Races of *Puccinia graminis* f. sp. *tritici* in the United States and Mexico in 1980

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ABSTRACT

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No wheat stem rust was found to have overwintered in the United States. A survey of Mexico during the spring revealed no stem rust outside of wheat breeding plots and trap nurseries. The disease appeared late in the season in the United States and in amounts too sparse to threaten the wheat crop. This was the least amount of rust found in the United States since the rust survey began in 1918. Race 15-TNM was the most frequently identified, or 43% of the 143 isolates studied. Race 151-QFB constituted 26% of the isolates. The two most commonly isolated races in Mexico, 113-RPQ and 151-QSH, were not found in the United States. No virulence was found for seedlings with *Sr* genes 13, 22, 24, 25, 26, 27, 29, 30, Gt, Tt2, and Wld-1.

Additional key words: specific resistance

Wheat stem rust caused by *Puccinia graminis* Pers. f. sp. *tritici* Eriks. & E. Henn. has been gradually decreasing in prevalence and severity in North America (1,5). Part of the decrease is the result of the removal of the alternate host (*Berberis vulgaris* L.); however, most of this effect occurred before 1930 (2,3). Resistant cultivars have also had an effect, but there have been no major changes in resistance or virulence in the past 7 yr. Unfavorable environmental conditions are an unlikely cause of this decrease in disease, because a similar decrease has not occurred in oat stem rust caused by *P. graminis* f. sp. *avenae* Eriks. & E. Henn. (4). It is thus possible that most of the decrease in disease has been caused by a lack of aggressiveness in the virulent cultures.

Continual monitoring of the pathogen population is necessary to detect any changes that would again make it a serious pathogen. Annual field surveys are made to obtain uredial collections of the pathogen, which are analyzed for their virulence on differential and "universally" resistant host lines.

MATERIALS AND METHODS

Field surveys were conducted over a 24,000-km route covering the Great Plains and the Gulf Coast areas of the United States. In 1980, additional surveys covered parts of the Mexican states of Coahuila, Guanajuato, Nuevo León, Sinaloa, Sonora, and Tamaulipas. The surveys followed generally circular routes through areas where small grain cereals are important crops and where rust has been a problem. Stops were made at a commercial field each 32 km or at the first field thereafter. Stops were also made at nurseries and trap plots along the route. In 1980, there were about 72 trap plots. A collection was made whenever rust was observed. Each consisted of a varying number of stems or leaves bearing rust from a cultivar in a field or nursery. These collections were supplemented by collections furnished by cooperators throughout North America.

Upon receipt of uredial collections at the laboratory, two samples of spores were taken. One portion was used to inoculate 7-day-old seedlings of wheat (*Triticum aestivum* L.) cultivar McNair 701 (CI 15288), which was treated with maleic hydrazide to enhance spore production. After 12–14 days, up to four leaves—each bearing or pruned to a single uredium—were saved and reincubated to germinate loose uredospores. Three to 4 days later, spores were

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Table 1. Cereal Rust Laboratory races of *Puccinia graminis* f. sp. *tritici*

Code[a]	Response of host with *Sr* genes			
Set 1	5	9d	9e	7b
Set 2	11	6	8	9a
Set 3	Tt-1	9b	13	10
B	R[b]	R	R	R
C	R	R	R	S
D	R	R	S	R
F	R	R	S	S
G	R	S	R	R
H	R	S	R	S
J	R	S	S	R
K	R	S	S	S
L	S	R	R	R
M	S	R	R	S
N	S	R	S	R
P	S	R	S	S
Q	S	S	R	R
R	S	S	R	S
S	S	S	S	R
T	S	S	S	S

[a]Combination of host response from set 1 determines the first letter of code, set 2 the second, and set 3 the third.
[b]R = host not susceptible; S = host susceptible.

Fig. 1. Ecologic areas for *Puccinia graminis* f. sp. *tritici* in the United States.

collected separately from up to three uredia (each an isolate), each of which yielded enough spores to inoculate a differential host series. The reaction of wheat lines with genes *Sr*5, 6, 7b, 8, 9a, 9b, 9d, 9e, 10, 11, 13, 15, 16, 17, Tt-1, and Tmp were evaluated (6).

The second portion of spores was bulked with those from other collections made in the same area at about the same time and was used to inoculate the "universally" resistant series. This series consisted of lines with the host *Sr* genes *Sr*22, 24, 25, 26, 27, 29, 30, Gt, Tt-2, Wld-1 and the cultivars Era, Cando, Olaf, and Ward. These lines and cultivars have been selected over a period of years as resistant to stem rust (6).

The plants were inoculated by being sprayed with an atomizer containing spores suspended in a lightweight mineral oil. Inoculated plants were placed in a dew chamber overnight at 18 C. This was followed by a 3-hr period of fluorescent light, 10,000 lux, as the temperature gradually rose to 30 C. Plants were then placed in a greenhouse at 18–28 C. Infection types were observed after 10–14 days. Races were identified by means of the Cereal Rust Laboratory differentials (Table 1).

The data were arranged according to ecologic areas (Fig. 1) based on the geographic location where the collections were made. No collections were obtained from areas 1S, 1N, and 4, nor from western Mexico except in the vicinity of inoculated nurseries.

RESULTS AND DISCUSSION

Field surveys in Mexico revealed traces of stem rust in mid-April on susceptible wheat cultivars from Celaya to the Rio Grande; however, no rust was found in commercial fields. No stem rust was found overwintering in the United States.

Uredia were first found at Dallas, TX, on 10 June, 16 days later than normal for that location. By 16 June, trace amounts of stem rust resulting from an early June infection were found in susceptible wheat plots in northern Kansas and southern Nebraska. In mid-July, wheat stem rust was present on susceptible spring wheat plots and in trace amounts in a commercial field in Wisconsin. By mid-August, traces of wheat stem rust were observed in trap plots of susceptible cultivars as far north as Langdon, ND.

Environmental conditions in 1980 were favorable for stem rust, but little rust developed because of lack of inoculum and resistance of commonly grown cultivars. This was the least amount of wheat stem rust found in the United States since the rust survey began in 1918. It is difficult to quantify the amount of decrease in disease over the years because of variation in numbers of observations and susceptible trap plots from year to year. Although greater efforts have been made to collect rust since 1965, there has been a steady decline in numbers of collections and in the amount of rust reported (Table 2) for the last 7 yr. Only during 1918 through 1928 were there fewer than 300 collections available annually for evaluation.

The data of the 1980 race survey are presented in Table 3 for the United States, its five ecologic areas, and Mexico. Data obtained from collections made from commercial fields and naturally occurring hosts were separated from those from nurseries and plots. No data were included from collections made in or near known inoculated nurseries.

The most prevalent race was 15-TNM, which was found in 43% of all U.S. isolates. This was the most prevalent race in the northern United States, where most wheat cultivars are highly resistant to race 15-TNM. A related race, 15-TDM, was isolated from area 6; it comprised 8% of the U.S. isolates. These two races were

Table 2. Collections of *Puccinia graminis* f. sp. *tritici* studied annually during 1918 through 1980, as an indicator of frequency of disease occurrence

Year	Collections (no.)	Year	Collections (no.)	Year	Collections (no.)
1918	131	1939	735	1960	585
1919	149	1940	902	1961	942
1920	83	1941	804	1962	546
1921	77	1942	680	1963	1,021
1922	65	1943	982	1964	834
1923	58	1944	1,126	1965	1,351
1924	81	1945	704	1966	237
1925	63	1946	753	1967	578
1926	86	1947	491	1968	418
1927	270	1948	1,053	1969	527
1928	204	1949	474	1970	758
1929	525	1950	810	1971	548
1930	288	1951	686	1972	756
1931	364	1952	991	1973	459
1932	372	1953	844	1974	914
1933	333	1954	1,096	1975	882
1934	507	1955	574	1976	671
1935	787	1956	686	1977	445
1936	618	1957	668	1978	295
1937	1,025	1958	566	1979	171
1938	1,030	1959	516	1980	54

Table 3. Summary of the identified races of *Puccinia graminis* f. sp. *tritici* by area and source of collection in 1980

		Number of		Percentage of isolates of each race[b]													
				15		151			113			11		17	29	56	[c]
Area[a]	Source	Collections	Isolates	TNM	TDM	QFB	QSH	QCB	RKQ	RTQ	RPQ	RCR	RHR	HDL	HJC	MBC	BBC
USA	Field	9	26	27		27			12	4		12	8				12
	Nursery	45	117	46	10	26		5	3					1	1	3	5
	Total	54	143	43	8	26		4	5	1		2	1	1	1	2	6
2	Nursery	2	2					50							50		
3	Nursery	5	12			75										25	
5	Field	8	23	30		30			13	4		13	9				
	Nursery	6	15	60		27			13								
	Total	14	38	42		29			13	3		8	5				
6	Nursery	30	82	55	15				2					1			
8	Field	1	3														100
	Nursery	2	6														100
	Total	3	9														100
Mexico	Nursery	29	70			11	20	7	1		50				1	9	

[a]See Figure 1 for description of areas.
[b]Cereal Rust Laboratory races.
[c]Typical of races originating from aeciospore infections.

Table 4. Virulence of *Puccinia graminis* f. sp. *tritici* isolates on the single-gene differentials used in the 1980 survey

Area[a]	Percentage of isolates virulent on *Sr* genes[b]													
	5	6	7b	8	9a	9b	9d	9e	10	11	15	17	Tt-1	Tmp
2	50	50	50	50	50	0	100	0	50	0	100	100	0	0
3	100	0	25	75	75	0	75	0	25	0	100	100	0	25
5	100	21	71	87	58	29	100	42	55	50	58	63	71	42
6	100	0	100	100	0	0	100	100	100	79	0	18	100	100
8	0	0	0	0	0	0	0	0	100	0	100	100	0	0
United States 1980	92	8	64	84	39	9	92	48	64	44	49	56	61	53
United States 1979[c]	93	20	71	88	31	20	97	48	60	56	51	45	65	52
United States 1972–1979	97	16	78	87	22	15[d]	98	66	80[d]	73	31[e]	35[e]	76[d]	70[e]
Mexico	99	21	61	83	69	71	91	0	30	70	97	51	51	0

[a] See Figure 1 for description of areas.
[b] All isolates were virulent on *Sr*16 and 100% avirulent on *Sr*13.
[c] Roelfs et al (5).
[d] Mean values for 1973–1979.
[e] Mean values for 1975–1979.

virulent on *Sr*16 and Tmp and avirulent on *Sr*15. Except for 10% of the isolates of TNM, these races were avirulent on *Sr*17. Neither race 15-TNM nor 15-TDM was found in Mexico, but they seem to be better adapted environmentally than the other races, based on their prevalence through the years. This is in spite of their avirulence on the commercial wheats.

Race 151-QFB, the second most frequently isolated race in the United States, made up 26% of all isolates; a related race, 151-QCB, made up 4%. Race 151-QSH made up 15% of the Mexican isolates but was not found in the United States. These three races were all virulent on lines with *Sr* genes 15, 16, and 17 and were avirulent on Tmp. Races 113-RKQ, -RTQ, and -RPQ were found infrequently in the population (Table 3). Race RPQ was found only in Mexico. Races RKQ and RTQ were virulent on lines with *Sr* genes 15 and 16, whereas 57 and 100% were virulent on *Sr*17, respectively. Race RPQ was virulent on lines with *Sr* genes 15 and 16.

No virulence was detected for seedling wheats having *Sr* genes 13, 22, 24, 25, 26, 27, 29, 30, Gt, Tt2, and Wld-1. The important spring wheat cultivars Era and Olaf and durum wheat cultivars Cando and Ward were resistant as seedlings. The incidence of virulence for the differential host resistance genes tested is shown in Table 4 and is compared with previous surveys for the United States.

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