Evidence for Dilatory Resistance to Anthracnose in Sorghum

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ABSTRACT

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Dilatory resistance to *Colletotrichum graminicola* and the latent period of anthracnose were evaluated on 10 sorghum genotypes in isolated plots in the United States and Brazil. There was a great variation among sorghum cultivars in the United States, and a large, but smaller, range of dilatory resistance was recorded on the sorghum genotypes in Brazil. Values of area under the disease progress curves from both locations were highly correlated. The dilatory resistance expressed in both locations was highly correlated to the latent period measured under greenhouse conditions.

Anthracnose, caused by *Colletotrichum graminicola* (Ces.) G.W. Wils. (syn. *C. sublineola* Henn. in Kab. & Bubák), reduces the yield of sorghum (*Sorghum bicolor* (L.) Moench) substantially and is particularly damaging in sorghum grown in warm, humid areas (2,8,9). Genetic control of anthracnose through host resistance has been transitory because of the high variability in populations of this pathogen (1,5,6,13). The instability of race-specific host resistance has promoted the search for more stable forms of resistance characterized by a slow rate of disease development (3,11,14,19,20). This type of resistance is expressed as a reduced infection frequency, a slower rate of development in the host, and a slower rate of spore production over a shorter period of time (15).

Dilatory resistance to *C. graminicola* was identified in commercial sorghum hybrids in a field test by Cardwell et al (4). The objectives of this study were to evaluate dilatory resistance to *C. graminicola* in 10 sorghum genotypes and to investigate the relationship of this type of resistance to the latency of *C. graminicola*.

MATERIALS AND METHODS

Ten sorghum genotypes that varied in levels of dilatory resistance to *C. graminicola* were selected from the 1989 All Disease and Insect Nursery planted in the Field Laboratory of Texas A&M University located near College Station. The genotypes were 85L5286, MR103-3, 88BD1997, B1, 850G4300-5, GR105-6, 86EO328, 87BH8606, Tx430, and B8610 (Table 1).

Evaluation of latent period. This study was conducted using the greenhouse facilities of the Department of Plant Pathology & Microbiology of Texas A&M University. Sorghum cultivars were planted in the greenhouse in a randomized complete block design with three replications of four or five plants per replication, and the experiment was repeated twice. A virulent isolate of *C. graminicola*, obtained in 1989 from the Field Laboratory at College Station, was used for the inoculation. Inoculum was obtained by flooding 7-day-old cultures, grown on oatmeal agar plates under continuous light at 25 C, with distilled water, dislodging the conidia with a scalpel, and passing the conidia through two layers of cheesecloth to separate mycelia. Tween 20 (3 drops per liter) was added to the spore suspension as a wetting agent. The inoculum was adjusted to 10^6 conidia per milliliter and applied on the leaf surface of 30-day-old plants with a hand sprayer. Plants were incubated for 18–20 hr in the dark at 24 C and 100% RH.

Latent period was measured as the number of days from inoculation until the appearance of acervuli observable with a 10× hand lens. Evaluations were made daily beginning 2 days following the inoculation by examining the fifth leaf from the primary leaf of four or five plants to obtain an average value for the latent period. Lesions were examined for the presence of conidia under a compound microscope.

Evaluation of dilatory resistance. Dilatory resistance was evaluated at College Station and at the National Corn and Sorghum Center of EMBRAPA (Empresa Brasileira de Pesquisa Agropecuária) in Sete Lagoas, Minas Gerais, Brazil. Plantings were done on 24 March 1990 and 2 February 1991.

A randomized complete block design with three replications was adopted in both locations. Cultivars were planted in single-row plots, separated by two rows of the resistant genotype SC283 to prevent interplot contamination. Field rows were 7 m long in College Station and 5 m long in Sete Lagoas and were 0.75 m apart with 5–10 cm between plants. Replications were isolated by a range of equivalent length planted with corn at College Station and with SC283 at Sete Lagoas.

Table 1. Pedigree of sorghum accessions used for characterization of dilatory resistance to anthracnose

Sorghum line	Pedigree
85L5286	(MR63-12-8*Tx2766)-1-BK-4
850G4300-5	[Gb430*(Sc170*4671)]
86EO328	[TAM428*(SC170)*4671)]
87BH8606	[Tx433*(SC748*SC630)]
88BD1997	Tx432*SC23
B1	(BTx625*B35)-HL19-HL9
B8610	[(Tx378*SC110-9)*Tx615]
GR105-6	[Tx430*(Tx2783*GR-263-1)]
MR103-3	(MR63-12-8*Tx2766a)-BK-15-1
Tx430	(Tx2536*SC23)der.

Table 2. Area under the disease progress curve (AUDPC) of anthracnose on 10 sorghum genotypes at College Station, Texas, measured at three distances from a source of inoculum

	AUDPC		
Sorghum line	0.5 m	3.0 m	6.0 m
86L5286	2,488.0 a[z]	1,030.0 a	902.3 a
MR103-3	1,606.0 b	726.8 b	699.9 b
850G4300-5	1,126.2 c	372.5 c	123.9 c
GR105-6	991.2 c	394.0 c	98.6 cd
B1	931.8 c	60.2 e	49.9 d
86EO328	633.8 d	68.8 e	17.5 d
Tx430	633.1 d	93.7 d	22.6 d
87BH8606	541.3 d	88.2 d	15.6 d
B8610	520.3 d	98.2 d	12.6 d
88BD1997	443.1 d	134.3 d	78.2 d

[z] Means followed by the same letter do not differ significantly at $P = 0.05$, according to Duncan's multiple range test.

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Inoculum was prepared as previously described for the greenhouse experiments. Inoculum was applied at College Station on the first 0.5 m of each row with a pressurized sprayer in the proportion of approximately 10 ml per plant. Inoculation at Sete Lagoas was done on 0.5-m spreader rows formed by the susceptible genotype Tx623 planted 0.5 m apart and in front of each block. Inoculum was applied at about 100 ml/m. In both locations, plants were inoculated at 60 days after planting with a spore suspension at the concentration of 10^6 conidia per milliliter. The same isolate used for the evaluation of the latent period in the greenhouse was applied in the field at College Station. At Sete Lagoas, a mixture in equal proportion of the Brazilian standard races 31C and 31H (6) was used. These races were chosen for their broad virulence spectrum to minimize possible expression of vertical resistance, as these genotypes were not previously evaluated for their vertical resistance against Brazilian races.

Disease severity was evaluated on a weekly basis starting 7 days after inoculation. Ratings were taken at three different locations within each plot: 0.5 and 3.0 m from the source of inoculum and at the end of the plot (6.0 and 5.5 m from the source of inoculum at College Station and Sete Lagoas, respectively). A scale for disease severity based on James (10) and Sharma (17) was used. For each location of evaluation, an area under the disease progress curve (AUDPC) was calculated (16).

Table 3. Area under the disease progress curve (AUDPC) of anthracnose on 10 sorghum genotypes at Sete Lagoas, Minas Gerais, Brazil, measured at three distances from a source of inoculum

Sorghum line	AUDPC		
	0.5 m	3.0 m	6.0 m
85L5286	2,163.5 a[z]	1,397.0 a	896.2 a
MR103-3	1,999.6 a	1,073.6 b	714.2 b
B1	1,047.1 b	440.5 c	183.6 ef
86EO328	1,031.3 b	401.5 c	197.6 e
87BH8606	936.3 b	473.2 c	128.4 f
Tx430	889.0 b	525.4 c	329.5 d
GR105-6	884.2 b	473.0 c	263.2 e
8506G4300-5	792.5 b	512.2 c	326.8 d
B8610	568.8 c	343.0 d	80.8 f
88BD1997	554.6 c	372.0 cd	430.5 c

[z] Means followed by the same letter do not differ significantly at $P = 0.05$, according to Duncan's multiple range test.

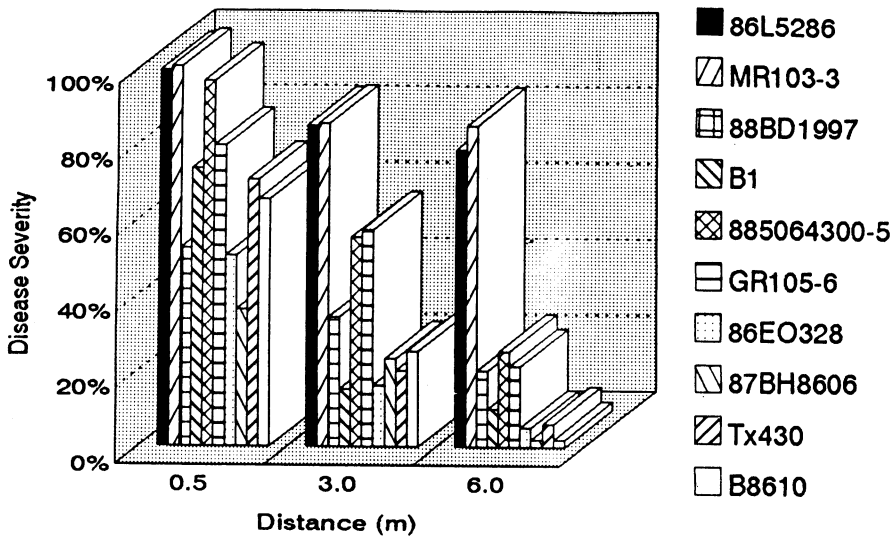

Fig. 1. Anthracnose severity on 10 sorghum genotypes evaluated in isolated plots at three distances from a source of inoculum at College Station, Texas.

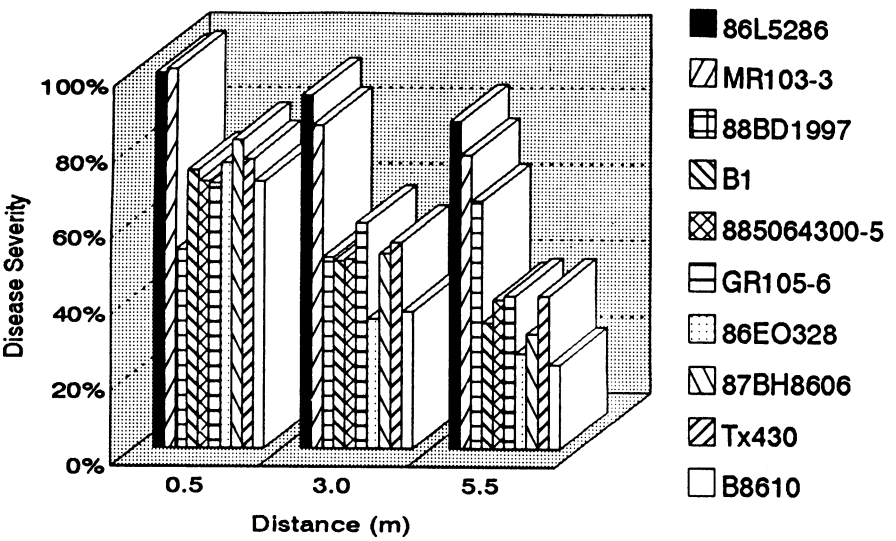

Fig. 2. Anthracnose severity on 10 sorghum genotypes evaluated in isolated plots at three distances from a source of inoculum at Sete Lagoas, Minas Gerais, Brazil.

RESULTS AND DISCUSSION

Cultivars showed no hypersensitive reaction to the isolates of *C. graminicola* used in Brazil and the United States. A large variation in the level of dilatory resistance was observed, as indicated by the values of AUDPC obtained for each sorghum genotype in the three distances of evaluation. An increase in the range for reaction to anthracnose among sorghum cultivars was recorded for each distance from the source of inoculum (Tables 2 and 3). Disease gradients from the closest to the furthermost points to the source of inoculum were steeper at College Station than at Sete Lagoas

Table 4. Average latent period of anthracnose, caused by *Colletotrichum graminicola*, measured in the greenhouse as the number of days from inoculation to the first appearance of sporulation on the inoculated leaves of 10 sorghum breeding lines

Sorghum line	Latent period (days)
87BH8606	9.67 a[z]
86EO328	9.50 a
Tx430	9.33 a
88BD1997	8.50 b
B1	8.50 b
B8610	8.50 b
850G4300-5	8.33 b
GR105-6	8.33 b
MR103-3	6.50 c
86L5286	6.00 c

[z] Means followed by the same letter do not differ significantly at $P = 0.05$, according to Duncan's multiple range test.

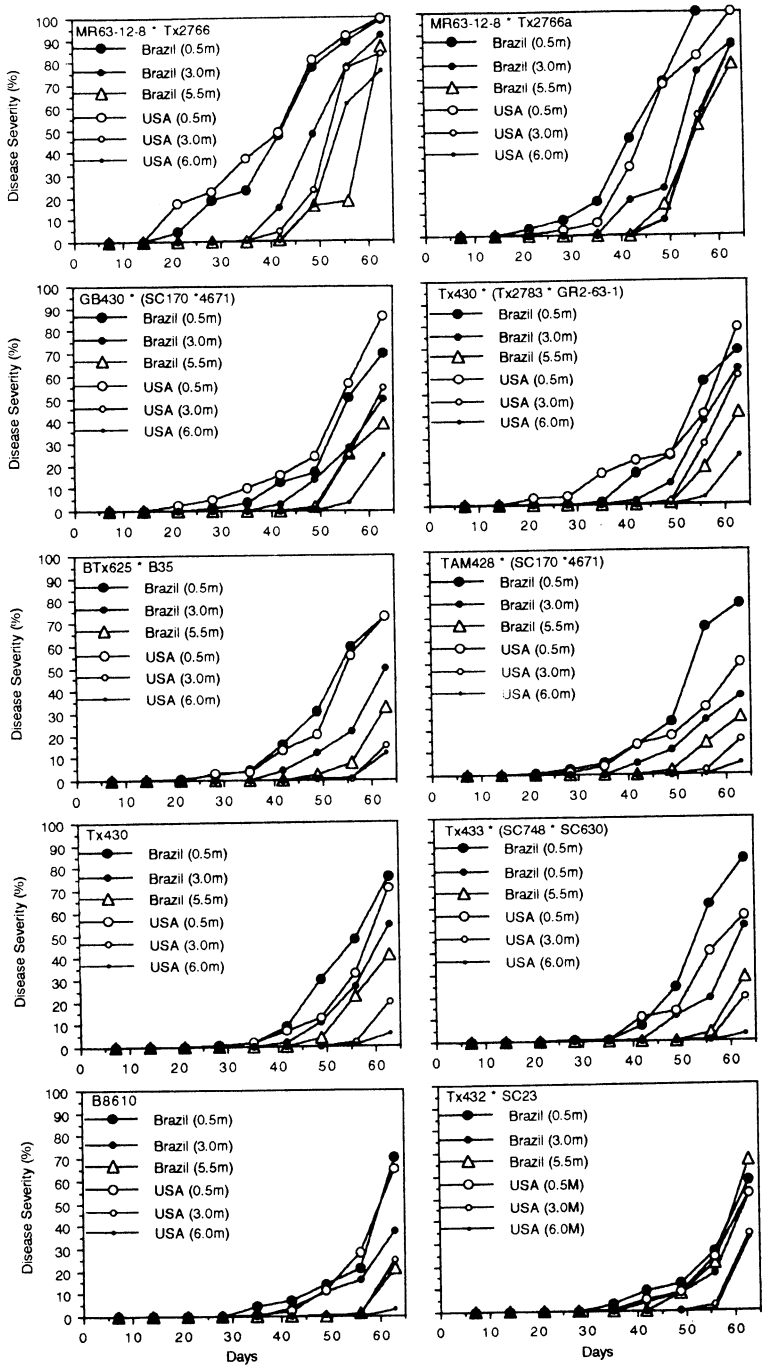

Fig. 3. Anthracnose progress curves on 10 sorghum genotypes evaluated in isolated plots at three distances from a source of inoculum at Sete Lagoas, Minas Gerais, Brazil, and College Station, Texas.

Table 5. Pearson correlation matrix between value of area under the disease progress curves (AUDPCs), measured in isolated plots, of 10 sorghum genotypes at three distances from a source of inoculum at two locations and between these values and the latent period of anthracnose, caused by *Colletotrichum graminicola*, measured under greenhouse conditions

	Factor						
Factor[z]	A	B	C	D	E	F	G
A	1.00						
B	0.95	1.00					
C	0.84	0.92	1.00				
D	0.90	0.95	0.86	1.00			
E	0.86	0.94	0.91	0.96	1.00		
F	0.94	0.98	0.94	0.94	0.96	1.00	
G	−0.82	−0.89	−0.91	−0.91	−0.94	−0.94	1.00

[z] A, B, and C = 0.5, 3.0, and 5.5 m, respectively, from the source of inoculum in plots at Sete Lagoas, Minas Gerais, Brazil; D, E, and F = 0.5, 3.0, and 6.0 m, respectively, from the source of inoculum in plots at College Station, Texas; G = latent period.

(Figs. 1 and 2). Even though differences in the amount of disease between locations were observed, a similar trend of anthracnose progress was observed at College Station and Sete Lagoas (Fig. 3). This was evidenced by the high correlation coefficient between AUDPC values at different distances of evaluation, both within and between locations. Differences in duration of latent period between cultivars were statistically significant. The most susceptible cultivars, 86L5286 and MR103-3, had the shortest latent periods (Table 4). AUDPCs were also highly correlated with the latent period of anthracnose measured in the greenhouse (Table 5).

The smaller range but greater anthracnose development among cultivars at Sete Lagoas than at College Station could be attributed to the reported presence of more aggressive races of the pathogen in Brazil than in the United States (7). It is also possible that some of these differences were determined by the use of a mixture of two races in Brazil, despite the fact that final inoculum concentration was the same at both locations. Even though differences in disease severity occurred and we used different isolates of the pathogen for creating epidemics, high correlation coefficients were obtained between the two locations, indicating that there was no significant cultivar × location interaction for dilatory resistance to *C. graminicola*.

The high correlation of the latent period to the level of dilatory resistance measured in Brazil and the United States is in agreement with observations obtained from other pathosystems in which the latent period has been found to be an important component of dilatory resistance (12,14,18,20). These data indicate that our method of evaluation may be helpful in selecting sorghum germ plasm for dilatory resistance to *C. graminicola* even in areas of high inoculum pressure, as is the case in Brazil.

Evaluation of the latent period in the greenhouse also promises to be helpful in the selection for this type of resistance. However, it would be useful to accumulate additional information on the latent period and its relationship to other components of dilatory resistance, since indications are that these components sometimes are not related (14,15). A precise characterization of these components would also have great value in the recognition of the genetic control of dilatory resistance to *C. graminicola*.

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