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Full Length Research Paper

Field evaluation of foliar anthracnose disease response for sorghum germplasm from the Matabeleland North Province of Zimbabwe

J. E. Erpelding

USDA-Agricultural Research Service, Tropical Agriculture Research Station, 2200 Pedro Albizu Campos Ave., Suite 201, Mayagüez, Puerto Rico 00680-5470, USA, Tel: (787) 831-3435, Fax: (787) 831-3386, Email: john.erpelding@ars.usda.gov

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Anthracnose occurs in most sorghum producing regions worldwide and the pathogen is highly variable; thus, additional sources of resistance are needed for sorghum improvement. To identify resistant sources, 41 sorghum accessions from the Matabeleland North Province of Zimbabwe were evaluated for foliar anthracnose disease response in Isabela, Puerto Rico during the 2006 and 2007 growing seasons. Eleven accessions showed a resistant response characterized by reddening of inoculated leaves and no acervuli development. Fourteen of the 30 accessions rated as susceptible showed a susceptible response within and between growing seasons. Four accessions rated as susceptible showed variation in disease response between growing seasons. In 2006, more accessions showed a susceptible response across replications, and infection of the flag leaf was more frequent; however, infection severity was greater for the susceptible accessions observed in 2007. Overall, in 2006 and 2007, infection severity was low and the majority of the accessions showed less than 10% infected leaf area. In addition to the accessions showing resistance, the accessions with low infection severity may benefit sorghum improvement programs.

Key words: *Colletotrichum sublineolum*, genetic resources, *Sorghum bicolor.*

INTRODUCTION

Anthracnose (*Colletotrichum sublineolum* P. Henn., Kabát and Bubák) is one of the most important diseases of sorghum (*Sorghum bicolor* (L.) Moench) and grain yield losses can exceed 50% (Harris et al., 1964; Thomas et al., 1996; Thakur and Mathur, 2000). The pathogen is capable of infecting all above ground tissue of the sorghum plant (Coleman and Stokes, 1954; Harris et al., 1964; Thakur and Mathur, 2000; Hess et al., 2002). Foliar infection is commonly observed and generally appears 30 - 40 days after seedling emergence. Anthracnose infection can occur at every stage of plant development (Thakur and Mathur, 2000), but infection before seed development can reduce grain fill resulting in greater yield losses. Disease symptoms appear as small circular, elliptical, or elongated lesions. For susceptible varieties, lesions can cover most of the leaf surface, resulting in leaf senescence and plant death. Acervuli (asexual fruiting bodies) appear as black spots in the center of the lesions and provide a source of inoculum for secondary infection.

Resistant varieties can be used to manage the disease; however, the pathogen is highly variable (Ali and Warren, 1987; Cardwell et al., 1989; Pande et al., 1991; Marley et al., 2001; Valério et al., 2005) and loss of host plant resistance has been observed (Rosewich et al., 1998). Pyramiding of resistance genes can be effectively used to increase the longevity of resistant genotypes, but additional sources of resistance are needed for sorghum improvement. Sorghum germplasm collections have been a major source of disease resistance genes utilized in plant breeding programs. Anthracnose resistant germplasm has been identified from sorghum collections from Mali, Mozambique, and Sudan (Erpelding and Prom, 2004; Erpelding et al., 2005; Erpelding and Prom, 2006). The sorghum collection from Zimbabwe may also be a source of anthracnose resistant germplasm. The objective of the study was to evaluate sorghum accessions for foliar anthracnose disease response under field conditions

to identify resistant accessions and to determine if this region would be a source of anthracnose resistant germplasm.

MATERIALS AND METHODS

Seed samples for 41 sorghum accessions from the Matabeleland North Province of Zimbabwe were obtained from the United States Department of Agriculture, Agricultural Research Service (USDA-ARS), Plant Genetic Resources Conservation Unit in Griffin, Georgia. The anthracnose evaluation was conducted at the USDA-ARS Tropical Agriculture Research Station in Isabela, Puerto Rico. The first evaluation was planted on March 2, 2006 and the second evaluation was planted on November 5, 2007. The accessions were planted in single rows, 1.8 m in length with 0.9 m row spacing, using a randomized complete block design with three replications. The experimental fields were surrounded by border rows of anthracnose susceptible genotypes. Fertilizer was applied at a rate of 560 kg ha^{-1} (15-5-10 NPK) at planting. Lorsban 15G (Chlorpyrifos) granular insecticide (Dow AgroSciences, Indianapolis, IN) was applied at a rate of 8 kg ha^{-1} at planting to prevent seed loss from fire ants. Supplemental irrigation was applied seven times after planting in 2006 and two times in 2007 prior to inoculation. No irrigation was applied after inoculation. Weeds were controlled with mechanical tillage and hand hoeing. Three sorghum accessions, NSL 4025, NSL 365745, and PI 533991, were included as anthracnose resistant control genotypes and four accessions, NSL 3848, PI 609151, PI 609251, and PI 609634, were included as susceptible control genotypes to evaluate disease response within and between evaluations. These accessions are maintained in the USDA-ARS sorghum collection (GRIN, 2006) and the susceptible accessions confer a highly susceptible response to anthracnose pathotypes present in Isabela, Puerto Rico.

Anthracnose infected leaf samples were collected at random from the research site before the evaluation to represent the pathotype population in Isabela, Puerto Rico. The preparation of anthracnose cultures, inoculation, and disease evaluation were as described by Erpelding and Prom (2006). Anthracnose inoculations were conducted 38 days after planting in 2006 and 39 days after planting in 2007. The anthracnose infection response was evaluated 31, 44, and 68 days after inoculation in 2006 and 32, 46, and 67 days after inoculation in 2007. The response to anthracnose infection was evaluated using a 1 - 5 rating scale based on disease response observed on inoculated leaves and disease progression on non-inoculated leaves (Erpelding and Prom, 2004). Plants rated as 1 or 2 show no acervuli development and are resistant. Susceptible plants showing acervuli development on inoculated leaves are rated as 3, 4, or 5. Highly susceptible plants rated as 5 show infection spreading to all leaves including the flag leaf. The predominant disease response was recorded for rows showing heterogeneity for infection response. The percentage of infected leaf area or disease severity was based on a visual rating of the susceptible plants in a row. Statistical analysis of the data was conducted using the disease severity from the final rating. The Statistix software package (Analytical Software, Tallahassee, FL) was used to conduct an analysis of variance.

RESULTS

The anthracnose field evaluation of 41 sorghum accessions from the Matabeleland North Province of Zimbabwe identified 11 accessions that showed a resistant response to anthracnose pathotypes in Isabela, Puerto Rico (Table 1). These accessions showed reddening of inoculated leaves within 30 days after inoculation and no acervuli development was observed on leaves during the final evaluation. No variation for infection response was observed within and between experiments for the 11 accessions rated as resistant. Fourteen accessions from the 30 accessions rated as susceptible showed a susceptible response across replications for the two evaluations. In 2006, a resistant response was observed for 14 accessions and 27 accessions were rated as susceptible. Twenty accessions rated as susceptible showed no variation for infection response across replications. Anthracnose infection of the flag leaf was observed for 13 accessions with five accessions showing a highly susceptible response across replications. For the 2007 evaluation, 12 accessions showed a resistant response with 29 accessions rated as susceptible. A susceptible response across replications was observed for 17 accessions with six accessions showing infection in the flag leaf. Only one accession in 2007 was rated as highly susceptible across the three replications. More susceptible accessions showed variation for infection response across replications in 2007, with seven accessions showing a susceptible response in two replications and five accessions showing a susceptible response in one replication. Four of the seven accessions that showed variation for infection response across replications in 2006 also showed variation for infection response across replications in 2007. Three accessions that showed a resistant response in 2006 were rated as susceptible in 2007. One accession rated as susceptible in 2006 showed a resistant response in 2007. These four accessions showing variation for infection response between growing seasons generally showed variation for infection response across replications within a growing season. All 41 accessions showed reddening of inoculation leaves within 30 days after inoculation. Lesion development with acervuli was observed within 50 days after inoculation for the accessions rated as susceptible.

Disease progression was generally slow for the 30 accessions rated as susceptible (data not shown). In 2006, only one accession showed a susceptible response across the three replications 31 days after inoculation and infection severity mean (ISM) was less than 1% for the accessions showing a susceptible response. The ISM increased to approximately 1.5% for the susceptible accessions 44 days after inoculation in 2006 and 15 accessions showed a susceptible response across the three replications. For the 2007 evaluation, two accessions showed a susceptible response across the three replications and ISM was also less than 1% for the accessions rated as susceptible 32 days after inoculation. Fourteen accessions showed a susceptible response across replications 46 days after inoculation in 2007 and ISM increased to approximately 1.5%.

Table 1. Anthracnose disease rating and severity for the 41 sorghum accessions from the Matabeleland North Province of Zimbabwe evaluated in Isabela, Puerto Rico during the 2006 and 2007 growing seasons.

	2006 Evaluation		2007 Evaluation	
Accession[1]	**Disease Rating[2]**	**Disease Severity[3]**	**Disease Rating**	**Disease Severity**
PI 527152	2	0.0^{a}	2	0.0^{a}
PI 527154	2	0.0^{a}	2	0.0^{a}
PI 527160	2	0.0^{a}	2	0.0^{a}
PI 527161	2	0.0^{a}	2	0.0^{a}
PI 527165	2	0.0^{a}	2	0.0^{a}
PI 527166	2	0.0^{a}	2	0.0^{a}
PI 527168	2	0.0^{a}	2	0.0^{a}
PI 527171	2	0.0^{a}	2	0.0^{a}
PI 527173	2	0.0^{a}	2	0.0^{a}
PI 527181	2	0.0^{a}	2	0.0^{a}
PI 527183	2	0.0^{a}	2	0.0^{a}
PI 527149	2\4\4	0.3^{a}	2	0.0^{a}
PI 527163	2	0.0^{a}	2\2\4	0.2^{a}
PI 527182	2	0.0^{a}	2\4\4	0.5^{a}
PI 527164	2	0.0^{a}	4	0.5^{a}
PI 527153	2\2\4	0.2^{a}	2\2\4	0.2^{a}
PI 527184	2\2\4	0.2^{a}	2\2\4	0.3^{a}
PI 527155	2\4\4	0.7^{ab}	2\2\4	0.3^{a}
PI 527169	4\5\5	7.0^{b-e}	2\2\4	6.7^{a-c}
PI 527180	2\4\4	0.5^{a}	2\4\4	2.0^{ab}
PI 527188	4	2.2^{a-c}	2\4\4	3.5^{ab}
PI 527189	4	1.0^{ab}	2\4\4	0.5^{a}
PI 527167	4\4\5	2.3^{a-c}	2\4\4	16.7^{cd}
PI 527177	4\4\5	5.3^{a-e}	2\4\4	0.7^{a}
PI 527185	4\5\5	3.7^{a-d}	2\4\4	13.3^{bc}
PI 527172	2\2\4	0.2^{a}	4	10.3^{a-c}
PI 527178	2\4\4	0.7^{ab}	4	5.3^{a-c}
PI 527159	4	0.7^{ab}	4	2.3^{ab}
PI 527174	4	0.8^{ab}	4	7.0^{a-c}
PI 527175	4	0.8^{ab}	4	5.0^{a-c}
PI 527176	4	0.8^{ab}	4	5.3^{a-c}
PI 527150	4\4\5	1.3^{a-c}	4	1.0^{a}
PI 527179	4\4\5	1.0^{ab}	4	8.3^{a-c}
PI 527156	5	7.0^{b-e}	4	8.3^{a-c}
PI 527162	5	10.3^{ef}	4	6.8^{a-c}
PI 527187	4	1.0^{ab}	4\4\5	4.0^{ab}
PI 527170	4\4\5	4.0^{a-e}	4\4\5	33.3^{e}
PI 527151	5	5.3^{a-e}	4\4\5	27.0^{de}
PI 527157	5	7.7^{c-e}	4\4\5	36.7^{e}
PI 527186	5	7.0^{b-e}	4\4\5	6.7^{a-c}
PI 527158	5	10.0^{de}	5	33.3^{e}
NSL 4025	2	0.0^{a}	2	0.0^{a}
NSL 365745	2	0.0^{a}	2	0.0^{a}
PI 533991	2	0.0^{a}	2	0.0^{a}
NSL 3848	5	7.0^{b-e}	5	36.7^{e}
PI 609151	5	16.7^{f}	5	70.0^{f}
PI 609251	5	90.0^{h}	5	90.0^{g}
PI 609634	5	26.7^{g}	5	76.7^{f}

[1]Plant introduction numbers for the sorghum accessions (GRIN, 2006). Accessions are arranged by disease response from resistant (rating = 2) to susceptible (rating = 4 or 5). Three anthracnose resistant control genotypes, NSL 4025, NSL 365745, and PI 533991, and four susceptible control genotypes, NSL 3848, PI 609151, PI 609251, and PI 609634, were included in the evaluation.
[2]The disease rating is based on a 1-5 scale (Erpelding and Prom, 2004) with resistant accessions rated as 1 or 2 and susceptible accessions rated as 3, 4, or 5. Accessions rated as 5 showed anthracnose infection in the flag leaf. Disease ratings for the three replications are presented for accessions showing variation for infection response between replications within an evaluation.
[3]Values represent the anthracnose disease severity mean for the three replications in each evaluation based on the percentage of infected leaf area observed for the susceptible plants within a row. Numbers followed by the same letters were not significantly different ($LSD_{0.05}$).

Infection severity for the susceptible accessions was lower in 2006 as compared to 2007 for the evaluation conducted approximately 70 days after inoculation (Table 1). In 2006, the ISM for the 27 accessions rated as susceptible was approximately 3% for the evaluation conducted 68 days after inoculation. No accessions showed an ISM greater than 10% in 2006. The ISM for the 29 accessions rated as susceptible in 2007 was approximately 10% for the evaluation conducted 67 days after inoculation. The ISM was greater than 10% for six accessions with four accessions showing an ISM greater than 25% for the 2007 evaluation. Infected severity was generally low for the accessions that showed variation for infection response within and between experiments. The ISM was less than 1% for the four accessions that were rated as susceptible in one growing season, but showed a resistant response in the other growing season.

The seven control genotypes included in the evaluation showed the expected infection response (Table 1). The three anthracnose resistant control genotypes, NSL 4025, NSL 365745, and PI 533991, showed the development of red spots on inoculated leaves within 30 days after inoculation and no lesion development with acervuli was observed during the final evaluation. A highly susceptible response was observed for the four anthracnose susceptible control genotypes, NSL 3848, PI 609151, PI 609251, and PI 609634, included in the evaluation. Infection of the flag leaf was observed within 50 days after inoculation for the susceptible control genotypes and senescence of inoculated leaves was observed during the final evaluation. Variation for infection severity between evaluations was also observed for the susceptible control genotypes. Infection severity was lower in 2006 with an ISM of 35% compared to an ISM of 68% in 2007 for the susceptible control genotypes. Infection of the flag leaf occurred more rapidly in 2007 and lesion development with acervuli was observed within 30 days after inoculation. PI 609251 showed the highest infection severity for both evaluations with infection of the flag leaf and senescence of inoculated leaves observed within 30 days after inoculation. Plant death and stalk breakage were also observed during the final evaluation for PI 609251.

DISCUSSION

Approximately 27% of the sorghum accessions from the Matabeleland North Province of Zimbabwe showed foliar anthracnose resistance in Isabela, Puerto Rico. This frequency of anthracnose resistant accessions is lower than the frequency reported in Mali (Erpelding and Prom, 2004) and Mozambique (Erpelding and Prom, 2006). Disease pressure may be lower in this region of Zimbabwe, thus reducing the selection for host plant resistance. However, disease severity was generally low for the susceptible sorghum accessions and no accessions were as severely infected as the susceptible control genotypes. Zimbabwe is considered a region with aggressive anthracnose pathotypes (Pande et al., 1994) and coevolution of the pathogen and host plant may favor selection of sorghum genotypes showing susceptibility, but with low infection severity. Thus, the accessions with low infection severity could also provide a mechanism of resistance for sorghum improvement. Pande et al. (1994) considered accessions with an infection severity of less than 6% as resistant. Infection severity mean was less than 6% for 20 accessions rated as susceptible and greenhouse screening could be used to further evaluate the disease response for these accessions. The 41 accessions were collected from farmer's fields and heterogeneity was observed for several traits within accessions; therefore, seed purification should be conducted before using the germplasm for disease resistance breeding.

Variation for disease response was observed for approximately 40% of the accessions included in the evaluation. Climatic conditions can significantly influence host plant response to anthracnose (Pande et al., 1994; Néya and Le Normand, 1998; Hess et al., 2002; Ngugi et al., 2002). Infection severity was greater in 2007 suggesting more favorable climatic conditions; however, more accessions showed infection of the flag leaf and no variation in the susceptible response across the three replications in 2006. For germplasm evaluation, field screening over multiple growing seasons provides an effective method to identify sources of anthracnose resistance. In this evaluation, 11 accessions rated as resistant in 2006 and 2007 were identified and only four accessions showed variation for infection response between growing seasons.

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REFERENCES

Ali MEK, Warren HL (1987). Physiological races of *Colletotrichum graminicola* on sorghum. Plant Dis. 71:402-404.

Cardwell KF, Hepperly PR, Frederiksen RA (1989). Pathotypes of *Colletotrichum graminicola* and seed transmission of sorghum anthracnose. Plant Dis. 73: 255-257.

Coleman OH, Stokes IE (1954). The inheritance of resistance to stalk red rot in sorghum. Agron. J. 46:61-63.

Erpelding JE, Prom LK (2004). Evaluation of Malian sorghum germplasm for resistance against anthracnose. Plant Pathol. J. 3: 65-71.

Erpelding JE, Prom LK, Rooney WL (2005). Variation in anthracnose resistance within the Sudanese sorghum germplasm collection. Plant Genet. Resour. Newsl. 141:1 1-14.

Erpelding JE, Prom LK (2006). Variation for anthracnose resistance

within the sorghum germplasm collection from Mozambique, Africa. Plant Pathol. J. 5: 28-24.
GRIN (2006). USDA-ARS National Genetic Resources Program, Germplasm Resources Information Network (GRIN). Online database. National Germplasm Resources Laboratory, Beltsville, MD, USA, 5 January 2006, http://www.ars-grin.gov/.
Harris HB, Johnson BJ, Dobson Jr. JW, Luttrell ES (1964). Evaluation of anthracnose on grain sorghum. Crop Sci. 4: 460-462.
Hess DE, Bandyopadhyay R, Sissoko I (2002). Pattern analysis of sorghum genotype x environment interaction for leaf, panicle, and grain anthracnose in Mali. Plant Dis. 86:1374-1382.
Marley PS, Thakur RP, Ajayi O (2001). Variation among foliar isolates of *Colletotrichum sublineolum* of sorghum in Nigeria. Field Crops Res. 69:133-142.
Néya A, Le Normand M (1998). Responses of sorghum genotypes to leaf anthracnose (*Colletotrichum graminicola*) under field conditions in Burkina Faso. Crop Prot. 17: 47-53.
Ngugi HK, King SB, Abayo GO, Reddy YVR (2002). Prevalence, Incidence, and severity of sorghum diseases in western Kenya. Plant Dis. 86: 65-70.
Pande S, Mughogho LK, Bandyopadhyay R, Karunakar RI (1991). Variation in pathogenicity and cultural characteristics of sorghum isolates of *Colletotrichum graminicola* in India. Plant Dis. 75: 778-783.
Pande S, Thakur RP, Karunakar RI, Bandyopadhyay R, Reddy BVS (1994). Development of screening methods and identification of stable resistance to anthracnose in sorghum. Field Crops Res. 38:157-166.
Rosewich UL, Pettway RE, McDonald BA, Duncan RR, Frederiksen RA (1998). Genetic structure and temporal dynamics of a *Colletotrichum graminicola* population in a sorghum disease nursery. Phytopathology 88:1087-1093.
Thakur RP, Mathur K (2000). Anthracnose. In Frederiksen RA, Odvody GN (eds) Compendium of Sorghum Diseases, The American Phytopathological Society, St. Paul, MN, USA, pp. 10-12.
Thomas MD, Sissoko I, Sacko M (1996). Development of leaf anthracnose and its effect on yield and grain weight of sorghum in West Africa. Plant Dis. 80:151-153.
Valério HM, Resende MA, Weikert-Oliveira RCB, Casela CR (2005). Virulence and molecular diversity in *Colletotrichum graminicola* from Brazil. Mycopathologia 159:449-459.