Agassiz, B. C.; Edmonton, Beaverlodge, Lacombe, and Lethbridge, Alta.: Indian Head, Scott, and Melfort, Sask.; Brandon, Man.; Kapuskasing, Fort William, and St Catharines, Ont.; La Pocatière, Quebec, Lennoxville, L'Assomption, and Normandin, Que.; Kentville, N. S.; Frcdericton, N. B.; Charlottetown, P. E. I.; and St. John's. Nfld.

The protection afforded by the identified resistance genes (Table 5) was similar to 1966. Genes Sr6, ~~Sr8~~, Sr9a, and Sr9b continued to be the most effective, each conferring resistance to over 80% of the isolates. The other genes are relatively ineffective because they do not condition resistance to race C18 (15B-IL).

Composite collections of all cultures identified in 1967, in groups of about 20 cultures, were used to inoculate the highly resistant varieties 'Kenya Varmer' (R. L. 2768. l), 'Mida-McMurachy-Exchange II-47-26', 'Frontana-K58-Newthatch II-50-17', 'Justin', 'Chris', 'C. T. 282', C.T. 296', 'Nd 60-54', 'St 464', 'C. I. 8155', 'R. L. 4204.28, 'D. T. 191', 'D. T. 199', 'D. T. 316', 'D. T. 188', and 'Tobari 66'. No new combinations of virulence genes were revealed.

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Table 3. Virulence formulas, formula numbers, and equivalent physiologic race numbers of wheat stem rust used in 1967

Formula Number	Virulence formula (effective/ineffective host genes)	Physiologic race
C1	5, 6, 7, 9a, 9b, 10, 11/8	17
c2	5, 6, 7, 9a, 9b, 10/8, 11	17A
c3	5, 6, 9a, 11/7, 8, 9b, 10	29-4 (Can.)
c4	5, 6, 11/7	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, 10/1, 5, 11	15B-1L (Can.)
C10	6, 7, 8, GB/1, 5, 9a, 9b, 10, 11	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	6, 7, 10, 11/1, 5, 8, 9a, 9b	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, 11/5	39
C17	1, 6, 8, 9a, 9b, 11/5, 7, 10	11, 56
C18	6, 8, 9a, 9b/1, 5, 7, 10, 11	15B-1L (Can.)
C19	1, 6, 10, 11/5, 7	10, 38
c20	1, 7, 8, 11/5, 6, 9a, 9b, 10	11, 87
c21	9a, 11/5, 6, 7, 8, 9b, 10	32
c22	1, 9a/5, 6, 7, 8, 9b, 10, 11	32
C23	/5, 6, 7	38
C24	5, 7, 9a, 9b, 10/6, 8, 11	17
C25	/5, 6, 7, 10, 11	38
C26	6, 7, 8, 9b/5, 9a, 10, 11	15B-4 (Can.)
C27	6. 11/5, 7, 10	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
C31	5, 6, 7, 10, 11/	27
C32	1, 9a, 9b, 11/5, 6, 7, 8, 10	32

* GB = Golden Ball.

Table 4. Distribution by provinces of physiologic races of Puccinia graminis f. sp. tritici collected on wheat, barley, and grasses in 1967

Virulence formula number	Physiologic race number	Number of isolates from: Que.	Ont.	Man.	Sask.	Total no. of isolates	Percent of total isolates
C1	17	0	0	1	1	2	1.0
c9	15B-IL	1	2	0	0	3	1.4
C14	38	0	1	0	0	1	0.5
C17	56	0	4	1	0	5	2.4
C18	5B-IL	9	57	79	15	60	77.3
C19	38	0	7	0	0	7	3.4
C20	11	1	12	12	2	27	13.0
C29	17	0	1	0	0	1	0.5
C32	32	0	1	0	0	1	0.5
		11	85	93	18	207	100.0

Table 5. Percentage of total isolates avirulent on single identified resistance genes

Resistsnce genes	Avirulent isolates (%)
Sr 1	19.8
Sr 5	1.5
Sr 6	86.5
Sr 7	16.4
Sr 8	94.1
Sr 9a	83.1
	82.6
Sr 10	6.8
Sr 11	21.3