CBCS
http://agrobiol.sggw.waw.pl/cbcs

Communications in Biometry and Crop Science
Vol. 2, No. 1, 2007, pp. 26–31

International Journal of the Faculty of Agriculture and Biology,
Warsaw University of Life Sciences, Poland

NOTE

Chinese sorghum germplasm evaluated for resistance to downy mildew and anthracnose

Louis K. Prom[1]*, John E. Erpelding[2], Noe Montes-Garcia[3]

[1] USDA-ARS, Southern Plains Agriculture Research Center, 2765 F & B Road, College Station, TX 77845.
[2] USDA-ARS Tropical Agriculture Research Station, 2200 Pedro Albizu Campos Ave., Mayaguez, PR 00680.
[3] Instituto Nacional de Investigaciones Forestales, Agricolas y Pecuarias, Centro de Investigación Regional del Noreste, Rio Bravo, Tamaulipas, Mexico CP 88900.
* Corresponding author: L.K. Prom, E-mail: lprom@cgru.usda.gov

CITATION: Prom, L.K., Erpelding, J.E., Montes-Garcia, N. (2007). Chinese sorghum germplasm evaluated for resistance to downy mildew and anthracnose. *Commun. Biometry Crop Sci.* 2 (1), 26-31.

Received: 19 January 2007, Accepted: 5 March 2007, Published online: 12 March 2007

ABSTRACT

Forty Chinese sorghum [*Sorghum bicolor* (L.) Moench] accessions maintained by the USDA-ARS, Plant Genetic Resources Conservation Unit, Griffin, Georgia were evaluated for multiple disease resistance. The level of sorghum downy mildew (SDM) infection with systemic infection and local lesion development for infected plants was low to very high. Accessions PI511832, PI563519, PI563521, PI563850, PI610677 and P 610724 were the most resistant to sorghum downy mildew, whereas PI610692 and PI610720 were the most susceptible SDM. Thirty-three of the 40 sorghum accessions tested were susceptible to anthracnose. Four accessions, PI430471, PI563905, PI563924 and PI563960, were uniformly resistant to anthracnose. No sorghum accession exhibited resistance to both downy mildew and anthracnose. Because resistance was observed for anthracnose or downy mildew within the subset of the Chinese germplasm collection, additional screening of the collection could help identify accessions conferring resistance to multiple diseases to enhance sorghum improvement.

Key Words: *Peronosclerospora sorghi; Colletotrichum sublineolum; Sorghum bicolor*.

INTRODUCTION

Sorghum downy mildew, caused by *Peronosclerospora sorghi* (Weston and Uppal) C.G. Shaw, is a serious threat to sorghum [*Sorghum bicolor* (L) Moench] productivity, especially in areas where the disease is endemic (Odvody and Frederiksen, 1984; Pande et al., 1997; Craig,

2000). *Peronsclerospora sorghi* causes two types of symptoms, local and systemic. Systemic symptoms generally appear within 2 to 3 weeks after planting. Systemically infected plants are stunted with chlorotic areas from the base of the first leaves covering up to half of the leaf lamina (Pande et al., 1997; Craig, 2000) and can result in leaf-shredding of infected plants (Pande et al., 1997). The development of local lesion symptoms due to conidial infection usually takes 7 d (Pande et al., 1997). Local lesions are characterized by necrotic or chlorotic areas with abundant conidia on the abaxial leaf surface during humid conditions (Pande et al., 1997; Craig, 2000). Downy mildew infection of sorghum cultivars has resulted in grain yield losses ranging from 12% to 78% in Africa and India, respectively (Bock et al., 1998; Thakur and Mathur, 2002). Frederiksen et al. (1969) also reported production losses of $2.5 million due to downy mildew on sorghum, forage sorghum, broomcorn (*Panicum miliaceum* L.), and corn (*Zea mays* L.) in the coastal plains of Texas in 1969. Physiological races of *P. sorghi* have been described in Texas and elsewhere in the USA (Craig and Frederiksen, 1980, 1983; Craig, 2000).

Sorghum anthracnose, caused by *Colletotrichum sublineolum* P. Henn., Kabát & Bubák, is presently found in most sorghum-growing regions (Ali and Warren, 1987; Cardwell et al., 1989; Pande et al., 1991; Sherriff et al., 1995; Thakur and Mathur, 2000). The pathogen infects all plant parts, including the leaves, stalks, and panicles. Depending on cultivar and environmental conditions, foliar symptoms may range from small, circular, elliptical spots to elongated necrotic lesions with abundant acervuli formation (Thakur and Mathur, 2000). Severe foliar infection on susceptible cultivar may result in yield losses of up to 50%, whereas panicle infection can result in losses ranging from 30 to 50% (Pande et al., 1991; Ngugi et al., 2000; Thakur and Mathur, 2000). The occurrence of pathotypes within the pathogen population and changes in virulence patterns require the identification of additional sources of resistance (Ali and Warren, 1987; Cardwell et al., 1989; Pande et al., 1991; Casela et al., 1992).

For sorghum downy mildew and anthracnose, host resistance offers the best means of control for long-term sustainability of sorghum productivity and profitability. Based on molecular genetic evaluations, the Chinese germplasm collection is considered a unique gene pool as compared to sorghum collections from other countries, and could be a source of genetic diversity for disease resistance (GRIN; De Oliveira et al., 1996; Yang et al., 1996). Thus, the objective of this research was to evaluate 40 Chinese sorghum accessions for downy mildew and anthracnose resistance.

MATERIALS AND METHODS

Forty Chinese sorghum accessions maintained by the USDA-ARS, Plant Genetic Resources Conservation Unit, Griffin, Georgia, were selected based on their tolerance to sorghum ergot. The evaluations were conducted during the 2005 growing season at the Texas A&M Agricultural Research Farm, College Station, Texas. The soil type was a Ships clay (very-fine, mixed, active, thermic Chromic Hapluderts) with a pH of 8.4. Seeds were planted April 9 and plants harvested July 29. The experiment was 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. Conventional tillage consisting of disking, deep fall plowing, spring disking, and shaping of rows was used in field preparation. The compound fertilizer at 40 kg of N per ha and 65 kg of P_2O_5 and 90 kg K_2O ha^{-1} was applied to the field plots. An additional 90 kg N per ha was applied as top dressing 35 d after planting. The pre-emergent insecticide 'Counter 20 CR' [S-1{1.1-Dimethyethyl} thiolmethyl} O,O-diethyl phosphorodithioate (CAS)] (BASF Group, Southfield, MI) was applied at a rate of 1.79 kg a.i. ha^{-1} and the pre-emergent herbicide 'Atrazine' [6-chloro-N^2-ethyl-N^4-isopropyl-1,3,5-triazine-2,4-diamine(IUPAC)] (Syngenta Crop Protection Inc., Greenboro, NC) at a rate of 1.68 kg a.i. ha^{-1} before planting to protect against seedling insects and to control weeds, respectively.

Anthracnose inoculum was prepared by soaking sorghum grains in water for 48 h and then draining and autoclaving them in covered steel pans at 121° C for 30 min. The grains were autoclaved a second time to ensure complete sterilization. Agar plugs containing anthracnose fungal isolates were added to the sterilized grains and incubated for 14 d at 25° C. Every 3 to 4 d, the grains were mixed with a spatula to facilitate complete colonization of the grains by the fungus. Plants were inoculated 30 d after planting by placing 10 to 12 *C. sublineolum*-colonized grains into plant whorls. Fifty percent of the plants within a row were inoculated. Disease assessments were conducted 30 d post-inoculation and, thereafter, at 7-d intervals until the flowering stage. 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 and no spreading to other leaves; 3 = lesions on inoculated 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 on the flag leaf containing abundant acervuli. Each replication was assigned a single score value based on the reaction of the plants. The symptom types were then categorized into two reaction classes, resistant = rated as 1 or 2; and susceptible = rated as 3, 4, or 5.

For sorghum downy mildew, disease infection resulted from inoculum present in the soil; disease evaluation was conducted at flowering. Plants showing systemic and/or local lesions were counted as infected and disease incidence was calculated thereafter. The number of plants per row ranged from 20 to 50. In each row, all the plants were evaluated for both sorghum downy mildew and anthracnose.

PROC GLIMMIX (SAS version 9.1, SAS Institute, Cary, NC) was used to model the sorghum downy mildew disease response for the accessions using the beta distribution as the conditional distribution and a logit link function. To include extreme incidences (0, 1) into the analysis, the constant 0.001 was added to the lowest incidence and subtracted from the highest before performing the analysis. The Pearson Chi-Square to degrees-of-freedom ratio (0.98) indicated that the model was a good fit to the data. Accession least-squares means were compared using the Tukey-Kramer *P*-value adjustment for multiple comparisons.

RESULTS AND DISCUSSION

Sorghum downy mildew was significantly affected by accessions ($P < 0.0001$). Sorghum accessions, PI511832, PI563519, PI563521, PI563850, PI610677 and PI610724, exhibited the lowest levels of downy-mildew infection, whereas PI610692 and PI610720 exhibited the highest levels of infection. The latter two had a significantly higher disease incidence than the 25 lowest of the 40 accessions tested. Eighty-three percent of the accessions were susceptible to anthracnose (Table 1). Seven accessions conferred a resistant response to anthracnose with four accessions (PI563924, PI563905, PI430471, and PI563960) showing a resistance response in all three replicates. Three accessions (Grif7270, PI542767, and PI610688) had a few symptomatic plants in at least one replicate. A resistance response to both downy mildew and anthracnose was not observed for the 40 accessions evaluated. Synergism among some plant pathogenic fungi, especially soil borne pathogens, does occur (Chang, 1994; Peters and Grau, 2002). However, in sorghum downy mildew and anthracnose, it has not yet been demonstrated. The potential was there for added effect on the disease response of the host to these two fungal pathogens. However, the plants were inoculated with anthracnose, and conducting an independent disease evaluation for this disease under greenhouse conditions would not have altered the susceptible response of the accessions. Although the results obtained from this study are preliminary and the disease reaction of the germplasm needs to be confirmed, the results from this subset of the Chinese sorghum collection indicated that resistance to downy mildew and anthracnose occurs at a low frequency.

Table 1. Disease reaction of 40 Chinese sorghum accessions to downy mildew and anthracnose from experiments conducted during the 2005 growing season at the Texas A&M Agricultural Research Farm, College Station, TX.

No.	Accession	Downy mildew incidence[a]		Anthracnose reaction
1	PI610692	0.925	a	Susceptible
2	PI610720	0.925	a	Susceptible
3	PI610691	0.764	ab	Susceptible
4	PI568025	0.490	abc	Susceptible
5	PI563924	0.450	abc	Resistant
6	PI63923	0.434	abc	Susceptible
7	PI610735	0.407	abc	Susceptible
8	PI563938	0.415	abc	Susceptible
9	Grif7270	0.417	abc	Resistant[b]
10	PI563905	0.397	abc	Resistant
11	PI563990	0.361	abc	Susceptible
12	PI563998	0.203	bc	Susceptible
13	PI568039	0.195	bc	Susceptible
14	PI610702	0.330	abc	Susceptible
15	PI430471	0.311	abc	Resistant
16	PI563991	0.321	abc	Susceptible
17	PI567951	0.122	bc	Susceptible
18	PI568005	0.295	abc	Susceptible
19	PI610742	0.119	bc	Susceptible
20	PI563960	0.171	bc	Resistant
21	PI610681	0.171	bc	Susceptible
22	PI542747	0.167	bc	Susceptible
23	PI563957	0.158	bc	Susceptible
24	PI563921	0.110	bc	Susceptible
25	PI567929	0.152	bc	Susceptible
26	PI563550	0.145	bc	Susceptible
27	PI563568	0.138	bc	Susceptible
28	PI610674	0.106	bc	Susceptible
29	PI542767	0.101	bc	Resistant[b]
30	PI567987	0.127	bc	Susceptible
31	Grif608	0.125	bc	Susceptible
32	PI610688	0.097	bc	Resistant[b]
33	Grif627	0.094	bc	Susceptible
34	PI610749	0.093	bc	Susceptible
35	PI610677	0.075	c	Susceptible
36	PI563850	0.075	c	Susceptible
37	PI563521	0.075	c	Susceptible
38	PI610724	0.075	c	Susceptible
39	PI511832	0.075	c	Susceptible
40	PI563519	0.075	c	Susceptible

[a] Means within a column followed by the same letter(s) are not significant (P = 0.05) based on the Tukey-Kramer adjustment for multiple comparisons.

[b] These accessions had a few symptomatic plants in at least one replicate.

In addition, the infection response for the evaluation would suggest that large-scale, non-replicated disease evaluations could be used to identify disease-resistant accessions from the Chinese sorghum collection for more extensive evaluation. For example, in the anthracnose evaluation, replicated control design in which each accession was included only once could have been used to exclude all the susceptible accessions from further disease evaluation, because all plants in the replicates for the susceptible accessions were infected (Table 1).

The re-emergence of sorghum downy mildew in Texas (Isakeit and Odvody, 2002) and the importance of anthracnose in sorghum-production regions have prompted the search for new sources of host resistance. Germplasm collections have been important resources for the identification of new sources of disease resistance. With more than 1,000 accessions in the Chinese collection, it may be possible to identify germplasm lines with resistance to multiple diseases. Because the majority of the Chinese accessions are photoperiod-insensitive compared to other collections within the U.S. sorghum germplasm that are mostly photoperiod-sensitive, new sources of disease resistance could be more readily introgressed into advanced breeding lines for sorghum improvement.

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 U.S. Department of Agriculture.

REFERENCES

Ali, M.E.K., Warren, H.L. (1987). Physiological races of *Colletotrichum graminicola* on sorghum. *Plant Dis*. 71, 402–404.

Bock, C.H., Jeger, M.J., Mughoho, L.K., Cardwell, K.F., Adeente, V., Mtisi, E., Akpa, A.D., Kaula. G., Mukasambina, D., Blair-Myers, C. (1998). Occurrence and distribution of *Peronosclerospora sorghi* [Weston and Uppal (Shaw)] in selected countries of West and Southern Africa. *Crop Protect.* 17, 427–439.

Cardwell, K.F., Hepperly, P.R., Frederiksen, R.A. (1989). Pathotypes of Colletotrichum graminicola and seed transmission of sorghum anthracnose. *Plant Dis.* 73, 255–257.

Casela, C.R., Ferreira, A.S., Schaffert, R.E. (1992). Physiological races of Colletotrichum graminicola in Brazil, In: de Milliano W.A.J, Frederiksen, R.A., Bengston, G.D. (Eds.): *Sorghum and Millets diseases: A second world review*. Patancheru, India: International Crops Research Institute for the Semi-Arid Tropics. 209–212

Chang, K.F. (1994). Effect of interactions between *Fusarium*, *Rhizoctonia*, and *Pythium* on root and rhizome rot of Alstroemeria. *Z. Pflanzenk. Pflanzen.* 10, 460–464.

Craig, J. (2000). Sorghum downy mildew, In: Frederiksen R.A., Odvody G.N. (Eds.): *Compendium of Sorghum Diseases*. 2nd ed. American Phytopathological Society, St. Paul, MN, 25–27.

Craig, J., Frederiksen, R.A. (1980). Pathotypes of *Peronosclerospora sorghi*. *Plant Dis.* 64, 778–779.

Craig, J., Frederiksen, R.A. (1983). Differential sporulation of pathotypes of *Peronosclerospora sorghi* on inoculated sorghum. *Plant Dis*. 67, 278–279.

De Oliveira, A.C., Richter, T., Bennetzen, J.L. (1996). Regional and racial specificities in sorghum germplasm assessed with DNA markers. *Genome* 39, 579–587.

Erpelding, J.E., Prom, L.K. (2004). Evaluation of Malian sorghum germplasm for resistance against anthracnose. *Plant Pathol. J.* 3, 65–71.

Frederiksen, R.A., Amador, J., Jones, B.L., Reyes, L. (1969). Distribution, symptoms and economic loss from downy mildew caused by *Sclerospora sorghi* in grain sorghum in Texas. *Plant Dis. Reptr.* 53, 995–998.

USDA, ARS, National Genetic Resources Program. Germplasm Resources Information Network - (GRIN) [Online Database]. National Germplasm Resources Laboratory, Beltsville, Maryland. URL: http://www.ars-grin.gov/ (01 March 2007)

Isakeit, T., Odvody, G.N. (2002). Resurgence of sorghum downy mildew on the Upper Coast of Texas: Preventing a future epidemic. Texas Cooperative Extension. The Texas A&M University System. Bulletin 5/02.

Ngugi, H.K., Julian, A.M., King, S.B., Peacocke, B.J. (2000). Epidemiology of sorghum anthracnose (*Colletotrichum sublineolum*) and leaf blight (*Exserohilum turcicum*) in Kenya. *Plant Pathol.* 49, 129–140.

Odvody, G.N., Frederiksen, R.A. (1984). Use of systemic fungicides metalaxyl and fosetyl-Al for control of sorghum downy mildew in corn and sorghum in South Texas. 1: Seed treatment. *Plant Dis*. 68, 604–607.

Pande, S., Bock, C.H., Bandyopadhyay, R., Narayana, Y.D., Reddy, B.V.S., Lenné, J.M., Jeger, M.J. (1997). *Downy mildew of sorghum*. ICRISAT, Patancheru, India. Publication No. 51.

Pande, S., Mughogho, L.K., Bandyopadhyay, R., Karunakar, R.I. (1991). Variation in pathogenicity and cultural characteristics of sorghum isolates of *Colletotrichum graminicola* in India. *Plant Dis.* 75, 778–783.

Peters, R.D., Grau, C.R. (2002). Inoculation with nonpathogenic *Fusarium solani* increases severity of Pea root rot caused by *Aphanomyces euteiches*. *Plant Dis*. 86, 411–414.

Sherriff, C., Whelan, M.J., Arnold, G.M., Bailey, J.A. (1995). rDNA sequence analysis confirms the distinction between *Colletotrichum graminicola* and *C. sublineolum*. *Mycol. Res*. 99, 475–478.

Thakur, R.P., Mathur, K. (2000). Anthracnose, In: Frederiksen, R.A., Odvody, G.N., (Eds.): *Compendium of sorghum diseases*. The American Phytopathological Society. St. Paul, MN, USA. 10–12

Thakur, R.P., Mathur, K. (2002). Downy mildews of India. *Crop Prot*. 21, 333–345.

Yang, W., De Oliveira, A.C., Godwin, I., Schertz, K., Bennetzen, J.L. (1996). Comparison of DNA marker technologies in characterizing plant genome diversity variability in Chinese sorghums. *Crop Sci.* 36, 1669–1676.