New sorghum leaf blight resistance sources: Identification, description and reactions of F_1 hybrids[1]

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ABSTRACT

Leaf blight [*Setosphaeria turcica* (Luttrell) Leonard & Suggs] limits sorghum [*Sorghum bicolor* (L.) Moench.] under sub-humid climates with moderate temperature. Under a severe leaf blight epidemic, 152 sorghum conversion lines were screened for resistance in Isabela, Puerto Rico, in 1985. Among all entries, a mean of 2.4 lesions per leaf was found. One or fewer lesions/leaf were found on 25 lines, 20 of which were not previously known for their leaf blight resistance. In late summer and early fall, resistant sources were crossed with leaf blight susceptible male sterile, ATx623 and TP24, used as females. Leaf blight reactions of the resistant sources (male parents), susceptible female parents (ATx623 and TP24), and F_1 hybrids (ATx623 × resistant sources and TP24 × resistant sources) were evaluated in spring 1986. The *t*-statistic showed highly significant ($P \leq 0.001$) differences between resistant male parents (0.4 lesions/leaf) and ATx623 and TP24, respectively. Significant ($P \leq 0.05$) difference was found between F_1 hybrids (0.9 lesions/leaf) and the male resistant sources (0.4 lesions/leaf). F_1 hybrids were significantly more resistant ($P \leq 0.01$) than both susceptible female populations. Susceptible female populations ATx623 and TP24 showed no significant difference in their leaf blight readings. More than 25% of leaf blight resistant sources had high seed astringency. Astringency was found in less than 10% of the original screening and was not found in female populations. Astringency appeared dominant in F_1 hybrids. Variability of resistant sources in morphology and origin, decreased resistance and increased variability of F_1 hybrids for leaf blight suggest genetic factors other than a sole dominant resistance allele are influencing leaf blight reactions in sorghum.

INTRODUCTION

Leaf blight (LB) by *Setasphaeria turcica* (Luttrell) Leonard & Suggs (St) is a major disease of sorghum [*Sorghum bicolor* (L.) Moench], maize (*Zea mays* L.), teosinte (*Euchlaena mexicana* Schrad.), and some wild grasses (10). In sorghum, quantitative estimates of LB losses are unavailable. In corn, losses exceeding 50% are recorded (6). In Florida, 13 applications of mancozeb fungicide were needed for leaf blight control on sweet corn (2). Considering the cost and inconvenience of chemical control, crop resistance appears the best strategy for LB control in sorghum.

[1] Manuscript submitted to Editorial Board October 20, 1986.

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In sorghum a single dominant gene for LB resistance was found in SC 0326 developed in Texas (7). Relying on single major genes for LB resistance can lead to emergence of races with virulence complicating disease control. Breakdown of the Ht gene for LB resistance in corn is already documented (3, 15). Conferring useful and durable resistance for long term crop improvement probably demands use of pyramiding appropriate major gene resistance and development of polygenic minor gene resistance (11). Diverse resistant sources with several resistance mechanisms need be identified and characterized to employ these strategies.

Because few sources of LB resistance are presently known or characterized in sorghum, we screened 152 newly converted sorghum lines for LB resistance under a severe field epidemic in Isabela, Puerto Rico, in 1985. We will report on the identity of 20 newly identified LB resistance sources, describe them, and give information on the expression of resistance in F_1 hybrids made by crossing LB susceptible male steriles with the LB resistant sources.

MATERIALS AND METHODS

The trials were planted in northwestern Puerto Rico in the Isabela substation of the Tropical Agriculture Research Station of the United States Department of Agriculture, Tropical Agriculture Research Station in Mayagüez. The substation offers a tropical oceanic environment approximately, lat. 18° N, at 128 m altitude. Climate is sub-humid with about 1.7 m annual precipitation. Winter-spring (December to May) mean temperatures vary from 22 to about 24° C, whereas summer temperatures range from 24 to 26° C. Leaf blight is epidemic only in the winter-spring season and disappears on all but the most susceptible sudangrasses during summer-fall.

Entries in the trial were 3- or 4-dwarf lines with photoperiod insensitivity newly developed for release by the sorghum conversion program (14). Lines were machine planted with a 2-row planter at a rate of 3 g seed/3 m row on 1-m row centers, January 15, 1985. Twenty-one days after planting entries were thinned to 10 to 15 plants/meter. Upwind (planted north to south) was ATx623 × greenleaf a highly LB susceptible sorghum × sudangrass forage hybrid (this was the disease starter). Every 10 rows, A_3 Tx398 (Martin) was planted north-south as a disease spreader. On March 27 and April 15, 1985, milk and physiologically mature stages, respectively, disease notes were taken on leaf blight and rust severity. A modified Elliot-Jenkins scale (0–5) expressed in mean number of lesions per leaf was used for leaf blight readings (5). Notes were taken on panicle density, leaf midrib color, seed size and color, awn presence, glume coverage, and seed astringency. Seed astringency was determined by noting bird avoidance and a confirmatory bite test. Other notes followed Sorghum Descriptor guidelines as outlined by IBPGR and ICRISAT (12). Entries showing leaf blight resistance were selected, bagged, and self-fertilized.

Resistant source, TP24, and ATx623 were planted in a crossing block July 25, 1985 to provide susceptible × resistant hybrids. ATx623 is a cytoplasmic male sterile with susceptibility to LB. TP24 is a sorghum population segregating for ms_3ms_3 genetic male sterility. Plants of TP24 were first selected for collapsed male sterile anthers. Then apical portions in flower were removed and panicles were bagged. Three to 7 days after bagging, pollen from the resistant source was transferred to the female TP24 plant. Pollen was collected by identifying plants at 10 to 20% anthesis and bagging them. On the subsequent morning, panicles were bent and shaken to disperse the pollen inside the bag. Pollen filled bags were removed and used to cover female plants of ATx623 or TP24 which were protected to avoid unwanted cross pollinations.

On February 1, 1986 experimental hybrids and the male and female parents were planted as for the first trial. Notes on LB were taken as before at milk stage (April 19, 1986) and parents and their hybrids were compared using the *t*-statistic. Variance of F_1's and male resistant sources were compared using the F-statistic.

RESULTS AND DISCUSSION

In spring 1985, a mean of 2.4 LB lesions/leaf was found over 152 entries screened. A majority of the entries were moderately to very susceptible (3 to 5 lesions/leaf). Fewer than 1 lesion/leaf was found on 25 entries. A_3 Tx398 planted periodically throughout the field showed a uniform disease reaction (3.1 ± 0.2). Twenty of the low LB entries were previously unknown for their resistance. Most resistance sources showed no LB lesions.

Leaf blight resistant sources varied greatly in seed color and size, panicle morphology and disease reactions (tables 1, 2). Open lax panicles and high coverage of seed by glumes show several of the sources are closely related to wild sorghums. To transfer disease resistance without unwanted traits, we may need genetic recombination and selection.

Seed astringency was detected by noting bird avoidance and confirming bitterness by a bite test. Six of the resistant sources showed high astringency. Astringency is associated with high levels of polyphenols which precipitate proteins of the mucous membrane of the mouth (1). Although less than 10% of screened entries were astringent, over 25% of the LB resistant sources showed this trait. Astringency can reduce preharvest seed germination and seed molds as well as birds; nevertheless, reduced performance of animals on sorghum diets and lower demand and prices for astringent sorghums are possible (4, 8, 9, 13). In this study, astringency appeared to be inherited as a simple dominant trait.

TABLE 1.—*Phenotypic characteristics of early combine converted tropical sorghums [*Sorghum bicolor *(L.) Moench] resistant to severe field epidemics of leaf blight by* Setosphaeria turcica *(Luttrell) Leonard & Suggs in Puerto Rico*

Sorghum conversion number	I.S. no.	Panicle[1] density	Glume[2] coverage	Awns[3] presence	Seed		
					Size[4]	Color[5]	Astringency[6]
0006	12526	O	50	+	MS	Br	−
0066	12575	O	35	−	MS	Wh	+
0098	12603	O	85	−	M	Wh	−
0100	12605	O	75	−	MS	Wh	−
0147	12638	SO	NA[7]	NA	NA	NA	NA
0166	12657	C	60	+	S	Br	+
0222	12683	NA	NA	NA	NA	NA	NA
0235	1058	SO	10	−	M	Pi	+
0258	1201	SC	NA	NA	NA	NA	NA
0291	7617	O	120	+	M	Wh	−
0303	3620	O	120	+	VS	Wh	−
0320	6882	C	20	−	L	Wh	−
0322	1309	SC	25	−	M	Pi	+
0333	3063	C	30	−	L	Br	−
0397	7536	C	75	−	ML	Ye	−
0418	1335	SC	15	−	ML	Wh	−
0566	7254	SO	35	−	L	Ye,Wh	−
0736	NA	C	20	−	S	Wh	−
0969	NA	C	15	−	M	Pi	+
0972	NA	C	15	−	M	Pi	+
0372	7452	SC	50	+	L	Ye	−
0388	7776	SC	60	+	L	Ye	−
0289	7534	O	120	+	ML	Wh	−
0062	12572	SC	35	−	M	Wh	−
0577	7241	C	60	−	MS	Ta	−

[1] O = Open; SO = Semi-open; SC = Semi-closed; and C = Closed.
[2] As percentage of seed diameter.
[3] + = with and − = without awns.
[4] L, ML, M, MS, S, and VS denote large, mod. large, medium, med. small, small, and very small sorghum seed, respectively.
[5] Br, Pi, Ta, Ye, and Wh denote brown, pink, tan, yellow, and white seeds, respectively.
[6] Based on bird avoidance and a bite test. + = astringent, and − = nonastringent sorghum grain.
[7] NA = No available data.

TABLE 2.—*Foliar disease severity ratings for early combine converted tropical sorghums showing leaf blight resistance in Puerto Rico*

Sorghum conversion number	I.S. no.	Disease severity		
		Leaf blight[1]	Rust[2]	Grey leaf spot[3]
0006	12526	0.0	1.5	2.5
0066	12575	0.0	3.0	0.0
0098	12603	0.0	2.5	NA[4]
0100	12605	0.0	3.0	2.0
0147	12638	0.0	1.0	NA
0166	12657	0.0	1.5	2.0
0222	12683	0.0	4.0	NA
0235	1058	0.0	2.0	4.0
0258	1201	0.5	1.5	NA
0291	7617	0.0	3.0	3.0
0303	3620	0.0	3.5	0.0
0320	6882	0.5	2.0	1.5
0322	1309	0.0	2.5	NA
0333	3063	0.0	2.0	0.0
0397	7536	0.5	1.5	NA
0418	1335	0.5	2.0	2.0
0566	7254	0.5	1.5	0.0
0736	NA	0.0	4.5	0.0
0969	NA	0.5	1.5	1.0
0972	NA	0.0	1.5	NA
0372	7452	0.5	3.0	4.0
0388	7776	0.5	2.5	1.5
0289	7534	0.0	5.0	3.0
0062	12572	0.0	1.0	3.0
0577	7241	0.0	3.0	1.5

[1] Modified Elliot-Jenkins scale expressed as estimated leaf blight lesions/leaf.

[2] Modified Peterson rust scale where 0 = no infection, 3 = 10% coverage and 5 = 24% coverage.

[3] Frederiksen disease scale where 3 = apparent economic damage, and 5 = maximum disease.

[4] No data.

Because of the high level of astringency in the LB resistant sources and the diverse effects of astringency on molds, birds, and even sorghum germination, studies of the possible pleiotropic effect of astringency on LB warrant attention.

Resistant sources (used as males), male steriles (ATx623 and TP24 used as females), and F_1 hybrids of these were evaluated for LB reaction during spring 1986. Leaf blight susceptible females, ATx623 and TP24, showed 2.2 and 2.6 lesions/leaf, respectively, with no statistically significant ($P \leq 0.05$) difference among their means. Both females showed significantly greater LB than male resistant sources (0.4 lesions/leaf; $P \leq 0.001$) and F_1 hybrids (0.9 lesions/leaf; $P \leq 0.01$). Compared to the male steriles, F_1 hybrids and male resistant sources showed 62 and 83% less LB, respectively.

Mean LB for F_1 hybrids (0.9 lesions/leaf) was significantly ($P \leq 0.05$) greater than that of male resistant sources (0.4 lesions/leaf). A comparison of the variances of LB readings for F_1 hybrids and male resistant source showed increased variance of the F_1 hybrids (F statistic; $P \leq 0.05$). Although LB resistance was mostly dominant, a sole completely dominant single allele for resistance to LB is not supported by all our data.

The increased association of seed astringency with resistance sources, the reduced resistance of F_1 hybrids compared to that of resistant sources, and the increased variability of F_1 hybrids compared to resistant sources, suggest that unidentified genetic loci and alleles other than the single dominant allele for LB discovered in SC0326 in Texas are influential as determinants of LB resistance in sorghum. Further study of newly identified LB resistant sources should yield information on previously unknown genes for LB resistance.

Texas workers found maternal influences affecting LB resistance in progeny of crosses with SC00326 (7). Elucidating modes of resistance to LB in sorghum should be helpful in developing durable LB control. This in turn should increase the range of sorghums to moderate temperature sub-humid regions where leaf blight severely limits production of susceptible sorghums particularly highly susceptible forage sorghums.

RESUMEN

Nuevas fuentes de resistencia al tizón foliar del sorgo

En la primavera de 1985, en la Finca de Isabela de la Estación de Investigaciones en Agricultura Tropical se estudiaron 152 líneas enanas insensitivas al fotoperiodismo con el propósito de identificar fuentes de resistencia al tizón foliar causado por *Setosphaeria turcica* (syn. *Helminthosporium turcicum*). Las líneas resistentes desarrollaron menos de una lesión por hoja, mientras que el híbrido ATx623 × Greenleaf (sorgo × pasto sudán), mostró de 5 a 15 lesiones del tizón foliar por hoja, el cual se utilizó como fuente inicial de inóculo. Para promover una infección uniforme, se establecieron hileras alternadas de la línea B Tx398, que produjo de 2 a 4 lesiones por hoja. En el otoño de 1985 se cruzaron 25 selecciones resistentes al tizón foliar con la línea androestéril ATx623 o TP-24 (estéril genético), como hembras. La resistencia al tizón foliar es dominante a base de la reacción de los híbridos. Las fuentes resistentes mostraron 0.5 lesiones; los híbridos 1.0 y las líneas ATx623 y TP-24, 2.2 y 2.6 lesiones por hoja, respectivamente. Pruebas estadísticas (*t-test*) mostraron que hubo diferencias (P = 0.05) entre las fuentes de resistencia utilizadas como machos y sus híbridos, con respecto a sus reacciones al tizón foliar. Éstas variaron (P = 0.01) de las reacciones de ATx623 y TP-24. No se observaron diferencias entre ATx623 y TP-24 con respecto al tizón foliar. Las fuentes de resistencia mostraron gran variabilidad en sus reacciones a otras enfermedades (es-

pecialmente roya) y en sus características morfológicas y agronómicas. La resistencia de 20 de las 25 líneas identificadas como resistentes no había sido informada anteriormente. Estas fuentes y su recombinaciones constituyen un banco valioso de germoplasma para mejorar sorgos graníferos y forrajeros para regiones donde el *tizón foliar* reduce *la calidad* y rendimiento de las cosechas causando daños económicos.

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