STEM RUST OF WHEAT, RYE AND BARLEY IN CANADA IN 1964

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Prevalence and importance in western Canada

Wheat stem rust (Puccinia graminis Pers. f. sp. tritici Erikss. and Henn.) was an unimportant factor in wheat production throughout western Canada in 1964. In the rust area of Manitoba and southeastern Saskatchewan the predominant bread wheat varieties, Selkirk and Pembina, were free from infection at maturity and the predominant durum wheat variety, Ramsey, showed only traces of stem rust. The bread wheat variety Lee and certain varieties of durum wheat, which are susceptible to race 15B and not widely grown, had moderate infections of up to 50 per cent.

Stem rust appeared later than usual. In most years it is first observed in Manitoba in the last two weeks of June but in 1964 it was not found until July 7. It developed rapidly on susceptible varieties in experimental plots in Manitoba and southeastern Saskatchewan. Infections were first observed on July 24 in central Saskatchewan end on July 23 in southern Alberta. Infections were light but widely distributed in those provinces at harvest.

Losses from stem rust were small in aggregate but the severe infections on susceptible varieties in experimental plots in the main rust area demonstrated that, despite the late initial appearance of the rust, abundant inoculum was carried into the area and environmental conditions favored its development. The resistance of the predominant varieties again prevented a destructive epidemic.

Incidence in the rust nurseries

Uniform rust nurseries that included the varieties shown in Table 1 were grown at 37 locations across Canada in 1964. The nurseries were cared for by Canada Department of Agriculture and University personnel. A small sheaf was cut from each row of each nursery before the plants matured and sent to Winnipeg where disease ratings were made.

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The susceptible varieties Red Bobs and Marquis were most heavily infected in rust nurseries located in eastern Saskatchewan, Manitoba, Ontario and western Quebec. The severity of the infections indicated that there was abundant inoculum and favorable environmental conditions for rust development in these areas. In the prairie provinces there was no rust in nurseries located west of Melfort, Sask. The light infections at Creston, B.C., appear to have been initiated by inoculum originating in Washington and Idaho.

Infections on the varieties Lee and Thatcher were the heaviest recorded in the rust nurseries since 1955. These varieties are resistant to all prevalent races excepting 15B. The moderately severe infections on them indicate a general increase in the prevalence of a subrace of 15B, presumably 15B-1L (Can.). The light infection on the important resistant commercial variety Selkirk at La Pocatière, Que., indicates the presence of a race that did not occur elsewhere, or a breakdown of the resistance of Selkirk caused by high temperature. The occasional light infections on Kenya Farmer were of the resistant type. This variety has been resistant at all locations since it was first grown In the nurseries in 1954.

Stem rust of barley and rye in the rust nurseries

The barley variety Montcalm is susceptible to wheat stem rust and was rusted (Table 2) about the same as susceptible varieties of wheat (Table 1). Stem rust of rye (Puccinia graminis Pers. f. sp. secalis Erikss. and Henn.) (Table 2) was widely distributed. Severe or moderately severe infections occurred at several locations. The barley varieties Parkland and Vantage are resistant to wheat stem rust but susceptible to rye stem rust. Most of the rust on them at Creston, B.C., was, presumably, rye stem rust.

Distribution of physiologic races

The prevalence and diversity of races of wheat stem rust in Canada changed appreciably in 1964. Races 15B-1L (Can.) and 56 occurred

Table 1. Per cent infection of stem rust of wheat (Puccinia graminis f. sp. tritici) on 11 wheat varieties in 23[a] uniform rust nurseries in Canada in 1964.

Locality	Common Wheat									Durum Wheat	
	Red Bobs	Marquis	Lee	Thatcher	Selkirk	McMurachy	Kenya Farmer	Exchange	Frontana	Mindum	Ramsey
Creston, B.C.	20	5	0	0	t	0	0	t	0	0	0
Melfort, Sask.	t	0	t	0	0	0	0	0	0	0	0
Indian Head, Sask.	40	40	10	2	0	0	0	1	t	10	0
Brandon, Man.	60	40	1	t	0	0	0	t	t	10	0
The Pas, Man.	80	60	t	t	0	0	0	t	t	t	0
Glenlea, Man.	80	80	50	30	t	5	t	5	20	20	t
Fort William, Ont.	10	15	t	5	0	0	0	0	0	0	0
Kapuskasing, Ont.	60	30	t	t	0	0	0	0	0	5	0
St. Catharines, Ont.	40	2	t	t	0	t	0	0	t	t	0
Guelph, Ont.	60	60	20	1	0	20	t	50	30	20	t
Kemptville, Ont.	70	40	10	15	t	20	5	10	1	10	t
Merrickville, Ont.	60	60	40	30	0	20	10	20	40	50	10
Appleton, Ont.	80	70	50	10	0	0	0	10	20	30	0
Williamstown, Ont.	70	80	20	5	0	1	t	20	5	5	5
Alfred, Ont.	80	80	40	20	0	25	20	10	40	25	t
Verner, Ont.	50	50	1	t	1	t	1	1	40	5	t
Douglas, Ont.	1	t	0	0	0	t	0	0	0	0	0
Macdonald College, Que.	50	70	40	30	0	5	10	20	5	50	1
Lennoxville, Que.	30	5	t	t	0	0	t	1	0	0	0
La Pocatière, Que.	80	70	5	5	20	50	5	0	50	t	0
L'Assomption, Que.	70	70	t	t	0	t	0	1	t	1	0
Québec, Que.	t	t	t	0	0	0	-	-	-	-	-
Fredericton, N.B.	t	1	0	0	0	0	0	0	0	0	0

a/ No rust was observed at 1 other nurseries grown at Sas ichton and gassi , B.C , Beaverlodge, Edmonton, Lethbridge, and Lacombe, Alta., Scott, Sask., Normandin, Que., Kentville, Nappan, Boulardarie and Brule, N.S., Charlottetown, P.E.I., and St. John' West, Nfld.

commonly in eastern and western Canada and race group 11, 32, 113 was common in eastern Canada (Table 3). Race 15B-1L (Can.) increased and displaced race 56 as the most prevalent race. Races identified from rust collected on susceptible varieties (Table 4) confirmed the results obtained with rust from both resistant and susceptible varieties (Table 3).

The increased prevalence of race 15B-1L (Can.) seems to have resulted from the rapid increase of a comparatively new biotype that appeared in 1962. The new biotype is virulent on the lines of Marquis carrying genes Sr7 and Sr10. The original biotype, first found in 1956, is avirulent on these lines.

No new races were found in the prairie provinces but several occurred in eastern Canada. The most interesting new races are in the race 11, 32, 113 group and race 38. Races 11, 32 and 113 were grouped because their differentiation on the standard hosts was not always clear. Race 11 produced infection type 4 on the varieties Marquis and Mindum, race 32 is like race 11 except that it produces a mesothetic reaction on Mindum, and race 113 is like race 11 except that it produces a mesothetic reaction on both Marquis and Mindum. The mesothetic reaction of these varieties is unstable and varies widely under different environmental conditions. The isolates in this group differed on other hosts.

Table 2. Per cent infection of stem rust (Puccinia graminis Pers.) on 3 varieties of barley and 1 variety of rye in 20[a] uniform rust nurseries in Canada in 1964.

Locality	Barley			Rye
	Montclm	Parklnd	Vantage	Prolific
Creston, B.C.	10	20	30	80
Lethbridge, Alta.	0	0	0	1
Indian Head, Sask.	10	0	0	0
Brandon, Man.	40	t	0	t
Glenlea, Man.	60	10	t	t
The Pas, Man.	-	0	0	t
Fort William, Ont.	5	0	0	0
Guelph, Ont.	t	0	0	
Kemptville, Ont.	60	t	t	30
Merrickville, Ont.	50	10	1	80
Appleton, Ont.	70	10	5	5
Williamstown, Ont.	5	0	0	t
Alfred, Ont.	40	t	0	40
Verner, Ont.	80	5	0	5
Macdonald Coll., Que.	60	t	0	20
Lennoxville, Que.	0	0	0	5
La Pocatière, Que.	5	0	0	t
L'Assomption, Que.	60	t	t	5
Québec, Que.	0	0	0	10
Kentville, N.S.	0	0	0	t

[a] No rust was observed in 17 other nurseries located at Saanichton and Agassiz, B.C., Beaverlodge, Edmonton and Lacombe, Alta., Scott and Melfort, Sask., Kapuskasing, St. Catharines and Douglas, Ont., Normandin, Que., Fredericton, N.B., Nappan, Brule and Boulardarie, N.S., Charlottetown, P.E.I., St. John's West, Nfld.

Five biotypes of race 11, 4 of race 32 and 2 of race 1-13 were found (Table 5). A race identified as 38 occurred commonly in Ontario. It was not typical of race 38 because it produced infection type 3 - instead of 4 on the variety Reliance. Two biotypes of race 38 were distinguished (Table 5). Other races that have not been found in Canada in recent years are: 10, 14, 23, 39, 48 and 87.

The new races and the changed prevalence of the known races had little practical importance. The increased prevalence of race 15B-1L (can.) in western Canada resulted in moderately severe attacks on the bread wheat variety Lee and susceptible varieties of durum wheat, but these varieties were grown in only a few fields in the rust area. The biotypes of race 32 that can attack the varieties Selkirk and Pembina in the seedling stage did not increase in the rust area of western Canada where these varieties predominate.

In 1963, virulence formulae (effective/ineffective host genes) were used to describe the virulence of groups of cultures on lines of Marquis wheat carrying identified resistance genes. The formulae were necessary because the variation encountered could not be described with the system of physiologic race numbers and subrace designations in use. Similar variation occurred within the physiologic races obtained in 1964 (Table 5). Some of the variants have practical importance because they are virulent on a number of varieties carrying identified host genes that have been used at Winnipeg in breeding resistant varieties. Formulae have again been used to describe this variation and to make the formulae more useful they have been numbered (Tables 5 and 6). The numbers of the formulae appear in Tables 3 and 4 that present the results of the physiologic race survey. The prefix "C" has been used to indicate "Canadian" and avoid confusion with race numbers of other systems.

Formulae for races avirulent on Marquis are not as complete as the formulae for races virulent on that variety. The Marquis lines carrying the identified resistance genes, excepting Marquis-Sr7, have the resistance of Marquis that is expressed as a type 2 infection. Genes Sr8, Sr9a and Sr9b also condition a type 2 infection and Srll a type 1. These reactions are often difficult to distinguish from the reaction of Marquis. The Sr5 (type 0), Sr6 (fleck) and Srl0 (fleck and type 1) can usually be distinguished from the Marquis resistance because they are epistatic to it.

Composite samples of urediospores from all 1964 rust collections were used to inoculate the very resistant varieties Kenya Farmer, Mayo 54, Mida-McMurachy-Exchange II-47-26, Frontana-K58-Newthatch II-50-17, Crim, Justin, St. 464, C.I. 8155, C.T. 261, C.T. 263, and D.T. 161. Rare type 3 infections were observed on the varieties Crim, Mayo 54, Justin, St. 464, and C.T. 263. Isolates from these infections were identified as common races indicating that the type 3 infections developed because of favorable environmental conditions and not because of broadened pathogenicity in the rust.

Table 3. Distribution by provinces of physiologic races of Puccinia graminis f. sp. tritici collected on wheat, barley and grasses in 1964.

Race	Virulence Formula Number	Province						Number of Isolates	Per cent of Total Isolates
		N.B.	Que.	Ont.	Man.	Saak	B.C.		
11, 32, 113	C12,C13,C15,C17 C20,c21,c22	0	10	50	3	4	1	68	18.3
10	C19	0	0	1	0	0	0	1	0.3
14	C14	0	1	1	0	0	0	2	0.5
15B-1 (Can.)1/	C10	0	0	1	0	0	0	1	0.3
15B-1L (can.)	C9	2	4	12	30	9	0	57	15.4
15B-1L (Can.)2/	C18	0	5	35	46	30	0	116	31.3
15B-4 (Can.)	C11	0	1	2	1	1	0	5	1.4
17	C1	0	0	3	0	0	0	3	0.8
17A	C2	0	0	1	0	0	0	1	0.3
23	c4	0	0	0	0	0	1	1	0.3
29-1 (can.)	c5	0	1	0	0	5	0	6	1.6
29-2 (can.)	C6	0	0	1	0	0	0	1	0.3
29-4 (Can.)	C3	0	0	1	0	0	0	1	0.3
38	C14,C23	0	2	16	0	0	0	18	4.9
39	C16	0	0	2	0	0	0	2	0.5
48A	C8	0	1	1	0	1	0	3	0.8
48	c7	0	0	1	0	0	0	1	0.3
56	C17	0	6	36	32	6	1	81	21.9
87	C20	0	0	1	1	0	0	2	0.5
Total Isolates		2	31	165	113	56	3	370	100.0

1/ Races 15B-1 (Can.), 15B-1L (Can.) and 15B-4 (Can.) appear to be equivalent to races 15B-1, 15B-2 and 15B-3 respectively, of the Cooperative Rust Laboratory, St. Paul, Minnesota.

2/ Cultures of race 15B-1L (Can.) virulent on Marquis-Sr7 and Marquis-Sr10.

Table 4. Distribution by provinces of physiologic races of Puccinia graminis f. sp. tritici collected on wild barley and susceptible varieties of wheat and barley in 1964.

Race	Virulence Formula Numbers	Province						Number of Isolates	Per cent of Total Isolates
		N.B.	Que.	Ont.	Man.	Sask.	B.C.		
11, 32, 113	C12,C13,C15,C17 C20,C21,C22	0	2	19	2	0	1	24	11.8
14	C14	0	0	1	0	0	0	1	0.5
15B-1L (Can.)	C9	2	0	5	20	1	0	28	13.8
15B-1L (Can.)1/	C18	0	3	21	28	12	0	64	31.5
17	C1	0	0	2	0	0	0	2	1.0
17A	C2	0	0	1	0	0	0	1	0.5
23	C4	0	0	0	0	0	1	1	0.5
29-1 (Can.)	C5	0	0	0	0	1	0	1	0.5
29-4 (Can.)	C3	0	0	1	0	0	0	1	0.5
38	C14,C23	0	2	8	0	0	0	10	4.9
56	C17	0	6	26	30	6	1	69	34.0
87	C20	0	0	0	1	0	0	1	0.5
Total Isolates		2	13	84	81	20	3	203	100.0

1/ Cultures of race 15B-1L (Can.) virulent on Marquis-Sr7 and Marquis-Sr10.

Table 5. Infection types produced on wheat varieties and on lines of Marquis wheat with single substituted resistance genes by stem rust races in 1964, the virulence formula for each group of cultures, and formulae numbers.

Race	Variety													Virulence Formula (Effective/ Ineffective Host Genes)	Formula Number
	Lee	Golden Ball	Selkirk	Yuma	Marquis	Reliance (Sr5)	Marquis-Sr6	Marquis-Sr7	Marquis-Sr8	Marquis-Sr9a	Marquis-Sr9b	Marquis-Sr10	Marquis-Sr11		
Isolates Virulent on Marquis															
11	1	3	;	;	4	4	;	23CN	3	2	2	X=	2	6,7,9a,9b,10,11/5,8	C12
11	1	3	;	;	3	23	;	13CN	3	3	23	;2	23	6,7,10/5,8,9a,9b,11	C15
11	1	3	C	;	4	4	4	23CN	2	3	4	4	1	7,8,11/5,6,9a,9b,10	C20
11	4	2	;	;1	3C	4	;	13CN	3C	3C	23C	X	3C	6,7,10/5,8,9a,9b,11	C15
11	1	2	;	;1	4	4	;	4C	2	2	2	4	;1	6,8,9a,9b,11/5,7,10	C17
32	3	2	;	;1	4	4	;	23C	4	4	4	X	4	6,7,10/5,8,9a,9b,11	C15
32	1	4	C	;1	4	4	4	4	4	2	4	4	1	9a,11/5,6,7,8,9b,10	C21
32	1	2	;	;1	3	3	;	23C	3	3	3	X-	1	6,7,10,11/5,8,9a,9b	C13
32	3	4	C	;1	4	3	4	4	4	2	4	4	4	9a/5,6,7,8,9b,10,11	C22
113	1	2	;	;1	X	3	;	13CN	X	C	X			6,7,10,11/5,8,9a,9b	C13
113	3	2	;	;1	X	4	;	23CN	X	X	X	1	X	6,7,10/5,8,9a,9b,11	C15
15B-1	3	2	;	;	4	4	;	23CN	2	4	4	4	4	6,7,8/5,9a,9b,10,11	C10
15B-1L	3	2	;	3C	4	4	;	23CN	2	2	2	X-	4	6,7,8,9a,9b,10/5,11	C9
15B-1L	4	2	;	3C	4	4	;	3C	2	2	2	4	4	6,8,9a,9b/5,7,10,11	C18
15B-4	3	4	1	;1	4	4	;1	23CN	2	4	4	4	4	6,7,8/5,9a,9b,10,11	C11
17	1	4	;	;1	4	0	;	23CN	4	2	2	;2	1	5,6,7,9a,9b,10,11/8	C1
17A	3	4	;	1	4	0	;	13CN	4	2	2	;1	4	5,6,7,9a,9b,10/8,11	C2
29-1	1	4	C	;	4	0	4	4	4	2	2	4	1	5,9a,9b,11/6,7,8,10	C5
29-2	1	2	C	;	4	0	4	4	4	2	2	4	1	5,9a,9b,11/6,7,8,10	C6
29-4	1	4	;	;	4	0	;	4	4	2	4	4	1	5,6,9a,11/7,8,9b,10	C3
56	1	2	;	;	4	4	;	4	2	1	2	4	1	6,8,9a,9b,11/5,7,10	C17
87	1	4	4	;	4	4	4	23CN	2	4	4	4	1	7,8,11/5,6,9a,9b,10	C20
Isolates Avirulent on Marquis															
10	1	3	;	;1	2	3						;1	;1	6,10,11/5,7	C19
14	1	3	;	;1	2	2	;	23CN	1	2	1	;1	;1	6,7,10,11/5	C14
23	1	3	23	;1	2	0	;	4	2	2	2	2	1	5,6,11/7	C4
38	2	3	;	;1	2	3	2	4	2	2	2	1	2	/5,6,7	C23
38	1	3	;	;1	2	3	;	23CN	2	2	2	;1	;1	6,7,10,11/5	C14
39	1	3	3	;1	2	3	;	23CN	1	1	2	1	;1	6,7,11/5	C16
48	1	2	2	;1	2	0	2	3	2	2	2	2	;1	5,11/6,7	C7
48A	1	4	2	;1	2	0	2	4	2	2	2	2	1	5,11/6,7	C8

Table 6. Virulence formulae and formulae numbers for isolates of various races of wheat stem rust obtained in 1964.

Virulence Formula (Effective/Ineffective Host Genes)	Physiologic Race	Formula Number
5,6,7,9a,9b,10,11/8	17	C1
5,6,7,9a,9b,10/8,11	17A	C2
5,6,9a,11/7,8,9b,10	29-4 (Can.)	C3
5,6,11/7	23	C4
5,9a,9b,11/6,7,8,10,GB[1/]	29-1 (Can.)	C5
5,9a,9b,11,GB/6,7,8,10	29-2 (Can.)	C6
5,11,GB/6,7	48	C7
5,11/6,7,GB	48A	C8
6,7,8,9a,9b,10/5,11	15B-1L (Can.)	C9
6,7,8,GB/5,9a,9b,10,11	15B-1 (Can.)	C10
6,7,8/5,9a,9b,10,11,GB	15B-4 (Can.)	C11
6,7,9a,9b,10,11/5,8	11	C12
6,7,10,11/5,8,9a,9b	32	C13
	113	
6,7,10,11/5	14	C14
	38	
6,7,10/5,8,9a,9b,11	11	C15
	11	
	32	
	113	
6,7,11/5	39	C16
6,8,9a,9b,11/5,7,10	11	C17
	56	
6,8,9a,9b/5,7,10,11	15B-1L (Can.)	C18
6,10,11/5,7	10	C19
7,8,11/5,6,9a,9b,10	11	C20
	87	
9a,11/5,6,7,8,9b,10	32	C21
9a/5,6,7,8,9b,10,11	32	C22
/5,6,7	38	C23

1/ GB indicates the reaction of the variety Golden Ball