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

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ABSTRACT

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The only known overwintering site for oat stem rust in the United States in 1980 was in a Beeville, TX, nursery. Surveys of Mexico in April and May found little rust in commercial fields. Disease incidence increased in Texas nurseries, and rust appeared earlier in the year than normal in the north central states; however, the earlier than normal plant maturity negated the effect of the early initial infections. The 1,150 isolates from 434 uredial collections from the United States consisted of 78% race NA-27, 11% NA-16, and 9% NA-5. No virulence for oat lines with genes *Pg*-9, -13, -16, and -a and the host lines Saia, CI 9221, S.E.S. Selection No. 52, X-1588-2, Kyto, or CI 9139 was found in Mexico or the United States in 1980.

Additional key words: specific resistance

Oat stem rust caused by *Puccinia graminis* (Pers.) f. sp. *avenae* Eriks. & E. Henn. is a major disease of oats (*Avena sativa* L.). The disease has caused few losses in recent years in the United States, even though the most common race, NA-27, is virulent on most commercial cultivars. The date of onset of the disease is correlated with the losses produced in the north central states (3). This work is part of an ongoing program to monitor the disease and to characterize pathogen virulence.

MATERIALS AND METHODS

Annual field surveys were conducted over a 24,000-km route covering the Great Plains and the Gulf Coast 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 follow a preselected, generally circular route through areas where small grain cereals are important and rust has historically been a problem. Stops are made at a commercial field each 32 km or at the first field thereafter. Additional stops are made at nurseries and trap plots along the route. In 1980, there were approximately 37 trap plots. Whenever rust was observed in a field or nursery, a collection consisting of a varying number of leaves or stems bearing rust uredia from a single plant or cultivar was made.

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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 from each collection. One sample was used to inoculate 7-day-old seedlings of the oat cultivar Marvellous, CI 7027, which was treated with maleic hydrazide to enhance spore production. Each culture was maintained in a separate, clear plastic chamber. After 12–14 days, up to four leaves—each bearing or pruned to a single uredium—were saved and reincubated to germinate any loose uredospores. Three to 4 days later, enough uredospores were collected separately from up to three uredia (each an isolate) to inoculate a differential host series. Oat lines with genes *Pg*-1, -2, -3, -4, -8, -9, -13, -15, -16, and -a were evaluated (4).

The second sample of spores from each collection was bulked with those from other collections made in the same area at about the same time and was used to inoculate a "universally" resistant series. This series consisted of the host lines Saia (CI 7010), CI 7221, S.E.S. Selection No. 52 (CI 3034), X-1588-2 (CI 8457), Kyto (CI 8250), MN 730358, and CI 9139. These lines have been selected over a period of years as resistant to stem rust.

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 in fluorescent light, 10,000 lux, as the temperature rose gradually to 30 C. Plants were then placed in a greenhouse at 18–28 C. Infection types were observed after 10–14 days, and races were described after Martens et al (1).

The U.S. data were arranged into five ecologic areas (Fig. 1) based on the geographic location where the collections were made. No collections were received from area 3. One collection was obtained from Tifton, GA, in area 2; two were obtained from Pullman, WA, and Esparto, CA, in area 5. Collections from Canada were from Ontario where barberry (*Berberis vulgaris* L.) may still function as an alternate host. The rust collections from Mexico were from the states of Guanajuato, Hidalgo, Nuevo León, Sinaloa, Sonora, and Tamaulipas.

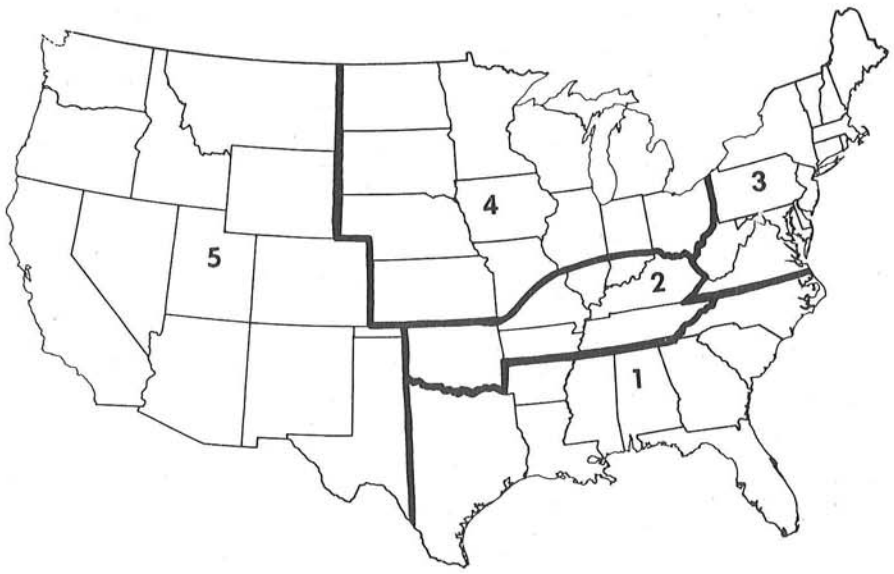

Fig. 1. Ecologic areas for sampling *Puccinia graminis* f. sp. *avenae* for virulence.

Table 1. Identified races of *Puccinia graminis* f. sp. *avenae* by area and source of collection, 1980

Area[a]	Source	Collections[b] (no.)	Isolates (no.)	North American (NA) physiologic race[c]						
				5	12	16	23	25	26	27
USA	Field	180	464	2		13	...[d]			85
	Nursery	254	686	14		10	2			73
	Total	434	1,150	9		11	1			78
1	Field	1	3	100						
	Nursery	164	460	19		8	3			70
	Total	165	463	19		8	3			69
2	Field	1	3							100
4	Field	176	452	...		13	1			86
	Nursery	90	226	4		15				81
	Total	266	678	2		13	...			84
5	Field	2	6	83		17				
Mexico	Field	14	42	5		43				52
	Nursery	19	36	3		11				86
	Total	33	78	4		28				68
Ontario,	Field	1	2		100					
Canada	Nursery	15	22		27		4	41	14	14
	Total	16	24		33		4	38	12	12

[a] See Figure 1 for ecologic areas in the United States.
[b] Uredia from a single field, plant, or received separately were considered a collection, from which up to three single-pustule isolates were identified.
[c] After Martens, et al. Each entry is a percentage of isolates.
[d] ... = less than 0.6%.

Table 2. Virulence of oat stem rust isolates for the resistance of the single-gene differential lines in the 1980 survey

Area[a]	Percentage of isolates virulent on *Pg*									
	−1	−2	−3	−4	−8	−9	−13	−15	−16	−a
USA	91	79	100	78	91	0	0	9	0	0
1	81	72	100	69	81	0	0	19	0	0
2	100	100	100	100	100	0	0	0	0	0
4	98	98	100	85	98	0	0	2	0	0
5	17	0	100	0	17	0	0	83	0	0
Mexico	96	68	100	68	96	0	0	4	0	0
Ontario, Canada	67	100	100	96	17	83	12	83	0	0

[a] See Figure 1 for ecologic areas in the United States.

RESULTS AND DISCUSSION

Field surveys in April and early May revealed only trace amounts of rust on susceptible oat lines in nurseries in eastern Mexico. Rust was observed in a single commercial field near Salvatierra, Guanajuato, and on scatter wild oats (*A. fatua* L.) in the states of Guanajuato, Sinaloa, and Sonora. No stem rust was found in commercial fields in Texas during April; however, trace amounts were found in a Beeville, TX, nursery on 31 March. Stem rust increased in Texas and became severe in some nurseries, but not in commercial fields. Uredia were first found in the spring oat area in South Dakota in mid-June. This was earlier than normal (3); however, the crop was at a more advanced growth stage than normal for this time of year, reducing the effect of early infection.

Data from the 1980 race survey are presented for the United States and four ecologic areas within it and for Mexico and Ontario (Table 1). Data from collections made from commercial fields and naturally occurring hosts are shown separately from those from nurseries and plots. No data were included from collections made in or near nurseries known to be inoculated with oat stem rust.

Race NA-27 continued to be the most abundant race (2,3), making up 78% of the 1,150 isolates in the United States (Table 1). In Mexico, NA-27 made up 68% of the 78 isolates from 33 collections studied. The second most prevalent race in both the United States and Mexico was NA-16, making up 11 and 28% of the isolates, respectively. NA-5 was also present in both countries, making up 4 and 9% of the isolates, respectively. The isolates from Ontario were different from those from Mexico and the United States, suggesting that the sexual state introduced the variation in virulence found in Ontario.

Uredia were collected from wild oats in California, Minnesota, North Dakota, South Dakota, and Washington. These 120 isolates from 50 collections consisted of race NA-27 (53% of the isolates), NA-16 (43%), and NA-5 (4%). Thus, NA-16 continued to be isolated more frequently (2,4) from uredial collections from wild oats than from commercial oats.

No cultures obtained from the United States or Mexico were virulent on oat lines with genes *Pg*-9, -13, -16, or -a in 1980 (Table 2). Virulences for *Pg*-9 and -13 were found in collections made in Ontario. Virulences for these two genes commonly exist in Ontario, the adjacent area 3, and the southern part of Texas (area 1) (2). Data are inadequate to ascertain whether this gene for virulence occurred in Mexico. All collections studied were avirulent on the lines in the "universally" resistant series, except the Canadian collections with virulence on *Pg*-13 that were virulent also on MN 730358. Thus, there was no major shift in race frequency in 1980 from those of the last 8 yr, nor were there any new genes for virulence found.

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