Virulence of *Puccinia recondita* in Texas from 1988 to 1990

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ABSTRACT

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A total of 1,307 urediniospore isolates of *Puccinia recondita* were collected from the eight agroecological areas of wheat adaptation in Texas and characterized for virulence to a set of 14 Thatcher near-isogenic lines. Thirty-seven virulence combinations were detected. The most prevalent virulence phenotypes found were MFB-10 (virulent to *Lr*1, *Lr*3, *Lr*10, *Lr*24, and *Lr*26) and MDB-10 (virulent to *Lr*1, *Lr*3, *Lr*10, and *Lr*24), constituting 11 and 10% of the isolates, respectively. In all areas, virulence to *Lr*11, *Lr*24, and *Lr*26 increased, and virulence to *Lr*16 decreased. Fewer races were found in southern than in northern Texas. However, the southwest and south Texas areas had a higher proportion of isolates virulent to *Lr*9 and *Lr*30 than other areas.

Additional keywords: leaf rust

A major component of breeding for resistance to wheat leaf rust (caused by *Puccinia recondita* Roberge ex Desmaz.) is current knowledge of virulence in populations of the pathogen. An annual wheat leaf rust survey has been conducted in Texas since the spring of 1985 (12,14), in addition to the surveys conducted by the USDA-ARS Cereal Rust Laboratory (6–10) for many years. These surveys have shown the ability of *P. recondita* to adapt rapidly to specific host cultivars. Directional selection imposed by a resistant cultivar on the *P. recondita* population resulted in the 1984–1985 leaf rust epidemic in central Texas, when the grain yields of Probrand 812 were decreased by at least 40% (12). The leaf rust survey of 1985–1986 determined that 52% of all the isolates were virulent to *Lr*16 (the major leaf rust resistance gene present in Probrand 812). Virulence to *Lr*16 subsequently dropped to 18% in 1986–1987, following a reduction in the planted acreage of Probrand 812 (14).

Virulence to resistance gene *Lr*24 increased in Texas (14) and throughout the Great Plains of North America (2,8–10,15,18) from 1985 to 1987. This increase followed widespread planting of several cultivars, such as Collin, Siouxland, and TAM 200, each with *Lr*24 (14,19). It is clear (at least in the southern plains) that single, major-effect genes for leaf rust resistance have been rapidly overcome by matching virulence in the pathogen. Therefore, one of our goals at the Texas Agricultural Experiment Station is to develop wheat cultivars with durable resistance to leaf rust. Understanding the mechanisms and factors responsible for virulence changes in leaf rust populations is very important in breeding resistant cultivars.

The objective of this study was to describe the virulence of *P. recondita* in the eight agroecological areas of wheat adaptation in Texas in the 3-yr period from 1988 through 1990 and to compare these results with previous surveys.

MATERIALS AND METHODS

Urediniospores were collected in fields of commercial wheat (*Triticum aestivum* L.) once in the fall and twice in the spring of each crop year, beginning in the fall of the 1987–1988 growing season. The surveys followed a planned route, stopping at fields about every 32 km. The eight agroecological areas of wheat adaptation (Fig. 1) contained variable numbers of wheat fields, and therefore the total number of urediniospore collections varied in the eight areas. The eight areas differ in geographic and environmental characteristics, in sowing time for wheat, and somewhat in the cultivars grown.

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All collections were transported to the laboratory of the Texas Agricultural Experiment Station in Dallas, where the urediniospores were used to inoculate seedlings of the cultivar Thatcher (CI 10003) that had been treated with chlormequat chloride to obtain a more compact plant. After 12 days, a set of Thatcher near-isogenic lines (differentials) were inoculated with single-pustule isolates and placed in a dew chamber for a 14-hr dark period at 18 C. The 14 differentials used contained resistance genes *Lr*1, *Lr*2a, *Lr*2c, *Lr*3, *Lr*3ka, *Lr*9, *Lr*10, *Lr*11, *Lr*16, *Lr*17, *Lr*18, *Lr*24, *Lr*26, and *Lr*30 (17). After the plants were removed from the dew chamber, they were placed on greenhouse benches at temperatures ranging from 23 to 27 C. Infection types were recorded 10–12 days after inoculation. Avirulent reactions were classified as types ; (fleck), 0, 1, and 2, and virulent reactions as types 3 and 4 (4).

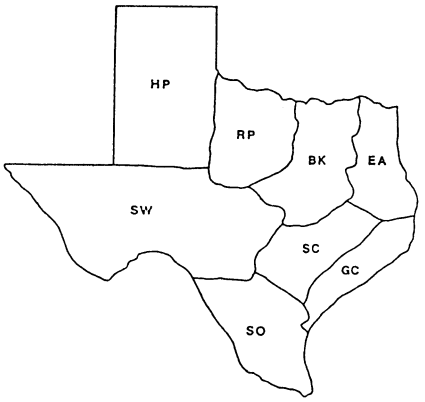

Fig. 1. Agroecological areas of wheat adaptation in Texas: BK = Blacklands, EA = east Texas, GC = Gulf Coast, HP = High Plains, RP = Rolling Plains, SC = south central Texas, SO = south Texas, and SW = southwest Texas.

RESULTS AND DISCUSSION

A total of 1,307 urediniospore isolates were characterized over the 3 yr of this study: 377 in 1987–1988, 444 in 1988–1989, and 486 in 1989–1990 (Table 1). Of these isolates, 30% came from the Blacklands, 17% from south central Texas, 15% from the Rolling Plains, 11% from east Texas, 11% from the Gulf Coast, 8% from the High Plains, 5% from southwest Texas, and 3% from south Texas.

The isolates were classified into 37 virulence combinations, grouped according to the *Prt* code (5); 32 races of *P. recondita* were found in the Blacklands, 31 in the Rolling Plains, 30 in the High Plains, 27 in south central and east Texas, 21 in the Gulf Coast, and 19 in southwest and south Texas. The two most prevalent phenotypes were MFB-10 (virulent to *Lr*1, *Lr*3, *Lr*10, *Lr*24, and *Lr*26) and MDB-10 (virulent to *Lr*1, *Lr*3, *Lr*10, and *Lr*24), constituting 11 and 10%, respectively, of the total number of isolates (Table 1). From 1985 to 1987, MDB-10 made up 10% of the isolates, and MFB-10 only about 1% (14). The most prevalent phenotype in the previous survey was MGB-10 (virulent to *Lr*1, *Lr*3, *Lr*10, and *Lr*16). From 1985 to 1987 this phenotype was found in about 16% of the collections, but in the present study it was found in only 1% of the collections.

Table 1. Virulence combinations of *Puccinia recondita* isolates on 14 differentials in Texas from 1988 to 1990

		Number of isolates per adaptation area[a] and year																							
		HP			RP			BK			SC			SW			EA			GC			SO			
Prt code	Virulence formula	88	89	90	88	89	90	88	89	90	88	89	90	88	89	90	88	89	90	88	89	90	88	89	90	Total
CBB-10	3,10	0	0	1	1	1	1	2	1	1	1	3	3	0	0	0	0	0	1	1	1	0	0	0	0	18
CBG	3,11	1	2	1	3	3	4	9	13	15	2	5	3	0	0	0	0	3	2	3	1	0	3	1	2	76
CBG-10	3,10,11	0	0	1	0	1	2	3	4	5	0	0	0	0	0	0	2	3	1	0	0	0	0	1	1	24
CCB-10	3,10,26	0	2	1	3	0	3	4	5	7	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	27
CDB	3,24	1	0	3	2	2	4	5	4	1	3	1	0	3	1	1	1	0	0	2	1	0	3	1	1	40
CDB-10	3,10,24	1	0	0	1	1	1	3	2	2	2	3	0	4	0	0	0	0	0	1	0	0	0	0	0	21
DBD-10	2c,10,17	2	4	2	2	2	0	1	0	0	0	0	0	2	3	3	0	0	1	0	0	0	0	0	0	22
FBL-18	2c,3,3ka,18	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
JCB	2a,2c,26	0	0	1	0	0	1	0	2	1	0	0	0	2	2	1	0	2	4	0	0	0	0	0	1	17
KBB-10	2a,2c,3,10	3	5	1	10	8	9	17	12	6	4	2	1	7	4	2	3	3	1	4	5	1	0	2	1	111
KBG-10	2a,2c,3,10,11	0	0	2	0	0	1	0	4	2	0	0	1	0	0	0	0	1	4	0	3	3	0	0	0	21
KDB-10	2a,2c,3,10,24	0	2	1	0	5	2	3	4	2	7	11	10	2	0	2	3	6	2	0	1	0	0	1	0	64
KFB-10	2a,2c,3,10,24,26	0	0	2	0	6	5	1	7	4	5	4	3	1	0	0	2	0	3	0	0	3	0	0	1	47
LBD-10,18	1,10,17,18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	0	0	0	6
LBG	1,11	0	0	1	0	1	1	0	2	1	0	2	3	0	0	0	2	4	2	0	0	1	0	0	0	20
MBB-10	1,3,10	0	0	0	0	0	1	4	6	3	0	0	1	0	0	0	3	0	0	0	0	0	1	1	0	20
MBD-10	1,3,10,17	2	3	1	4	0	1	2	1	4	3	2	0	0	0	0	1	0	0	3	1	6	0	0	0	34
MBD-10,18	1,3,10,17,18	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	1	2	2	2	2	2	0	1	1	16
MBG	1,3,11	0	0	1	2	3	4	4	8	11	2	5	8	0	1	3	0	1	2	0	0	1	1	0	0	57
MBG-10	1,3,10,11	0	3	4	5	8	6	3	9	12	2	3	3	0	0	0	2	1	1	0	1	1	0	0	0	64
MCB-10	1,3,10,26	0	0	2	0	1	3	0	2	6	1	4	6	0	0	0	0	2	2	5	6	9	0	2	1	53
MDB-10	1,3,10,24	0	2	1	0	3	6	14	16	17	7	6	13	0	1	3	4	5	4	7	7	11	1	1	2	131
MFB-10	1,3,10,24,26	2	5	6	6	6	9	13	17	15	5	4	4	0	0	2	4	7	6	8	9	11	0	1	1	141
MGB-10	1,3,10,16	2	0	0	2	0	0	4	1	1	6	1	0	0	0	0	0	0	0	1	1	0	0	0	0	17
MGB-10,18	1,3,10,16,18	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	2
MGG-10	1,3,10,11,16	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	4
PBM-18	1,2c,3,3ka,18,30	2	0	1	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	7
PBN-10	1,2c,3,3ka,10,17	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
PLM-18	1,2c,3,3ka,9,18,30	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0	0	1	0	1	6
TBB	1,2a,2c,3	1	0	0	0	2	0	1	1	2	0	0	0	0	0	0	0	1	1	1	2	2	0	0	0	14
TBB-10	1,2a,2c,3,10	3	1	3	3	2	0	2	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18
TBB-10,18	1,2a,2c,3,10,18	2	1	0	1	0	0	2	0	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	10
TBG	1,2a,2c,3,11	0	0	1	1	2	1	3	0	3	2	4	5	0	0	0	0	2	3	0	0	0	0	0	0	27
TBG-10	1,2a,2c,3,10,11	0	0	2	2	4	5	2	4	5	2	2	3	0	0	1	0	2	0	0	0	0	0	0	0	33
TBH-10	1,2a,2c,3,10,11,30	0	0	1	0	0	0	0	0	0	0	0	0	1	2	2	0	0	0	0	0	0	1	1	2	10
TDB-10	1,2a,2c,3,10,24	0	2	1	2	3	2	6	5	5	6	7	10	2	2	0	5	4	3	2	1	3	0	0	1	72
TFB-10	1,2a,2c,3,10,24,26	0	3	2	2	7	5	6	4	4	5	2	2	0	0	1	4	2	3	0	0	1	0	0	0	53
Total		23	35	43	53	72	76	116	136	140	68	73	81	27	19	22	37	52	50	41	43	57	12	14	17	1,307

[a]BK = Blacklands, EA = east Texas, GC = Gulf Coast, HP = High Plains, RP = Rolling Plains, SC = south central Texas, SO = south Texas, and SW = southwest Texas.

As in the previous survey (14), certain virulences tended to be more prevalent in particular agroecological areas than in others (Table 2). Virulence to *Lr*1 was most common along the Gulf Coast and least common in southwest Texas. The isolates from the southwest area also tended to have less virulence to *Lr*3, *Lr*11, and *Lr*26 and more virulence to *Lr*9 and *Lr*30 than isolates from most other areas. This higher virulence to *Lr*9 and *Lr*30 was also noted in the previous survey (14). A relatively high percentage of isolates virulent to *Lr*30 also was found in south Texas. Virulence to *Lr*16 was present in 7% of the isolates collected in south Texas, but in only 1% or less of the isolates from all other areas. The mean percentage of isolates virulent to *Lr*16 in all areas was just 1%, compared to 18% in 1985–1987 (Table 2). Long et al (8–10) found an increase in the number of isolates virulent to *Lr*16 from 1985 to 1986, followed by a decrease in 1987. In Canada, virulence to *Lr*16 was found in 12.8% of the isolates tested in 1984, but the percentage decreased to zero by 1989 (3). Researchers in Canada have recycled *Lr*16 into new wheat cultivars following reductions in virulence to the gene, which accompanied the removal of the cultivar Selkirk (16). A similar strategy of recycling *Lr*16—perhaps in combination with resistance genes that are expressed in the adult plant, such as *Lr*12 and *Lr*34 in Sturdy (1)—appears to warrant attention for wheat breeding in the southern plains of the United States, given the rapidity with which single *Lr* genes succumb to new races of *P. recondita* (13). Perhaps *Lr*16 could also be used in cultivar mixtures for leaf rust control in the southern plains. This strategy has been used successfully with other *Lr* genes (11).

Over the 5-yr period from 1985 to 1990, virulence to *Lr*11 increased from about 11 to 30% in Texas (Fig. 2). Virulence to *Lr*11 has been common in the eastern part of the United States for many years (6–10), but only recently has it increased in prevalence in the plains in the United States and the prairie regions of Manitoba and Saskatchewan (3). Over the same period in Texas, virulence to *Lr*16 became very rare, virulence to *Lr*26 steadily increased, and virulence to *Lr*24 increased until 1988 and then leveled off (Fig. 2). Similar trends have been found in the other areas of the U.S. plains (8–10) and in the Canadian Prairie Provinces (2,3).

Table 2. Isolates of *Puccinia recondita* virulent to near-isogenic lines of the wheat cultivar Thatcher in Texas from 1988 to 1990

	Percentage of isolates virulent to *Lr* genes:													
Area[a]	1	2a	2c	3	3ka	9	10	11	16	17	18	24	26	30
HP	60	40	51	90	4	0	84	21	0	15	6	34	26	4
RP	59	45	48	97	1	0	81	30	<1	4	1	40	27	1
BK	61	31	36	98	1	<1	77	31	<1	2	2	41	25	<1
SC	66	46	46	98	0	0	80	26	0	3	2	54	21	0
SW	41	51	71	81	7	4	72	7	1	12	10	37	13	15
EA	65	46	47	88	0	0	78	27	0	6	5	49	30	0
GC	79	23	23	96	0	0	90	10	0	14	7	48	37	0
SO	56	26	30	98	5	5	65	26	7	5	12	33	16	14
Mean	61	39	44	93	2	1	78	22	1	8	6	42	24	4
85–87[b]	66	36	43	92	5	1	79	13	18	8	15	24	4	5

[a]Wheat adaptation areas in Texas: BK = Blacklands, EA = east Texas, GC = Gulf Coast, HP = High Plains, RP = Rolling Plains, SC = south central Texas, SO = south Texas, and SW = southwest Texas.
[b]Mean percentage of isolates virulent to *Lr* genes during 1985–1987 (13).

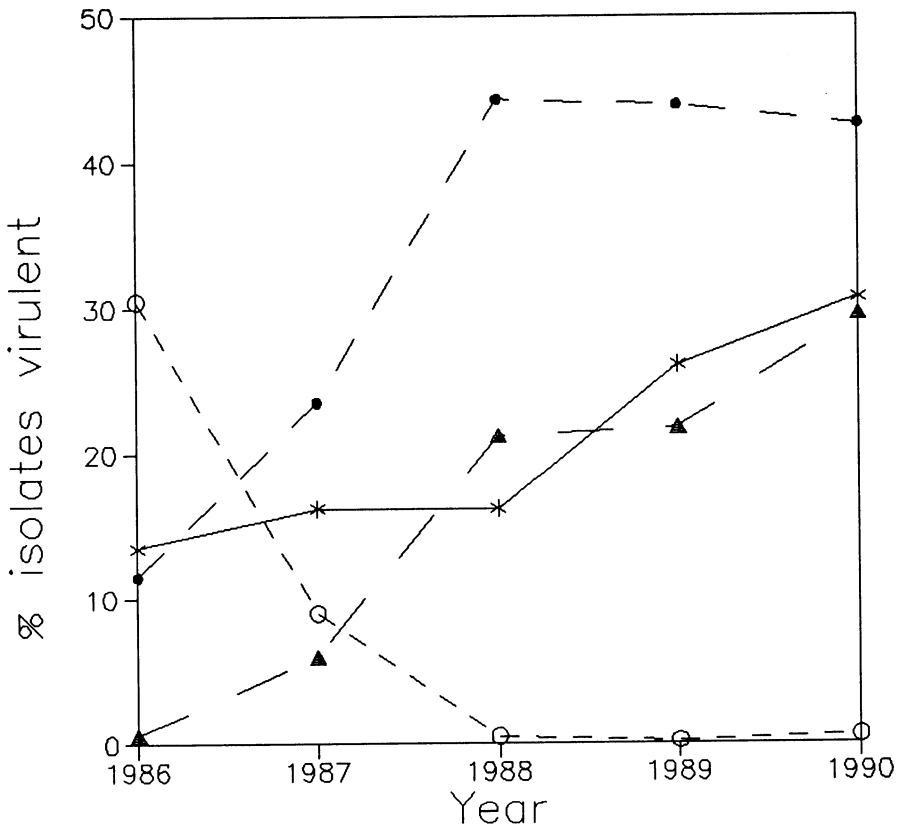

Fig. 2. Percentage of isolates of *Puccinia recondita* virulent to Thatcher near-isogenic lines containing leaf rust resistance genes *Lr*11 (*), *Lr*16 (○), *Lr*24 (●), or *Lr*26 (▲) in Texas during the 5-yr period from 1986 to 1990.

LITERATURE CITED

1. Dyck, P. L. 1991. Genetics of adult-plant leaf rust resistance in 'Chinese Spring' and 'Sturdy' wheats. Crop Sci. 31:309-311.
2. Kolmer, J. A. 1988. Physiologic specialization of *Puccinia recondita* f. sp. *tritici* in Canada in 1987. Can. J. Plant Pathol. 10:354-358.
3. Kolmer, J. A. 1990. Physiologic specialization of *Puccinia recondita* f. sp. *tritici* in Canada in 1989. Can. J. Plant Pathol. 12:428-430.
4. Levine, M. N., Ausemus, E. R., and Stakman, E. C. 1951. Wheat leaf rust studies at Saint Paul, Minnesota. Plant Dis. Rep. Suppl. 199.
5. Long, D. L., and Kolmer, J. A. 1989. A North American system of nomenclature for *Puccinia recondita* f. sp. *tritici*. Phytopathology 79:525-529.
6. Long, D. L., Schafer, J. F., and Roelfs, A. P. 1985. Specific virulence of *Puccinia recondita* f. sp. *tritici* in the United States from 1978 through 1983. Plant Dis. 69:343-347.
7. Long, D. L., Schafer, J. F., and Roelfs, A. P. 1986. Virulence and epidemiology of *Puccinia recondita* f. sp. *tritici* in the United States in 1984. Plant Dis. 70:395-397.
8. Long, D. L., Schafer, J. F., Roelfs, A. P., and Roberts, J. J. 1986. Virulence and epidemiology of *Puccinia recondita* f. sp. *tritici* in the United States in 1985. Plant Dis. 70:1107-1110.
9. Long, D. L., Schafer, J. F., Roelfs, A. P., and Roberts, J. J. 1988. Virulence of *Puccinia recondita* f. sp. *tritici* in the United States in 1986. Plant Dis. 72:22-24.
10. Long, D. L., Schafer, J. F., Roelfs, A. P., and Roberts, J. J. 1989. Virulence of *Puccinia recondita* f. sp. *tritici* in the United States in 1987. Plant Dis. 73:294-297.
11. Mahmood, T., Marshall, D., and McDaniel, M. E. 1991. Effect of winter wheat cultivar mixtures on leaf rust severity and grain yield. Phytopathology 81:470-474.
12. Marshall, D. 1988. Characteristics of the 1984–1985 wheat leaf rust epidemic in central Texas. Plant Dis. 72:239-241.
13. Marshall, D. 1989. National and international

breeding programs and deployment of plant germplasm: New solutions or new problems? Pages 182-203 in: Spatial Components of Plant Disease Epidemics. M. J. Jeger, ed. Prentice-Hall, Englewood Cliffs, NJ.
14. Marshall, D. 1989. Virulence of *Puccinia recondita* and cultivar relationships in Texas from 1985 to 1987. Plant Dis. 73:306-308.
15. Martens, J. W., and Dyck, P. L. 1988. Occurrence and virulence of *Puccinia recondita* in Canada in 1986. Can. J. Plant Pathol. 10:268-272.
16. Martens, J. W., and Dyck, P. L. 1989. Genetics of resistance to rust in cereals from a Canadian perspective. Can. J. Plant Pathol. 11:78-85.
17. Samborski, D. J. 1985. Wheat leaf rust. Pages 39-59 in: The Cereal Rusts. Vol. 2, Diseases, Distribution, Epidemiology, and Control. A. P. Roelfs and W. R. Bushnell, eds. Academic Press, Orlando, FL.
18. Samborski, D. J. 1986. Occurrence and virulence of *Puccinia recondita* in Canada in 1985. Can. J. Plant Pathol. 8:436-438.
19. Schafer, J. F., and Long, D. L. 1988. Relations of races and virulences of *Puccinia recondita* f. sp. *tritici* to wheat cultivars and areas. Plant Dis. 72:25-27.