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Field Assessment of Anthracnose Disease Response for the Sorghum Germplasm Collection from the Mopti Region

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Abstract: Problem statement: Sorghum anthracnose (*Colletotrichum sublineolum*) is a highly variable pathogen and new sources of host plant resistance are required for the development of resistant sorghum varieties. Germplasm collections are an important source of host plant resistance and screening germplasm will be essential to identify new sources of resistance. **Approach:** The sorghum (*Sorghum bicolor*) collection from the Mopti region of Mali was inoculated with *Colletotrichum sublineolum* and evaluated for foliar anthracnose disease response in Isabela, Puerto Rico during the 2004 and 2005 growing seasons using a partially balanced lattice design with three replications. **Results:** A resistant response was observed for 45 of the 97 accessions in the collection and mean infection severity for the 52 susceptible accessions was 27.6%. An association was observed between resistance and the administrative district where the germplasm was collected. More than 50% of the accessions from the Bandiagara and Bankass districts showed a resistant response. The lowest frequency of resistant germplasm was observed for the Mopti district with 25% of the accessions showing a resistant response. The susceptible accessions from the Mopti district, however, showed the lowest mean infection severity. Approximately 44% of the accessions from the Douentza district showed a resistant response with the susceptible accessions showing the highest mean infection severity. These results suggest an association between annual rainfall and anthracnose resistance, with sorghum accessions from drier regions showing greater susceptibility. Anthracnose resistance also showed an association with sorghum race classification and race guinea accessions were more frequently resistant as compared to accessions classified as race durra or durra-bicolor. **Conclusion:** The results indicated that anthracnose resistant sorghum germplasm is frequent in the Mopti region of Mali and that ecogeographic origin and sorghum characterization information can be used to aid in germplasm selection or germplasm acquisition to identify anthracnose resistant sources.

Key words: *Colletotrichum sublineolum*, genetic resources, host plant resistance, *Sorghum bicolor*, West Africa

INTRODUCTION

Anthracnose is considered one of the most destructive diseases for sorghum (*Sorghum bicolor* (L.) Moench) production due to the rapid development of the disease on susceptible cultivars. *Colletotrichum sublineolum* (P. Henn. in Kabat and Bubák) is the fungal pathogen responsible for sorghum anthracnose (Crouch *et al*., 2006) and was first reported in Togo, West Africa in 1902 (Thakur and Mathur, 2000). The disease occurs worldwide, but is more commonly observed in tropical or subtropical environments where frequent rainfall, high relative humidity and warm temperatures enhance the development and spread of the disease (Casela *et al*., 2001; Hess *et al*., 2002; Marley *et al*., 2001; Néya and Le Normand, 1998; Ngugi *et al*., 2002; Thakur and Mathur, 2000; Thomas *et al*., 1996; Valério *et al*., 2005). In the United States, anthracnose is more prevalent in the Southern Plains and Southeastern States (Rosewich *et al*., 1998; Ali and Warren, 1987; Cardwell *et al*., 1989). Sorghum anthracnose will typically appear on infected leaves approximately 30 to 40 days after seedling emergence; although, infection can occur at every stage of plant development. Anthracnose infection can be observed on all above ground tissues of the sorghum plant, including the leaf, stalk, panicle and seed (Hess *et al*., 2002; Thakur and Mathur, 2000). Foliar infection is more commonly observed and can be a source of inoculum for infection of other tissues. Typical

symptoms include circular, elliptical, or elongated lesions depending on host plant response. During sporulation of the fungus, acervuli, asexual fruiting bodies, will appear as black spots in the center of the lesions on susceptible cultivars.

Grain yield losses from foliar anthracnose infection are typically associated with a reduction in grain size as the infection will affect grain development. Yield losses greater than 50% may occur under epidemic conditions (Thakur and Mathur, 2000). In experimental evaluations, grain yield losses ranging from 30-67% have been report (Ali *et al*., 1987; Thomas *et al*., 1996). In Puerto Rico, grain yield losses of 100% have been observed for highly susceptible sorghum germplasm accessions with plant death occurring prior to flowering. The disease can be successfully managed through the use of resistant cultivars. However, the long-term durability of resistant cultivars is hindered by variation in virulence within the pathogen population (Ali and Warren, 1987; Cardwell *et al*., 1989; Marley *et al*., 2001 Pande *et al*., 1991; Thakur and Mathur, 2000; Valério *et al*., 2005). Pyramiding of resistance genes can aid in the development of resistant cultivars, but additional sources of resistance are needed for sorghum improvement.

The United States Department of Agriculture, Agricultural Research Service, National Plant Germplasm System (USDA-ARS, NPGS) sorghum collection is a valuable resource for the identification of new sources of anthracnose resistance. The NPGS maintains more than 43,000 sorghum accessions and field evaluation of germplasm from the collection has successfully identified anthracnose resistant sources (Erpelding and Prom, 2006; Erpelding and Wang, 2007). An anthracnose evaluation of a subset of sorghum germplasm from the Mali collection indicated resistance was frequent in this collection (Erpelding and Prom, 2004); however, it is unknown if resistance was associated with specific ecogeographic regions of Mali. Therefore, an anthracnose field evaluation was conducted for sorghum landraces from the Mopti region of Mali. The objectives of the anthracnose evaluation were: (1) determine the frequency of anthracnose resistance for the sorghum landraces from the Mopti region and (2) determine if resistance was associated with ecogeographic origin and sorghum phenotypic characteristics.

MATERIALS AND METHODS

Ninety-seven landraces from the Mopti region of Mali maintained in the NPGS sorghum collection were identified using available passport information and seed samples were obtained from the USDA-ARS Plant Genetic Resources Conservation Unit, Griffin, Georgia. Three anthracnose resistant control genotypes, NSL 365745, PI 148097 and SC748-6 and six susceptible control genotypes, PI 257599, PI 276842, PI 561472, PI 564163, PI 609251 and PI 609634, were included in the evaluation. PI 609251 was also included in the evaluation as a non-inoculated control. The anthracnose field evaluations were conducted at the USDA-ARS Tropical Agriculture Research Station in Isabela, Puerto Rico. The first evaluation was planted on 6 July 2004 with the second evaluation planted on 7 March 2005 using a partially balanced lattice design with three replications. The 97 sorghum accessions and 10 controls were planted in single rows 1.8 m in length with 0.9 m row spacing. A border row of anthracnose susceptible genotypes was planted around each experimental field. At planting, fertilizer was applied at a rate of 560 kg ha^{-1} (15-5-10 NPK) and to prevent seed loss from fire ants, Lorsban 15G (Chlorpyrifos) granular insecticide (Dow AgroSciences, Indianapolis, IN) was applied at a rate of 8 kg ha^{-1}. Supplemental irrigation was applied after planting for stand establishment and three times before inoculation for the evaluation conducted in 2004 and five times before inoculation for the evaluation conducted in 2005. No irrigation was applied after inoculation. Weeds were controlled with mechanical tillage.

The anthracnose inoculum used for disease evaluation was prepared from anthracnose infected sorghum leaves randomly collected from research plots in Isabela, Puerto Rico before establishment of experiments to represent the pathotypes present at the research location. Preparation of anthracnose cultures, field inoculation and disease evaluation were as described by Erpelding and Prom (2006). Plants were inoculated with anthracnose-colonized sorghum seed 37 days after planting in 2004 and 33 days after planting in 2005. Anthracnose infection response was evaluated at 18, 31, 56 and 81 days after inoculation in 2004. The third and final evaluations were delayed by a tropical storm and the evaluations were conducted after the plants recovered. Field evaluations in 2005 were conducted at 35, 48 and 63 days after inoculation. Anthracnose infection response 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). Resistant plants were rated as 1 or 2, moderately susceptible plants as 3, susceptible plants as 4 and highly susceptible plants as 5. Plants rated as 1 showed no disease symptoms and plants rated as 2 showed reddening of inoculated leaves and no acervuli development. Susceptible plants showed the development of acervuli on inoculated leaves with chlorotic lesions observed on plants rated as 3 and necrotic lesions observed on plants rated as 4 or 5. Plants

rated as 4 showed infection spreading to non-inoculated leaves with infection observed on most leaves including the flag leaf for plants rated as 5. The percentage of infected leaf area was also determined for the susceptible accessions during the final evaluation, with infection severity based on a visual estimate of leaf infection for the susceptible plants within a row. Statistical analysis was conducted on the disease severity data from the final evaluation using the Statistix software package (Analytical Software, Tallahassee, FL).

RESULTS

The anthracnose disease response for the 97 sorghum accessions from the Mopti region of Mali is presented in Table 1. A resistant response was observed for 53 accessions in 2004 with 44 accessions rated as susceptible. A highly susceptible response was observed for 28 accessions and 10 susceptible accessions showed variation for infection response across replications. In 2004, the mean infected leaf area was 28.2% for the 44 susceptible accessions. For the 2005 anthracnose evaluation, 47 accessions showed a resistant response with 50 accessions rated as susceptible. A highly susceptible response was observed for 38 accessions and variation for infection response across replications was observed for nine accessions. Infection severity was greater in 2005, with a mean infected leaf area of 31.8%. Eight accessions rated as resistant in 2004 showed a susceptible response in 2005 with three accessions showing a susceptible response across replications. For the 10 susceptible accessions that showed variation for infection response across replications in 2004, seven showed a susceptible response across replications in 2005, two were rated as resistant and one showed variation for infection response across replications. For the nine accessions that showed variation for infection response across replications in 2005, five were rated as resistant in 2004, three showed a susceptible response across replications and one accession showed variation for infection response across replications. Infection severity was generally lower for the accessions that showed variation for infection response within and between experiments. Overall, 79% of the accessions showed a similar infection response in 2004 and 2005, with 45 accessions rated as resistant, 31 accessions rated as susceptible and one accession showing variation across replications for both evaluations. All accessions showed reddening or red spots on inoculated leaves within 7 days after inoculation and the majority of the susceptible accessions, 81%, showed acervuli development on inoculated leaves within 30 days of inoculation (data not shown). Nearly 30% of the susceptible accessions showed acervuli formation on inoculated leaves 12 days after inoculation for the 2004 evaluation.

Table 1: Anthracnose disease response for the 97 sorghum accessions from the Mopti region of Mali inoculated with *Colletotrichum sublineolum* and evaluated for foliar infection in Isabela, Puerto Rico during the 2004 and 2005 growing seasons

	2004		2005			
Accession[a]	Disease rating[b]	Disease severity[c]	Disease rating	Disease severity	District[d]	Race[e]
PI 609624	2	0.0a	2	0.0a	Bandiagara	Bicolor
PI 609621	2	0.0a	2	0.0a	Bandiagara	Durra
PI 609177	2	0.0a	2	0.0a	Bandiagara	Durra
PI 609622	2	0.0a	2	0.0a	Bandiagara	Guinea
PI 609183	2	0.0a	2	0.0a	Bandiagara	Guinea
PI 526132	2	0.0a	2	0.0a	Bandiagara	Guinea
PI 609184	2	0.0a	2	0.0a	Bandiagara	Guinea
PI 526130	2	0.0a	2	0.0a	Bandiagara	Guinea
PI 609182	2	0.0a	2	0.0a	Bandiagara	Guinea
PI 585873	2	0.0a	2	0.0a	Bandiagara	Guinea
PI 585872	2	0.0a	2	0.0a	Bandiagara	Guinea
PI 609173	2	0.0a	2	0.0a	Bandiagara	Guinea
PI 609161	2	0.0a	2	0.0a	Bankass	Durra
PI 609168	2	0.0a	2	0.0a	Bankass	Durra
PI 609165	2	0.0a	2	0.0a	Bankass	Guinea
PI 609159	2	0.0a	2	0.0a	Bankass	Guinea
PI 585870	2	0.0a	2	0.0a	Bankass	Guinea
PI 609171	2	0.0a	2	0.0a	Bankass	Guinea
PI 609164	2	0.0a	2	0.0a	Bankass	Guinea
PI 585862	2	0.0a	2	0.0a	Bankass	Guinea
PI 585869	2	0.0a	2	0.0a	Bankass	Guinea
PI 609169	2	0.0a	2	0.0a	Bankass	Guinea
PI 609170	2	0.0a	2	0.0a	Bankass	Guinea
PI 609166	2	0.0a	2	0.0a	Bankass	Guinea
PI 609167	2	0.0a	2	0.0a	Bankass	Guinea
PI 609776	2	0.0a	2	0.0a	Douentza	Durra
PI 609138	2	0.0a	2	0.0a	Douentza	Durra-Bicolor
PI 609139	2	0.0a	2	0.0a	Douentza	Durra-Bicolor
PI 585846	2	0.0a	2	0.0a	Douentza	Durra-Bicolor
PI 609136	2	0.0a	2	0.0a	Douentza	Guinea
PI 609143	2	0.0a	2	0.0a	Douentza	Guinea
PI 585621	2	0.0a	2	0.0a	Douentza	Guinea
PI 608871	2	0.0a	2	0.0a	Douentza	Guinea
PI 609777	2	0.0a	2	0.0a	Douentza	Guinea
PI 609778	2	0.0a	2	0.0a	Douentza	Guinea
PI 609780	2	0.0a	2	0.0a	Douentza	Guinea
PI 585844	2	0.0a	2	0.0a	Douentza	Guinea
PI 609154	2	0.0a	2	0.0a	Douentza	Guinea
PI 585845	2	0.0a	2	0.0a	Douentza	Guinea
PI 609148	2	0.0a	2	0.0a	Douentza	Guinea
PI 609137	2	0.0a	2	0.0a	Douentza	Guinea
PI 609779	2	0.0a	2	0.0a	Douentza	Guinea-Bicolor
PI 585841	2	0.0a	2	0.0a	Mopti	Guinea
PI 609129	2	0.0a	2	0.0a	Mopti	Guinea
PI 609132	2	0.0a	2	0.0a	Mopti	Guinea
PI 585865	2	0.0a	2\2\4	0.2a	Bankass	Guinea
PI 585868	2	0.0a	2\2\5	1.7a	Bankass	Guinea
PI 609162	2	0.0a	2\4\4	0.3a	Bankass	Guinea
PI 526107	2	0.0a	2\4\4	0.3a	Bankass	Guinea
PI 585840	2	0.0a	2\4\4	1.8a	Mopti	Guinea
PI 609147	2	0.0a	4	0.7a	Douentza	Guinea
PI 585848	2	0.0a	4\4\5	5.3ab	Douentza	Durra-Bicolor
PI 609146	2	0.0a	4\5\5	25.0d-f	Douentza	Durra-Bicolor
PI 609130	2\2\4	3.3a-c	2	0.0a	Mopti	Guinea
PI 585852	2\4\5	6.7a-d	2	0.0a	Douentza	Durra
PI 609128	2\4\5	1.8ab	2\2\4	0.2a	Mopti	Guinea
PI 609176	2\2\4	1.7ab	4\4\5	10.7a-d	Bandiagara	Guinea

PI 585849	2\4\4	13.3a-f	4\4\5	2.3a	Douentza	Durra-Bicolor
PI 585843	2\4\4	2.0ab	4\4\5	7.2a-c	Mopti	Guinea
Table 1: Continued						
PI 609174	2\2\4	6.7a-d	4\5\5	13.7a-d	Bandiagara	Guinea
PI 609774	2\4\4	3.7a-c	5	40.0f-h	Douentza	Durra
PI 609150	2\4\4	10.3a-e	5	53.3g-k	Douentza	Durra
PI 609141	2\5\5	10.0a-e	5	7.3a-c	Douentza	Durra-Bicolor
PI 585842	4	3.8a-c	2\4\4	0.5a	Mopti	Guinea
PI 585871	4	25.0e-i	5	36.7e-g	Bandiagara	Guinea
PI 585866	4	40.0i-l	5	46.7g-i	Bankass	Guinea-Caudatum
PI 585863	4	16.7a-g	5	46.7g-i	Bankass	Durra
PI 609144	4	2.0ab	5	40.0f-h	Douentza	Durra-Bicolor
PI 609142	4	18.3b-g	5	43.3gh	Douentza	Guinea
PI 609179	4\5\5	11.7a-e	4	3.8ab	Bandiagara	Durra-Bicolor
PI 609623	4\4\5	40.0i-l	4\4\5	8.5a-d	Bandiagara	Guinea-Caudatum
PI 609134	4\4\5	25.3e-i	4\5\5	5.3ab	Mopti	Guinea
PI 609145	4\5\5	20.0c-h	4\5\5	23.7c-f	Douentza	Durra-Bicolor
PI 609178	4\4\5	20.3c-h	5	10.0a-d	Bandiagara	Guinea
PI 609163	4\4\5	15.0a-f	5	70.0k-m	Bankass	Durra
PI 585867	4\4\5	36.7h-l	5	46.7g-i	Bankass	Durra
PI 609181	4\5\5	50.0k-n	5	70.0k-m	Bandiagara	Caudatum
PI 609180	4\5\5	15.0a-f	5	20.0b-e	Bandiagara	Guinea
PI 609160	4\5\5	23.3d-i	5	20.0b-e	Bankass	Durra
PI 585864	4\5\5	36.7h-l	5	56.7h-l	Bankass	Durra
PI 609775	4\5\5	33.3g-k	5	70.0k-m	Douentza	Durra
PI 585851	4\5\5	43.3j-m	5	75.0m	Douentza	Durra
PI 609140	4\5\5	40.0i-l	5	50.0g-j	Douentza	Guinea
PI 609131	5	18.3b-g	2\4\4	0.3a	Mopti	Guinea
PI 609172	5	30.2f-j	2\4\5	8.5a-d	Bandiagara	Guinea
PI 585847	5	20.0c-h	4	4.2ab	Douentza	Durra-Bicolor
PI 585861	5	26.7e-j	4\4\5	4.0ab	Bankass	Guinea
PI 609175	5	60.0m-o	5	46.7g-i	Bandiagara	Durra
PI 585850	5	40.0i-l	5	63.3i-m	Douentza	Durra
PI 612772	5	63.3n-o	5	53.3g-k	Douentza	Durra-Bicolor
PI 585853	5	40.0i-l	5	63.3i-m	Douentza	Durra
PI 609149	5	63.3n-o	5	66.7j-m	Douentza	Durra-Bicolor
PI 609152	5	73.3o	5	73.3l-m	Douentza	Durra-Bicolor
PI 609153	5	66.7n-o	5	70.0k-m	Douentza	Durra-Bicolor
PI 609151	5	43.3j-m	5	70.0k-m	Douentza	Durra
PI 609135	5	66.7n-o	5	75.0m	Mopti	Durra
PI 609133	5	53.3l-n	5	76.7m	Mopti	Guinea

[a]: NPGS plant introduction number for the 97 sorghum accessions. Sorghum accessions are arranged by anthracnose infection response from resistant (rating = 2) to susceptible (rating = 4 or 5); [b]: Anthracnose disease rating for the accessions is based on a 1-5 scale (Erpelding and Prom, 2004). Resistant accessions are rated as 2, susceptible accessions are rated as 4 and highly susceptible accessions are rated as 5. Data from the three replications is presented when variation was observed across replications; [c]: Anthracnose disease severity is based on the percentage of infected leaf area averaged across replications for the susceptible plants within a row. Numbers followed by the same letters are not significantly different ($LSD_{0.05}$); [d]: Administrative districts for the Mopti region where sorghum landraces were collected; [e]: Phenotypic races of sorghum used to classify the landraces from the Mopti region

A similar infection response was observed in 2004 and 2005 for the nine inoculated control genotypes included in the evaluation (data not shown). The three resistant controls, NSL 365745, PI 148097 and SC748-6, showed reddening of inoculated leaves and no acervuli formation was observed during the final evaluation. The susceptible controls, PI 257599, PI 276842, PI 561472, PI 564163, PI 609251 and PI 609634, were rated as highly susceptible in 2004 and 2005. Infection severity for the susceptible controls was greater in 2004 with a mean infected leaf area of 79% compared to a mean infected leaf area of 46% observed in 2005. The inoculated and non-inoculated control genotype, PI 609251, showed a similar infection severity within and between growing seasons. Acervuli development was observed within 30 days on inoculated leaves for the susceptible controls in 2005. In 2004, the presence of acervuli on inoculated leaves for the susceptible controls was observed for the evaluation conducted 12 days after inoculation and disease rapidly progressed to non-inoculated leaves with the controls rated as susceptible or highly susceptible 31 days after inoculation.

The Mopti region is divided into eight administrative districts, Bandiagara, Bankass, Djenne, Douentza, Koro, Mopti, Tenenkou and Youvarou and sorghum landraces from the Bandiagara, Bankass, Douentza and Mopti districts are maintained in the NPGS sorghum collection (Table 1). Approximately 54% of the sorghum accessions from the Bandiagara and Bankass districts showed a resistant response with a similar infection severity for the susceptible accessions observed for the two districts. Mean infected leaf area was 24.4% for the susceptible accessions from the Bandiagara district and 22.3% for the susceptible accessions from the Bankass district. Approximately 44% of the accessions from the Douentza district showed a resistant response and 40% of the landraces evaluated for the sorghum collection from the Mopti region were from the Douentza district. Mean infected leaf area was 35.2% for the susceptible accessions from the Douentza district. For the Mopti district, 25% of the accessions showed a resistant response and mean infected leaf area was 19.3% for the susceptible accessions. Approximately 12% of the landraces included in the anthracnose evaluation were from the Mopti district. The differences in disease severity for all accessions from the four districts, however, were not significant.

Bankass is the southern-most district and would receive the highest annual rainfall for the region. The frequency of anthracnose resistant accessions and the infection severity for the susceptible accessions from the Bankass district was similar to the drier, northern Bandiagara district. Annual rainfall for the Mopti district would be similar to the Bandiagara district;

although, the lowest frequency of anthracnose resistant accessions was observed for the Mopti district. However, the susceptible accessions from the Mopti district showed the lowest infection severity. The Douentza district receives the lowest annual rainfall in the Mopti region. The highest infection severity for the susceptible accessions was observed for landraces from the Douentza district. A lower frequency of anthracnose resistant landraces was also observed for the Douentza district.

The landraces from the Mopti region were classified into seven sorghum phenotypic races (Table 1). A small number of landraces were classified as bicolor, caudatum, guinea-bicolor and guinea-caudatum and thus no comparisons could be made for these races. Race durra accessions showed greater disease severity with a mean infected leaf area of 42.6%. Only five of the 20 race durra accessions showed a resistant response. Race durra accessions were present in the germplasm collections from the four administrative districts, but were more frequent in the collections from the Bankass and Douentza districts. Mean infection severity for the race durra accessions was similar between the four administrative districts, but infection severity was generally higher for the durra landraces from the Douentza district. Sorghum landraces that were classified as race durra-bicolor also showed greater disease severity with a mean infected leaf area of 31.2%. Three of the 15 landraces classified as race durra-bicolor showed a resistant response and nearly all race durra-bicolor accessions were collected from the Douentza district. More than 60% of the durra and durra-bicolor landraces were rated as highly susceptible. Race guinea accessions were the most frequent and comprised approximately 59% of the accessions from the Mopti region. Approximately 61% of the race guinea accessions showed a resistant response and mean infected leaf area was 13.4% for the susceptible race guinea accessions. The mean infection severity was significantly lower for the race guinea accessions as compared to the race durra and durra-bicolor accessions. Race guinea accessions were present in the collections from the four administrative districts, but nearly all accessions from the Mopti district were classified as race guinea and more than 65% of the accessions from the Bandiagara and Bankass districts were race guinea. The Douentza district had the lowest frequency of race guinea accessions with approximately 38% of the accessions classified as race guinea. Also, the highest mean infection severity, 25.5%, was observed for the race guinea accessions from the Douentza district; whereas, the lowest mean infection severity, 3.6%, was observed for the race guinea accessions from the Bankass district. Additionally, most of the accessions that showed variation for infection response within and between experiments were classified as race guinea. The race guinea accessions from the Mopti region can be further classified into two sorghum working groups, guineense and margaritiferum (data not shown). Anthracnose resistance was more frequently associated with guineense landraces. Approximately 72% of the guineense landraces showed a resistant response as compared to 31% of the margaritiferum landraces. Infection severity was similar for the susceptible guineense and margaritiferum landraces with a mean infected leaf area of 10.9% for the guineense landraces and a mean infected leaf area of 15.0% for the margaritiferum landraces; however, the guineense landraces were significantly more resistant than the margaritiferum landraces. The lowest mean infection severity, 0.6%, was observed for the four susceptible guineense landraces from the Bankass district. In comparison, mean infection severity was 15.2% for the six susceptible guineense landraces from the Mopti district.

DISCUSSION

Approximately 46% of the landraces from the Mopti region showed a resistant response suggesting that this region of Mali could be an important source of anthracnose resistant germplasm. The Mopti region receives less than 800 mm of annual rainfall (Hess *et al*., 2002). Several studies have indicated that anthracnose infection severity is greater in regions receiving higher annual rainfall (Hess *et al*., 2002; Néya and Le Normand, 1998; Ngugi *et al*., 2002); thus, selection pressure may favor a higher frequency of anthracnose resistant germplasm in these wetter regions. Presumably, sorghum landraces from regions receiving low annual rainfall, such as the Mopti region, would show greater disease severity and a lower frequency of anthracnose resistant germplasm. Mean infection severity for the susceptible accessions was 27.6% and nearly 40% of the accessions were rated as highly susceptible with approximately 54% of the accessions showing susceptibility to anthracnose infection. Even though a greater percentage of the landraces from the Mopti region showed anthracnose susceptibility, the frequency of anthracnose resistant landraces in the collection would suggest resistance is being maintained in the germplasm from this region of Mali. This may suggest that climatic conditions favorable for the pathogen could occur in the Mopti region contributing to a higher frequency of anthracnose resistance in the

sorghum landrace population. It is also possible that sorghum landraces introduced from other regions more favorable for anthracnose disease development would have contributed to the greater frequency of resistance observed for the landraces. Additionally, the greater frequency of anthracnose resistance that is being maintained in the landrace collection from a region of low annual rainfall may contribute genetic diversity for disease resistance.

Although latitude and longitude passport information is lacking, the data that is available would suggest an association between disease response and ecogeographic origin, with anthracnose resistant accessions more frequently observed in regions receiving higher annual rainfall. However, the overall drier climatic conditions and lower variation in annual rainfall may influence selection for anthracnose resistance for the sorghum landraces cultivated in this region. The acquisition of additional sorghum germplasm from the Mopti region would enhance the ecogeographic assessment of anthracnose resistance for this region.

The results of this study would also suggest an association between resistance and sorghum race classification. Durra landraces are generally associated with regions receiving low annual rainfall. Compact panicles with large, white seed are common characteristics of race durra and these traits are also associated with higher susceptibility to grain mold, as such, durra landraces are commonly grown in regions where rainfall is infrequent during seed maturation. If selection pressure for anthracnose resistance is lower in drier regions, then race durra accessions should show greater susceptibility to anthracnose as was observed in this study. In contrast, race guinea accessions are typically associated with regions receiving higher annual rainfall. Selection pressure for anthracnose resistance should be greater in the wetter regions and race guinea accessions should show a greater frequency of anthracnose resistance with lower infection severity observed for the susceptible accessions. The majority of the race guinea accessions from the Mopti region showed a resistant response and infection severity was significantly lower for the susceptible guinea accessions suggesting greater selection for anthracnose resistance.

CONCLUSION

Anthracnose resistant germplasm was frequent in the sorghum collection from the Mopti region, even though this is a drier region of Mali. Additionally, resistance was associated with ecogeographic origin and sorghum race classification, which could be successfully used to select germplasm for anthracnose evaluation to increase the likelihood of identifying a greater frequency of resistant accessions.

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