Races of *Puccinia graminis* f. sp. *avenae* in the United States and Mexico During 1981

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ABSTRACT

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Overwintering oat stem rust in southern Texas in 1981 produced a large quantity of inoculum. Subsequent infections occurred earlier in the year than normal in the north central states, but earlier than normal planting dates nullified much of the effect of an early disease onset. The 1,530 isolates from 555 uredial collections from the United States consisted of North American (NA) races NA-27, 95%; NA-16, 3%; and NA-5, 1%. No virulence was detected for oat lines with genes *Pg*-13, -16, and -a or the host lines Saia, S.E.S. Selection No. 52, Kyto, CI 9221, and X-1588-2 in the United States.

In recent years in the United States, oat stem rust caused by *Puccinia graminis* (Pers.) f. sp. *avenae* has caused little loss even though the most common race, NA-27, is virulent on most of the commercial oat (*Avena sativa* L.) cultivars (2). The date of onset of the disease has been correlated with losses produced in the north central states (2). This work is part of an ongoing program to monitor the disease and characterize pathogen virulence in an effort to minimize crop loss and to understand the dynamics of a continental plant pathogen.

MATERIALS AND METHODS

Field surveys were made over a 24,000-km route through the Great Plains and the Gulf Coast of the United States. The surveys followed a preselected, generally circular route through areas where small-grain cereals are important and rust has historically been a problem. Stops were made at a commercial field each 32 km or at the first field thereafter. Additional stops were made at experimental nurseries and trap plots along the route. Whenever rust was observed, including on wild oats (*Avena fatua* L.), a varying number of uredia-bearing leaves or stems from a single plant or cultivar were collected. These collections were supplemented by others furnished by cooperators throughout North America.

Upon receipt of uredial collections at the laboratory, two samples of spores were taken from each. One sample was used to inoculate 7-day-old seedlings of oat cultivar CI 7027 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 a single uredium or pruned to a single uredium, were saved and reincubated to germinate loose uredospores. Three to 4 days later, sufficient uredospores were collected separately from up to three uredia (each an isolate) to inoculate a differential host series consisting of oat lines with genes *Pg*-1, -2, -3, -4, -8, -9, -13, -15, -16, and -a (1). 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 (3,4).

Spores suspended in a light-weight mineral oil were sprayed on plants, which were then 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 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 the system of Martens et al (1).

The data from the United States were analyzed individually for the five ecological areas (Fig. 1), based on oat production, cultural practices, and geographic separation. Most of the collections from area 1 were obtained from winter oat nurseries in southern Texas. The collections from area 2 were from Oklahoma and those from area 5 were from Montana and New Mexico. The collections from area 3 were from the International Rust Nursery at University Park, PA. Infections in this nursery often result from aeciospores from barberry (*Berberis canadenis* L.) on which telia are artificially placed. Thus, these data may not be representative of area 3. Collections from area 4 were from throughout the area and were probably representative of the area. The collections from Mexico were from the states of Chihuahua, Durango, Tlaxcala, and Mexico.

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Table 1. Frequency of identified races of *Puccinia graminis* f. sp. *avenae* by area and source of collection in 1981

Area[a]	Source	Collections[b] (no.)	Isolates (no.)	Percentage of each North American physiologic race[c]				
				NA-5	NA-6	NA-16	NA-25	NA-27
United States total	Field	259	695	1	....	2	....	97
	Nursery	296	835	1	*[d]	4	*	94
	Total	555	1,530	1	*	3	*	95
1	Field	47	119	5	....	8	....	87
	Nursery	170	474	2	*	7	....	91
	Total	217	593	2	*	7	....	90
2	Field	6	16	6	....	....	....	94
3	Nursery	5	12	....	....	....	17	83
4	Field	205	557	*	....	1	....	99
	Nursery	119	343	*	....	1	....	99
	Total	324	900	*	....	1	....	99
5	Field	1	3	....	....	....	....	100
	Nursery	2	6	....	....	....	....	100
	Total	3	9	....	....	....	....	100
Mexico[e]	Nursery	31	86	5	....	1	....	94

[a] See Figure 1 for ecological areas in the United States.
[b] Uredia from a single field plant or cultivar received separately is a collection from which up to three single-pustule isolates were identified.
[c] From Martens et al (1).
[d] * = Less than 0.6% of the isolates.
[e] Collections made in the states of Chihuahua, Durango, Tlaxcala, and Mexico in September and October.

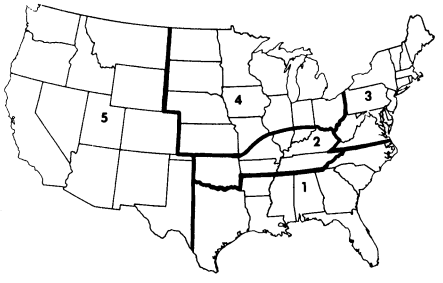

Fig. 1. Ecological areas for *Puccinia graminis* f. sp. *avenae* in the United States. Areas for oat stem rust: (1) winter oats, (2) mixed winter and spring oats, (3) spring oats and barberry, (4) major spring oat-producing area, and (5) widely isolated oat fields.

Table 2. Incidence of virulent oat stem rust isolates for the resistance of the single-gene differential lines in the 1981 survey

Area[a]	Percentage of isolates virulent on *Pg*[b]					
	1	2	4	8	9	15
United States total	99	96	96	99	*[c]	1
1	97	90	90	97	*	3
2	94	94	94	94	0	6
3	100	100	100	83	17	17
4	100	99	99	100	0	*
5	100	100	100	100	0	0
Mexico[d]	95	94	94	95	0	5

[a] See Figure 1 for ecological areas in the United States.
[b] All were virulent on *Pg*-3 and none were virulent on *Pg*-13, -16, and -a.
[c] * = Less than 0.6% of the isolates.
[d] Collections made in the states of Chihuahua, Durango, Tlaxcala, and Mexico in September and October.

RESULTS AND DISCUSSION

Oat stem rust was first observed on 6 April in a southern Texas nursery, 3 wk later than the 40-yr mean date (1941–1980) (2). By the end of the growing season, stem rust was widespread in Texas and caused losses in some fields. A vast quantity of inoculum produced in Texas presumably contributed to primary infections in the north central states first found on 11 June, which was 2 wk earlier than normal (2). The planting date in this area, however, was also 1–2 wk earlier than normal, which nullified much of the effect of the early disease onset. Losses occurred in only a few late-planted fields in the north central states.

Data from the 1981 race survey are presented for the United States, five ecological areas within the United States, and Mexico (Table 1). Data from collections made from commercial fields and naturally occurring hosts (principally wild oats) are shown separately for those from uninoculated nurseries and plots. No data were included from collections made in or near areas known to be inoculated with oat stem rust.

Race NA-27 continued to be the most abundant (3,4), making up 95% of the 1,530 isolates collected in the United States and 94% of the 86 isolates from Mexico (Table 1). Race NA-16 was the second most prevalent in the United States, comprising 3% of the isolates. Race NA-5 made up 1% of the isolates and was found in southern Texas early in the year, which is normal. Race NA-25 was found only in the Pennsylvania nursery believed to be infected by aeciospores from artificially inoculated barberries. In 1980, NA-25 was found on oats growing near barberry in Ontario, Canada (4).

No cultures obtained from the United States or Mexico in 1981 were virulent on oat lines with genes *Pg*-13, -16, or -a, but all cultures were virulent on *Pg*-3 (Table 2). Bulked uredospores from all collections were avirulent on the lines in the universally resistant series. Thus, there was no major shift in race frequency in the 1981 survey from the last 8 yr nor were any new combinations of virulences found.

LITERATURE CITED

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