STEM RUST OF WHEAT, BARLEY, AND RYE IN CANADA IN 1970[1]

G. J. Green[2]

Prevalence and importance in Western Canada

Wheat stem rust (Puccinia graminis Pers. f. sp. tritici Eriks. and E. Henn.) has been scarce in Western Canada in recent years. In 1970 it was more widespread and prevalent than it has been since 1965 but infections were generally moderate on susceptible plants and there was little damage to commercial fields. Urediospores were deposited in Manitoba and south-eastern Saskatchewan on June 6–9, and the first wheat stem rust infection was observed at Morden, Manitoba on June 23. Rust developed slowly on susceptible wild barley (Hordeum jubatum L.) and on susceptible wheat varieties in experimental plots. Moderate infections developed in a few fields of the Mexican variety Pitic 62, which is susceptible to a few uncommon races. Mere traces of rust were found in farm fields on the resistant varieties Manitou, Selkirk, and Neepawa. The resistance of the widely grown varieties delayed rust development, but by September, stem rust could be easily found on wild barley in Manitoba and much of Saskatchewan.

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

Wheat stem rust was widespread in 1970, occurring in 17 rust nurseries from British Columbia to Quebec (Table 1). However, because the epiphytotic developed slowly, infections were light in all nurseries except the one at Morden, Manitoba. Moderate infections developed on the susceptible varieties Red Bobs and Mindum, but Lee, which is susceptible to 15B, was not heavily

Table 1. Percentage infection of stem rust (Puccinia graminis f. sp. tritici) on 15 wheat varieties in uniform rust nurseries at 17 locations* in Canada in 1970

	Common wheat											Durum wheat			
Location	Red Bobs	Lee	Pitic 62	Selkirk	Manitou	Neepawa	Kenya Farmer	R.L. 5404	Thatcher 6 X Transfer	Exchange	Frontana	Mindum	Stewart 63	Hercules	D.T. 316
Creston, B.C.	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Edmonton, Alta.	tr**	0	0	0	0	0	0	0	0	0		tr	0	0	0
Melfort, Sask.	5	tr	0	0	0	0	0	0	0	0	0	0	0	0	0
Indian Head, Sask.	40	tr	0	0	0	0	0	tr	0	0	0	0	0	0	0
Brandon, Man.	60	10	0	0	0	0	0	t r t r t r			0	2 0	0	0	0
The Pas, Man.	10	tr	0	0	0	0	0	0	0	tr	0	5	0	0	0
Morden, Man.	80	5	tr	tr	tr	tr	tr	1	10	10	tr	50	0	tr	tr
Glenlea, Man.	40	10	2	tr	tr	tr	tr	tr	tr	tr	tr	tr	0	tr	tr
Thunder Bay, Ont.	10	30	0	0	0	0	0	2 0	1	tr	0	4 0	0	0	0
Guelph, Ont.	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kemptville, Ont.	tr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ottawa, Ont.	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Appleton, Ont.	tr	0	0	0	0 t r		0	0	0	0	0	0	0	0	0
New Liskeard, Ont.	50	tr	0	0	0	0	0	1	tr	20	0	2 0	0	0	1
Vineland, Ont.	40	t r t r			0	0	0	0	0	0	0 t r		0	0	0
Macdonald College, Qué.	tr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Québec, Qué.	tr	0	0	0	0	0	0	0	0	0	0	1	0	0	0

* No rust was observed in nurseries at 15 locations: Agassiz, B.C.; Beaverlodge, Lacombe, and Lethbridge, Alta.; Scott, Sask.; Williamstown and Apple Hill, Ont.; La Pocatière, Lennoxville, and Normandin, Qué.; Kentville and Truro, N.S.; Fredericton, N.B.; Charlottetown, P.E.I.; St. John's, Nfld.

** tr = trace

[1] Contribution No. 462, Research Station, Canada Department of Agriculture, Winnipeg, Manitoba.

[2] Plant Pathologist.

infected. Pitic 62 is susceptible to several new races but it was not heavily attacked in any nursery. The commercial varieties Selkirk, Manitou, Neepawa, Stewart 63, and Hercules were highly resistant in all nurseries. The test variety D.T. 316 and Kenya Farmer also were highly resistant. Kenya Farmer has been in the rust nurseries since 1954 and has rarely had more than a trace of stem rust. R.L. 5404, a hexaploid derivative of Aegilops squarrosa L. was infected at Thunder Bay, Ontario, (20%) but was nearly free from stem rust at all other locations. Thatcher[6] x Transfer is a leaf rust resistant Thatcher that reacts like Thatcher to stem rust. It had about the same amount of rust as Lee, the other 15B-susceptible variety. Exchange and Frontana are sources of leaf rust resistance that rarely show much stem rust.

The amount of stem rust on rye (Secale cereale L.) and barley (Hordeum vulgare L.) (Table 2) was greater than normal but slightly less than in 1969. Rye stem rust (P. graminis f. sp. secalis) continues to be widely distributed and the small amount of rust on barley probably resulted from the early maturity of the crop.

Distribution of physiologic races

Physiologic races were identified by the virulence formula method (Table 4) and by six "standard" differential hosts (Triticum aestivum L. 'Marquis' and 'Reliance'; T. durum Desf. 'Arnautka' and 'Mindum'; T. monococcum L. 'Einkorn'; and T. dicoccum Schrank 'Vernal'). Rust was collected mainly

Table 2. Percentage infection of stem rust (Puccinia graminis) on three varieties of barley and one variety of rye in uniform rust nurseries at 17 locations* in Canada in 1970

Location	Barley			Rye
	Mont-calm	Park-land	C.I. 10644	Pro-lific
Agassiz, B.C.	0	0	0	20
Creston, B.C.	40	25	10	60
Lacombe, Alta.	0	0		tr**
Brandon, Man.	1	tr	tr	0
The Pas, Man.	0	1	tr	0
Morden, Man.				1
Thunder Bay, Ont.	10	tr	tr	40
Williamstown, Ont.	0	0	0	25
Kemptville, Ont.	0	0	0	20
Ottawa, Ont.	0	0	0	40
Appleton, Ont.	1	10	5	60
Vineland, Ont.	0	0	0	50
Macdonald College, Qué.	0	0	0	25
Québec, Qué.	0	0	0	50
Kentville, N.S.	0	0	0	tr
Truro, N.S.	0	0	0	tr
Fredericton, N.B.	0	0	0	90

* No rust was observed in nurseries at 13 locations: Edmonton, Beaverlodge, and Lethbridge, Alta.; Scott, Melfort, and Indian Head, Sask.; Guelph and New Liskeard, Ont.; La Pocatière, Lennoxville, and Normandin, Qué.; Charlottetown, P.E.I.; Doyles, Nfld.

** tr = trace

Table 3. Distribution by provinces of physiologic races of Puccinia graminis f. sp. tritici collected on wheat, barley, and grasses in 1970

Virulence formula number	Physiologic race number	Number of isolates from						Total number of isolates	Percent of total isolates
		Qué.	Ont.	Man.	Sask.	Alta.	B.C.		
C1	17	1	0	1	0	0	0	2	1.0
C9	15B-1L (Can.)	0	0	1	0	0	0	1	0.5
C16	38-39	0	0	0	0	0	1	1	0.5
C17	11,56	0	2	0	0	0	1	3	1.5
C18	15B-1L (Can.)	3	5	78	39	2	0	127	62.2
C20	11	0	0	2	0	0	0	2	1.0
C27	23-59	0	0	0	0	0	1	1	0.5
c33	15B-1L (Can.)	0	4	19	11	0	0	34	16.6
c35	32-113	0	1	1	4	0	0	16	7.8
C36	48	0	0	0	1	0	0	1	0.5
C38	15B-1L (Can.)	0	0	4	5	0	0	9	4.4
c39	32-113	0	1	0	0	0	0	1	0.5
C40	32-113	0	0	1	1	0	0	2	1.0
C41	32-113	0	0	1	0	0	0	1	0.5
C42	15	0	0	1	1	0	0	2	1.0
c43	32	0	0	0	1	0	0	1	0.5
Total wheat stem rust isolates		4	13	119	63	2	3	204	100.0
Rye stem rust isolates		0	3	74	21	0	2	100	

Table 4. Virulence formulas, formula numbers, and corresponding physiologic race numbers used from 1964 to 1970

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, LO, 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, 13, 16/5, 6, 7, 8, 9b, 10, **11**, 14, 15	32
	C23	/5, 6, 7, 10, 15, 16	38
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, 13, 15/1, 5, 7, 8, 10, **11**, 14, 16	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
1970	C38	6, 8, 9a, 9b, 13/1, 5, 7, 10, **11**, 14, 15, 16	15B-1L(Can.)
	c39	**1**, 6, 10, 13/5, 7, 8, 9a, 9b, **11**, 14, 15	32-113
	C40	**1**, 6, 10, 13/5, 7, 8, 9a, 9b, **11**, 14, 15, 16	32-113
	C41	**1**, 10, 13/5, 6, 7, 8, 9a, 9b, **11**, 14, 15, 16	32-113
	C42	6, 8, 9a, 9b, **11**, 13, 15/1, 5, 7, 10, 14, 16	15
	c43	**1**, 6, 7, 8, 11/5, 9a, 9b, 10, 13, 14, 15	32

from susceptible varieties of wheat and wild grasses. The few collections from selective, resistant varieties were not an important source of bias.

In 1970, 204 isolates of wheat stem rust were identified as 16 'races (Table 3), the largest number identified since 1964. Six of them are new and interesting races.

Race C18 (15B-1L) continues to predominate but its prevalence declined from 82% of the isolates in 1969 to 62% in 1970. Race C33 (15B-1L), second in order of prevalence, increased from 6.4% of the isolates in 1964 to 16.6% in 1970, and race C35 (32-113), third in prevalence, increased very slightly to 7.8% of the isolates. Races C18 and C33 do not threaten the varieties now grown in Western Canada. Race C33 was first found in 1967 and has increased steadily since then. It is like C18 except that it is virulent on varieties carrying resistance gene Sr8 that are resistant to C18. Race C35 can attack the Mexican variety Pitic 62 that has recently been licensed in Canada and it has moderate virulence on the Thatcher derivatives Manitou and Neepawa that are very important in Western Canada. It is a potential threat to Pitic 62 and under favorable conditions can develop on Manitou and Neepawa, but its failure to increase appreciably over 1969 levels suggests that it will not be important on Thatcher derivatives in future years. Race C17 (2 isolates of "standard" race 56 and one of race 11) seems

close to extinction. Race 56 predominated from 1935 to 1950 and from 1957 to 1963. It has been present in Canada each year since 1931. Race C20 (11) was one of the first races found with virulence on Manitou, but like several other races with this virulence, it seems to be disappearing.

Six new races, C38 to C43 (Table 4), were found in 1970. They are biotypes of common "standard" races and are distinguishable from older cultures of these races on the "single-gene lines". Race C38 is like race C18 (15B-1L) except that it is virulent on resistance gene Sr15. Races C39, C40, C41, and C43 are variants of the "standard" race 32-113 complex, and race C42 resembles C18 (15B-1L) except that it is avirulent on Srll and on Lee. The new strains differ from older ones by virulence or avirulence on a single resistance gene, showing that virulence on single resistance genes changes frequently in the rust population.

In the past year uncertainties concerning the reactions of the "single-gene lines" Marquis-Sr13 and Marquis-Sr16 have been clarified and these gene numbers have been added to formulas C22 and C33. Similarly, Sr14 and Sr15 have been added to formula C33. The variety Renown, said to carry Sr17, has been used during the past year. It will also be added to the formulas when the data warrants. The addition of information to the formulas of prevalent races is preferable to writing new formulas because it avoids a proliferation of formulas and numbers for the same races. Some genes have been left out of certain formulas because the Marquis resistance is epistatic to them and others have been left out until more data is obtained. Most of the omissions concern uncommon races.

In Tables 3 and 4, a comma between "standard" race numbers indicates separate races, a dash indicates a race group in which there is difficulty in separating the races.

In addition to the 204 isolates of wheat stem rust, 100 isolates of rye stem rust were obtained. This is the third consecutive year that rye stem rust has been prevalent in Canada.

The effectiveness of the identified resistance genes (Table 5) has not changed much in recent years because race C18 has predominated. The main (change in 1970 was the reduced effectiveness of Sr8 brought about by the increased prevalence of race c33.

Table 5. Percent of total isolates avirulent on single identified resistance genes and number of avirulent races in 1970

Resistance gene	Avirulent isolates. (%)	Number of avirulent races
Sr 1	13.8	8
Sr 5	1.5	2
Sr 6	90.7	13
Sr 7a	4.0	6
Sr 8	71.1	7
Sr 9a	87.2	7
Sr 9b	87.2	7
Sr 10	11.3	5
Sr 11	14.3	9
Sr 13	97.0	11
Sr 14	0	
Sr 15	80.3	4
Sr 16	0	

Composite collections of urediospores from all isolates were used to inoculate 28 varieties that had been highly resistant in earlier tests. The varieties highly resistant to the composite collections are: Frontana-K58-Newthatch 11-50-17, ND264, Wis. 261. St 464, C.I. 8155, Agent, Romany, Bonny, Tama, Majus, Grandes Blances, Els 6304-6-B, Esp 518/9, R.L. 5244 (Triticum monococcum), Marquis with R.L. 5244 resistance, C.T. 92'8. D.T. 191, D.T. 316, D.T. 317, D.T. 320, and WRT 240 (a line of Manitou with a rye translocation). Varieties that had rare susceptible infections are: Mida-McMurachy-Exchange 11-47-26, Minn. 11-54-30, Minn. II-58-14, Chris, C.T. 296, C.T. 299 and Giza 144. Varieties with C.T. numbers are from the Western Canadian Spring Wheat Cooperative Test, and varieties with D.T. numbers are from the Durum Test.

Acknowledgments

The cooperation of those who cared for the rust nurseries and forwarded rust collections for race identification is gratefully acknowledged. Mr. J.H. Campbell did the technical work of the program.