American Journal of Plant Sciences, **2012, 3, 125-129**
http://dx.doi.org/10.4236/ajps.2012.31014 Published Online January 2012 (http://www.SciRP.org/journal/ajps)

Response of Sorghum Accessions from Four African Countries against *Colletotrichum sublineolum*, Causal Agent of Sorghum Anthracnose

Louis K. Prom[1], John Erpelding[2], Ramasamy Perumal[3], Thomas Isakeit[4], Hugo Cuevas[5]

[1]USDA-ARS, Southern Plains Agricultural Research Center, College Station, USA; [2]USDA-ARS, Mid South Area, Crop Genetics Research Unit, Stoneville, USA; [3]Western Kansas Agricultural Research Center, Kansas State University, Hays, USA; [4]Department of Plant Pathology and Microbiology, Texas A&M University, College Station, USA; [5]USDA-ARS, Tropical Agriculture Research Station, Mayaguez, Puerto Rico.
Email: louis.prom@ars.usda.gov

Received October 13th, 2011; revised November 9th, 2011; accepted November 29th, 2011

ABSTRACT

Seventy-two sorghum accessions were randomly selected from the Ethiopia, Mali, Sudan, and Uganda germplasm collections maintained by the US National Plant Germplasm System to evaluate variation in anthracnose resistance. The accessions were planted in a randomized complete block design in College Station, Texas during the 2007 and 2008 growing seasons. Twenty-six accessions exhibited a resistant response across growing seasons with 8 accessions showing a susceptible response. Twenty-nine accessions showed variation in disease response within and between experiments. Seven accessions were rated as resistant in 2007 but showed a susceptible reaction in 2008. The frequency of resistant germplasm varied based on country of origin with 80% of the accessions from Mali, 48% of the accessions from Uganda, 24% of the accessions from Sudan, and 7% of the accessions from Ethiopia exhibiting a resistance response. When the same accessions were evaluated in Isabela, Puerto Rico, 100% of the accessions from Mali, 43% of the accessions from Uganda, and 28% of the accessions from Sudan exhibited a resistant response. All the accessions from Ethiopia were susceptible to anthracnose when evaluated in Isabela, Puerto Rico. In both locations, 22 accessions exhibited a resistant response. Four accessions rated as resistant in Texas were found to be susceptible in Puerto Rico; whereas, five accessions rated as resistant in Puerto Rico showed a susceptible response in Texas. These results indicated that the Mali, Sudan, and Uganda sorghum collections may be an important source of anthracnose resistance. However, the identification of anthracnose resistant germplasm from many diverse regions could result in the identification of new sources of genetic variation for resistance. Also, greater genetic variation for resistance could be present in regions with a high frequency of resistant germplasm.

Keywords: Sorghum; Anthracnose; *Colletotrichum sublineolum*; Disease Response; Germplasm

1. Introduction

Sorghum anthracnose, caused by *Colletotrichum sublineolum* P. Henn., Kabát & Bubák, is one of the most destructive foliar diseases and, presently, it is found in most sorghum growing regions [1-5]. The pathogen infects all above-ground parts of the plants with infection of leaves more commonly observed as compared to infection of the stalks and panicles. Foliar infection can occur at any stage of plant development, but symptoms are generally observed 40 days after seedling emergence [5]. The symptoms on the leaves will depend on the type of cultivar planted and environmental conditions. Symptoms can range from small, circular or elliptical spots to elongated necrotic lesions with abundant acervuli formation [5]. Under severe conditions, the pathogen will cause premature defoliation and thereby delaying the development of the plant [5]. Panicle infection phase of the disease affects both the quality and quantity of the grain [5]. Grain yield losses of up to 50% may occur under severe foliar infection on susceptible cultivars; whereas panicle infection can result in losses ranging from 30% - 50% [3,5,6]. Yield loss is primarily due reduction in grain number and size [5]. The occurrence of different pathotypes and levels of pathogenicity within the pathogen population require the identification of additional sources of resistance [1-3,7]. Thus, the objectives of this study were to evaluate subsets of sorghum accessions collected from four African countries to identify new sources of anthracnose resistance and to determine if

Copyright © 2012 SciRes.

resistance was associated with country of origin.

2. Materials and Methods

Seventy-two sorghum accessions were randomly selected from the germplasm collections of four African countries, which included 14 accessions from Ethiopia, 10 accessions from Mali, 25 accessions from Sudan, and 23 accessions from Uganda. Seed samples for the evaluation were obtained from the USDA-ARS, Plant Genetic Resources Conservation Unit, Griffin, Georgia. BTx623 was included as a susceptible control and SC748-5 was the resistant control genotype. The anthracnose evaluation was conducted during the 2007 and 2008 growing seasons at the Texas AgriLIFE Experiment Station, College Station, Texas and also at the USDA-ARS, Tropical Agriculture Research Station in Isabela, Puerto Rico. Accessions were planted in a randomized complete block design, with each accession replicated three times. Seed was planted in 6 m rows at 0.31 m spacing between rows. Field preparation included fall plowing and incorporation of the compound fertilizer at 175 kg N/ha, and 116.5 kg/ha for both P_2O_5 and K_2O. An additional 175 kg N/ha was applied as top dressing five weeks after planting. To control weeds and seedling insects, a pre-emergent insecticide "Counter 20 CR" (BASF Group, Southfield, MI) and herbicide "Atrazine" (Syngenta Crop Protection Inc. Greenboro, NC) were applied before planting. In Isabela, Puerto Rico, each accession also replicated three times was planted in a single row of 1.8 m in length with 0.9 m spacing. A border row of an anthracnose susceptible genotype (PI 561472) was planted around the experimental fields. Fertilizer was applied at a rate of 560 kg/ha (15-5-10 NPK) during planting. Lorsban 15G (Chlorpyrifos) granular insecticide (Dow AgroSciences, Indianapolis, IN) was applied at a rate of 8 kg/ha during planting to prevent seed loss from fire ants. Weeds were controlled with mechanical tillage and hand hoeing.

The inoculation technique and disease assessment method were previously described by Erpelding and Prom [8] and Prom *et al.* [9]. Briefly, sorghum plants were inoculated 30 days after planting by placing 10 *C. sublineolum*-colonized grains into the leaf whorls using a mixture of 7 isolates of the pathogen. Disease assessments were conducted 30 days post-inoculation and thereafter, on a weekly basis for four consecutive weeks. Ratings were based on a scale of 1 to 5, where 1 = no symptoms or chlorotic flecks on leaves; 2 = hypersensitive reaction (reddening or red spots) on inoculated leaves but no acervuli formation and no symptoms observed on other leaves; 3 = lesions on inoculated and bottom leaves with acervuli in the center; 4 = necrotic lesions with acervuli observed on inoculated and bottom leaves with infection spreading to middle leaves; and 5 = most leaves dead due to infection with infection on the flag leaf containing abundant acervuli. The symptom types were then categorized into two reaction classes, resistant = rated as 1 or 2; and susceptible = rated as 3, 4, or 5. In cases where there was variation in disease response within accession, each replication was assigned a single score value and recorded. Except for a few accessions, the final disease response type for each accession was based on the majority of the disease response of the replications for the accession.

3. Statistical Analysis

Using the numerical values (rating scale of 1 to 5), data were subjected to the analysis of variance using the command PROC GLIMMIX (SAS version 9.2, SAS Institute, Cary, NC) to determine the main effect of sorghum accessions.

4. Results and Discussion

The hyper-variable nature of *C. sublineolum* requires the identification of new sources of resistance in order to breed resistant varieties. In this study, the anthracnose response was significantly affected by accession ($P < 0.01$). Across the two growing seasons in Texas, 26 accessions conferred a resistant response and 10 accessions showed a susceptible response (**Table 1**). Variation in disease response was observed within and between experiments for 29 accessions. This may be due to the fact that some of the sorghum landraces or accessions in the collection are heterogeneous. Five accessions exhibited susceptibility to anthracnose in all but one replication; whereas six accessions, PI276797, PI297204, PI305034, PI454164, PI568660, and PI569066, were rated as resistant in 2007 but showed susceptible response in 2008. Variation in susceptibility between replications was more frequent in 2007 with 21 accessions rated as susceptible in at least one replication. When the same accessions were evaluated in multiple years in Isabela, Puerto Rico, 27 accessions exhibited a resistant response, 44 accessions were rated as susceptible, and 5 accessions exhibited a variable response (**Table 1**).

In this study, 22 accessions PI608974, PI608986, PI608990, PI608992, PI609009, PI609015, PI609947, PI609991, PI277674, PI568373, PI568533, PI568637, PI570743, PI570873, PI154748, PI154788, PI154966, PI297093, PI297215, PI330983, PI584033, and PI584283 exhibited a resistant response in both Texas and Puerto Rico. Four accessions rated as resistant in Texas were found to be susceptible in Puerto Rico; whereas, five accessions rated as resistant in Puerto Rico showed a susceptible response in Texas. This indicates that there

Copyright © 2012 SciRes.

Table 1. Disease reaction of 72 accessions from Ethiopia, Mali, Sudan, and Uganda and two controls to inoculation with *Colletotrichum sublineolum* under field conditions[1].

				College Station, TX			Isabela, PR	
				2007	2008			
Accession	Origin	Race	Plant Color	Rating	Rating	CS[2]	Rating	PR[3]
BTX 623	US	Caudatum	red	5	5	S	5	S
SC 748-5	Sudan	Caudatum	purple	2	2	R	2	R
PI196054	Ethiopia	Durra	_[4]	3	4	S	5	S
PI196891	Ethiopia	Bicolor	_	3	4	S	5	S
PI251637	Ethiopia	_	_	2	2	R	2\4*	S
PI276797	Ethiopia	Guinea-Caudatum	purple-red	2	3	S	5	S
PI302134	Ethiopia	_	_	1/2/4*	3	S	5	S
PI305022	Ethiopia	_	_	1/3/4*	4	S	5	S
PI305034	Ethiopia	_	_	2	3	S	5	S
PI305035	Ethiopia	_	_	1	2/3/4*	S	5	S
PI305044	Ethiopia	_	_	3	3	S	5	S
PI305056	Ethiopia	_	_	1/3/3*	2/3/3*	S	2\4*	S
PI329771	Ethiopia	_	_	2/3*	2/3*	S	2\4*	S
PI330794	Ethiopia	_	_	3	3	S	4	S
PI454096	Ethiopia	Durra	red-purple	1/1/2*	2/3/4*	S	_	
PI454164	Ethiopia	Bicolor	red-purple	1	3	S	5	S
PI585687	Mali	Durra	purple-red	2/2/3*	2/3*	S	2	R
PI608974	Mali	Durra	purple-red	2	2	R	2	R
PI608986	Mali	Durra	purple-red	2	2	R	2	R
PI608990	Mali	Guinea	purple-red	2	2	R	2	R
PI608992	Mali	_	_	1	2	R	2	R
PI609009	Mali	Durra	red-purple	1	2	R	2	R
PI609015	Mali	Caudatum	purple-red	2	2	R	2	R
PI609044	Mali	Guinea	purple-red	1/1/3*	2/3/3*	S	2	R
PI609947	Mali	Guinea	red-purple	2	2	R	2	R
PI609991	Mali	Guinea	purple-red	2	2	R	2	R
PI152634	Sudan	Caudatum-Bicolor	purple	4/1/3*	4	S	5	S
PI152687	Sudan	Caudatum	purple	3/2/3*	2/3*	S	4	S
PI217674	Sudan	Caudatum	purple	2	2	R	2	R
PI217891	Sudan	_	purple	4	2/3*	S	5	S
PI563145	Sudan	Guinea-Caudatum	purple	3	5	S	5	S
PI563321	Sudan	Caudatum	red	3	4	S	5	S
PI563328	Sudan	Caudatum	purple	1/3/3*	2/3/3*	S	5	S
PI568284	Sudan	Caudatum	red	2	2/4/4*	S	5	S
PI568288	Sudan	Caudatum	purple	3	3	S	5	S
PI568373	Sudan	Bicolor	purple	2	2	R	2	R
PI568388	Sudan	Guinea-Caudatum	purple	1	3	S	5	S
PI568403	Sudan	Caudatum	purple	1/1/3*	2/2/3*	S	5	S
PI568406	Sudan	Caudatum	purple	2/3/3*	2/2/3*	S	4	S
PI568477	Sudan	Caudatum	red	1/2/3*	4	S	5	S
PI568485	Sudan	Caudatum	red-purple	1/3/4*	4	S	5	S
PI568533	Sudan	Caudatum	red-purple	2	2	R	2	R
PI568637	Sudan	Caudatum	red	2	2	R	2	R
PI568660	Sudan	Caudatum	mix	1	3	S	5	S

Copyright © 2012 SciRes.

Continued

PI569049	Sudan	Caudatum	purple-red	1	2/3/3*	S	4	S
PI569066	Sudan	Guinea-Kafir	red	1	3	S	4	S
PI569076	Sudan	Kafir-Caudatum	purple-red (GRIN)	1/3/4*	4	S	5	S
PI570211	Sudan	Caudatum	red	2	2/2/3*	S	2	R
PI570743	Sudan	Caudatum	tan	2	2	R	2	R
PI570873	Sudan	Caudatum	purple	2	2	R	2	R
PI571386	Sudan	Durra	purple-red	1/2/3*	2/2/3*	S	5	S
PI154748	Uganda	Guinea-Caudatum	purple-red	2	2	R	2	R
PI154758	Uganda	Guinea-Caudatum	purple	2/2/3*	2/2/3*	S	2	R
PI154788	Uganda	Caudatum	purple	2	2	R	2	R
PI154804	Uganda	Caudatum	purple	2/3*	2/3*	S	4	S
PI154901	Uganda	Caudatum	purple	3	4	S	5	S
PI154966	Uganda	Caudatum	purple	2	2	R	2	R
PI154973	Uganda	Caudatum	purple	2	2	R	2\4*	S
PI297093	Uganda	Durra-Caudatum	purple	2	2	R	2	R
PI297128	Uganda	Caudatum	purple	3	3	S	5	S
PI297139	Uganda	Caudatum	purple-red	2	2	R	2\5weak*	S
PI297141	Uganda	Caudatum	purple	2	2/3/3*	S	5	S
PI297144	Uganda	Caudatum	purple	2	2/2/3*	S	5	S
PI297192	Uganda	Durra	purple	2/3/4*	3	S	5	S
PI297196	Uganda	Durra-Caudatum	purple-red	1/2/3*	3	S	5	S
PI297204	Uganda	_	_	2	3	S	5	S
PI297212	Uganda	_	_	2	2	R	5	S
PI297215	Uganda	_	_	2	2	R	2	R
PI297218	Uganda	_	_	4	5	S	5	S
PI330983	Uganda	_	_	2	2	R	2	R
PI584033	Uganda	Caudatum	purple-red	2	2	R	2	R
PI584214	Uganda	Caudatum	red-purple	2/2/3*	2/3/3*	S	5	S
PI584283	Uganda	Caudatum	purple-red	2	2	R	2	R
PI584284	Uganda	Caudatum	red-purple	2/3*	2/3*	S	2	R

[1]Sorghum accessions were planted at the Texas A&M University Research Farm, Brazos Bottom near College Station, Texas and in Isabela, Puerto Rico. Ratings were based on a scale of 1 to 5 (Erpelding and Prom, 2004), where 1 = no symptoms or chlorotic flecks on leaves; 2 = hypersensitive reaction (reddening or red spots) on inoculated leaves but no acervuli formation; 3 = lesions on inoculated leaves and bottom leaves with acervuli in the center; 4 = necrotic lesions with acervuli on the bottom and middle leaves; and 5 = most leaves dead due to infection with infection on the flags leaf containing abundant acervuli. A rating of 1 or 2 is considered a resistant (R) response, whereas a rating of 3, 4, or 5 is considered a susceptible (S) response. Rows with a single value indicate no variation for disease response within an experiment. An accession with more than one disease response value indicates variation within experiment (data presented for the replications). [2]CS—response categories: resistant (R) or susceptible (S) for the accessions that were evaluated in College Station, Texas. [3]PR—response categories: resistant (R) or susceptible (S) for the accessions that were evaluated in Isabela, Puerto Rico. [4]_: data not available. *Variation within accessions and between experiments.

are different pathotypes of *C. sublineolum* between the two locations. Forty accessions were found to be susceptible in both locations.

Environmental conditions during evaluation of sorghum germplasm have profound influence on anthracnose infection response [5,10]. Erpelding and Prom [11] also noted variation in anthracnose response between experiments conducted during the dry and rainy growing seasons in Puerto Rico. During the 2007 evaluation in Texas, the mean temperature was 28.7˚C, total precipitation 266 mm, and 38 precipitation days in the period from June to August; in the same period in 2008, mean temperature was 29.7˚C, total precipitation 187 mm, and 24 precipitation days. Although, the 2007 evaluation received more rainfall, there were less susceptible accessions when compared with the 2008 evaluation. This indicates that other factors also could influence anthracnose development.

The frequency of resistant germplasm from various regions of Africa could be used to identify germplasm collection for further evaluation. For this study, 80% of the accessions from Mali, 48% of the accessions from

Copyright © 2012 SciRes.

Uganda, 24% of the accessions from Sudan, and 7% of the accessions from Ethiopia exhibited a resistance response to anthracnose in Texas; whereas, in Puerto Rico, 100% of the accessions from Mali, 43% of the accessions from Uganda, and 28% of the accessions from Sudan exhibited a resistant response, and all the accessions from Ethiopia exhibited a susceptible response (**Table 1**). However, Erpelding and Prom [12] evaluated a different subset of sorghum germplasm from Ethiopia for anthracnose disease response during the dry and wet seasons in Isabela, Puerto Rico, and noted that 20 accessions exhibited a resistance response, 13 accessions were susceptible, and 9 accessions showed variation in disease response within and between the growing seasons. These results indicated that the Mali, Sudan, and Uganda sorghum collections may be an important source of anthracnose resistance. The US National Plant Germplasm System maintains ~2400 accessions from Mali and ~1000 accessions from Uganda, thus further evaluations of these collections could identify a significant number of resistant accessions. Even though the lowest frequency of resistant accessions was observed for the Ethiopian collection, germplasm from Ethiopia has been widely used in many breeding programs and germplasm from this region may provide new sources of genetic variation for anthracnose resistance since anthracnose pathotypes are highly variable between regions.

Disclaimer: Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendations or endorsement by the US Department of Agriculture.

REFERENCES

[1] M. E. K. Ali and H. L. Warren, "Physiological Races of *Colletotrichum graminicola* on Sorghum," *Plant Disease*, Vol. 71, No. 5, 1987, pp. 402-404. doi:10.1094/PD-71-0402

[2] K. F. Cardwell, P. R. Hepperly and R. A. Frederiksen, "Pathotypes of *Colletotrichum graminicola* and Seed Transmission of Sorghum Anthracnose," *Plant Disease*, Vol. 73, No. 3, 1989, pp. 255-257. doi:10.1094/PD-73-0255

[3] S. Pande, L. K. Mughogho, R. Bandyopadhyay and R. I. Karunakar, "Variation in Pathogenicity and Cultural Characteristics of Sorghum Isolates of *Colletotrichum graminicola* in India," *Plant Disease*, Vol. 75, No. 8, 1991, pp. 778-783. doi:10.1094/PD-75-0778

[4] C. Sherriff, M. J. Whelan, G. M. Arnold and J. A. Bailey, "rDNA Sequence Analysis Confirms the Distinction between *Colletotrichum graminicola* and *C. sublineolum*," *Mycological Research*, Vol. 99, No. 4, 1995, pp. 475-478. doi:10.1016/S0953-7562(09)80649-7

[5] R. P. Thakur and K. Mathur, "Anthracnose," Compendium of Sorghum Diseases, The American Phytopathological Society, St. Paul, 2000, pp. 10-12.

[6] H. K. Ngugi, A. M. Julian, S. B. King and B. J. Peacocke, "Epidemiology of Sorghum Anthracnose (*Colletotrichum sublineolum)* and Leaf Blight (*Exserohilum turcicum*) in Kenya," *Plant Pathology*, Vol. 49, No. 1, 2000, pp. 129-140. doi:10.1046/j.1365-3059.2000.00424.x

[7] C. R. Casela, A. S. Ferreira and R. E. Schaffert, "Physiological Races of *Colletotrichum graminicola* in Brazil," Sorghum and Millets Diseases, International Crops Research Institute for the Semi-Arid Tropics, Patancheru, 1992, pp. 209-212.

[8] J. E. Erpelding and L. K. Prom, "Evaluation of Malian Sorghum Germplasm for Resistance against Anthracnose," *Plant Pathology Journal*, Vol. 3, No. 2, 2004, pp. 65-71. doi:10.3923/ppj.2004.65.71

[9] L. K. Prom, R. Perumal, J. E. Erpelding, T. Isakeit, N. Montes-Garcia and C. Magill, "A Pictorial Technique for Mass Screening of Sorghum Germplasm for Anthracnose (*Colletotrichum sublineolum*) Resistance," *The Open Agriculture Journal*, Vol. 3, 2009, pp. 20-25.

[10] A. Chala, T. Alemu, L. K. Prom and A. M. Tronsmo, "Effect of Host Genotypes and Weather Variables on the Severity and Temporal Dynamics of Sorghum Anthracnose in Ethiopia," *Plant Pathology Journal*, Vol. 9, No. 1, 2010, pp. 39-46. doi:10.3923/ppj.2010.39.46

[11] J. E. Erpelding and L. K. Prom, "Variation for Anthracnose Resistance within the Sorghum Germplasm Collection from Mozambique, Africa," *Plant Pathology Journal*, Vol. 5, No. 1, 2006, pp. 28-34. doi:10.3923/ppj.2006.28.34

[12] J. E. Erpelding and L. K. Prom, "Response to Anthracnose Infection for a Subset of Ethiopian Sorghum Germplasm," *Journal of Agriculture of the University of Puerto Rico*, Vol. 93, No. 3-4, 2009, pp. 195-206.

Copyright © 2012 SciRes.