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Incidence of Zonate Leaf Spot on Sorghum Accessions Under Disease-Conducive Growing Conditions Burleson County, Texas

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Abstract

The frequent rains coupled with cooler than normal maximum temperatures in the early part of the 2021 growing season created conditions for severe outbreaks of zonate leaf spot infection on sorghum plants in the experimental plots at the Texas A&M AgriLife Farm, Burleson County, Texas. As a result, the incidence of zonate leaf spot was recorded for 68 accessions planted in one of the field trials. In this study, 13 sorghum accessions, including TAM428, BTx635, PI330255, PI534157, PI570841, PI609251, PI570726, and PI267588 were free of zonate leaf spot infection, indicating that they were highly resistant to the disease. The lines identified in this study may possess genes for resistance which can be useful in breeding programs for introgression of the resistant genes to elite or parental lines.

Keywords: Sorghum; Disease resistance; *Gloeocercospora sorghi;* Zonate leaf spot; Environmental conditions.

1. Introduction

Environmental factors such as precipitation, temperature, and relative humidity are significant contributors to pathogen infectivity and susceptibility of the host as elucidated by the disease tetrahedron [1-5]. Moricca and Ragazzi [2], noted that climatic factors in the Mediterranean oak forests can change the endophyte *Discula quercina* into a weak pathogen or an opportunistic invader of aging plant tissues or healthy trees. Severe powdery mildew infection on winter wheat in the United Kingdom was shown to be influenced by temperature, humidity, and rain in April to June, while yellow rust severity was most influenced by temperature in February to June [5]. In India, wheat stripe (yellow) rust caused by *Puccinia striiformis* f. sp. *tritici* was most damaging under cool and moist weather conditions [4]. Rodríquez-Moreno, *et al.* [3], noted that in Mexico, dew temperature of <13.7ºC and mean temperature of <19.06ºC were better determinant of leaf rust severity on winter wheat. Grain mold of sorghum [*Sorghum bicolor* (L.) Moench] is most severe in areas with wet weather conditions late in the growing season, but less severe or absent in areas with drier weather conditions during grain maturity [6]. Prom, *et al.* [7], reported higher susceptibility of sorghum accessions evaluated for anthracnose resistance during the wet season than in the dry season. The current unpredictability of weather patterns due to global warming may change or alter our understanding of different pathosystems and will warrant continuous evaluation of germplasm to identify potential sources of resistance to major and minor diseases. Sorghum, is a drought tolerant crop grown in diverse environments where it is exposed to several plant pathogens, including those that incite zonate leaf spot [8-10].

Zonate leaf spot on sorghum, corn, millet, and other grasses is incited by *Gloeocercospora sorghi* Bain & Edgerton ex Deighton [8, 10]. The pathogen perennates as sclerotia on infected plant tissues and in the soil and is endemic in South Texas [8, 10]. The infection process is initiated when sclerotia germinate and conidia are rain-splashed unto the leaves [10]. Depending on the host, symptoms (Fig. 1) are characterized by roughly circular to semicircular if close to the leaf margins with alternating bands of dark purple, red, tan, or straw color giving it a concentric or zonate appearance [8, 10]. Early infection on seedlings could lead to defoliation and plant death [8]. On forage sorghum, *G. sorghi* can cause significant yield and quality losses [11].

During early part of the 2021 growing season, frequency of rainfall events and relatively cooler temperatures occurred. These environmental conditions were favorable for zonate leaf spot disease development in Burleson County, Texas. Thus, this communication reports the response of sorghum accessions, mainly from Ethiopia to zonate leaf spot.

2. Materials and Methods

2.1. Field Evaluation

Due to the favorable conditions after plant emergence, a total of 68 sorghum germplasm, including 50 accessions from Ethiopia were evaluated for resistance against *G. sorghi* at the Texas A&M AgriLife Research Farm, Burleson County, near College Station, TX during the 2021 growing season. Seeds from Ethiopia, France, Mali, and Sudan for the evaluation were provided by the USDA-ARS, Plant Genetic Resources Conservation Unit, Griffin, Georgia. Seeds were planted in a randomized complete block design and replicated three times. Seed was planted in 6 m rows at 0.31 m spacing between rows. Field preparation included fall plowing and the application of NPK according to local recommendation. Hand weeding of the plots was conducted during the season to control weeds.

2.2. Disease Rating

Disease incidence occurring under natural conditions was assessed at or before soft dough stage of development for each replicate. Percent incidence was based on the number of plants in a row divided by the number of zonate leaf spot infected plants in the same row then multiplied by 100.

2.3. Statistical Analysis

The data were analyzed using the command PROC GLM (SAS version 9.4, SAS Institute Inc., Cary, NC). The LSMEANS statement with LINES option was used to provide Tukey-Kramer multiple comparisons between accessions at the 5% probability level.

4. Results

During the 2021 growing season, the mean maximum temperature for April and May were lower than the previous five years, except for April 2018 and May 2016 (Table 1). Also, more rainy days (17) and higher relative humidity (85%) for the month of May and higher total precipitation (17.1 cm) for the month of June were recorded than the previous five years. These environmental conditions were favorable for the development of zonate leaf spot in sorghum plants in the experimental plots at Burleson County, Texas.

The main effect of accessions was highly significant ($P < 0.0001$), indicating that the accessions responded differently to zonate leaf spot infection. In this study, 13 sorghum accessions, including TAM428, BTx635, PI330255, PI534157, PI570841, PI609251, PI570726, and PI267588 were free of zonate leaf spot infection, indicating that they were highly resistant to the disease (Table 2). PI668717 exhibited the highest incidence of zonate leaf spot (96.7%), and this level was significantly different from the levels recorded from 41% of the accessions evaluated. A total of 18 accessions had less than 10% incidence and their infection levels ranged from 6.7% (PI669795 and PI534115) to zero.

5. Discussion

In drier sorghum producing regions, zonate leaf spot is considered a minor disease, causing negligible yield losses [12]. However, under humid and wet conditions, the disease can cause significant yield and quality losses, especially on forage and sweet sorghum [8, 12, 13]. In Asia, 78 sorghum accessions evaluated for resistance to zonate leaf spot noted that 26 accessions were resistant to the disease [14]. Prom, *et al.* [13], evaluated 181 sorghum lines for resistance to zonate leaf spot, 24 lines, including Dorado, Sureno, PI656034, PI576434, PI655999, and PI656075) recorded zero infection, indicating that these lines possess genes for zonate leaf spot resistance.

In most years, *G. sorghi* which can persist in infected debris on the soil is usually observed in low levels in grain and forage sorghum plants around Burleson County, Texas; however, with continuous sorghum cropping in the same field, inoculum is always available. And under favorable conditions early in the growing season as noted in 2015 [13], disease severity can be significant. In 2021 growing season, early and frequent rains with cooler than normal temperatures resulted in the appearance of zonate leaf spot in epidemic proportions. Out of the 68 lines evaluated for the disease in the field, 13 accessions recorded zero infection, suggesting that these accessions may possess gene for resistance to zonate leaf spot.

6. Conclusion

Zonate leaf spot is considered a minor disease; however, a shift in weather patterns to wetter conditions in this region, especially early in the growing season due to climate may change its status as a sorghum disease of economic importance. Therefore, the identification of new sources of resistance to the disease is warranted. The 13 accessions identified in this study may possess genes for resistance which can be useful in breeding programs for introgression of the resistant genes to elite or parental lines.

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Table-1. Weather parameters for 6 years (2016 to 2021)

	April					May					June				
Year	Tmax	Tmin	Precip	DP	RH	Tmax	Tmin	Precip	DP	RH	Tmax	Tmin	Precip	DP	RH
2016	27.0	20.5	12.1	15	74	28.5	23.0	34.8	16	79	34.0	28.0	5.9	14	74
2017	28.4	14.9	9.0	9	74	30.1	16.7	12.9	11	74	33.8	22.1	12.5	7	77
2018	24.5	12.5	3.7	4	69	31.5	20.5	5.3	4	75	34.0	24.0	4.8	4	77
2019	26.2	13.0	16.4	10	77	30.3	20.0	19.4	10	81	33.6	21.7	8.9	15	80
2020	26.4	13.8	8.4	9	79	30.9	17.5	11.2	8	77	34.1	20.9	5.1	7	77
2021	25.5	13.3	7.9	10	77	29.2	18.6	14.9	17	85	34.0	22.3	17.1	8	84

Abbreviations: Tmax = maximum temperature (ºC); Tmin = minimum temperature; Precip = total precipitation in cm; DP = Number of days with precipitation; and RH = average relative humidity (%).

Table-2. Reaction of 68 sorghum accessions to zonate leaf spot infection

Accession	Origin	Incidence (%)	Accession	Origin	Incidence (%)
PI668717	Ethiopia	96.7a[2]	PI534001	Ethiopia	23.3abcd
PI669699	Ethiopia	91.7ab	PI668757	Ethiopia	23.3abcd
PI669638	Ethiopia	86.7abc	PI267606	Ethiopia	23.3abcd
PI30296	France	81.8abcd	PI576376	Ethiopia	20.0abcd
PI148086	Ethiopia	80.0abcd	PI330261	Ethiopia	18.3bcd
PI669703	Ethiopia	76.7abcd	PI251637	Ethiopia	18.3bcd
PI576375	Ethiopia	75.7abcd	PI533799	Unknown	13.3cd
PI576381	Ethiopia	70.0abcd	PI669795	Ethiopia	6.7cd
PI330291	Ethiopia	68.3abcd	PI534115	Ethiopia	6.7cd
PI669698	Ethiopia	63.3abcd	PI569979	Sudan	5.0cd
PI644502	Ethiopia	63.3abcd	SC748	USA	3.3cd
PI668763	Ethiopia	63.3abcd	PI665167	Ethiopia	3.3cd
PI330292	Ethiopia	60.0abcd	PI564778	Ethiopia	3.3cd
PI330299	Ethiopia	60.0abcd	Brandes	USA	3.3cd
PI267618	Ethiopia	60.0abcd	PI534146	Ethiopia	2.7cd

PI576344	Ethiopia	58.3abcd	SC170	USA	1.7d
PI534151	Ethiopia	55.0abcd	RTx430	USA	1.7d
PI533918	Ethiopia	53.3abcd	BTx643	USA	1.7d
PI329346	Ethiopia	51.7abcd	BTx623	USA	1.7d
TX414	USA	51.7abcd	TAM428	USA	0d
PI330296	Ethiopia	51.7abcd	PI330255	Ethiopia	0d
PI669636	Ethiopia	48.3abcd	PI534157	Ethiopia	0d
PI330276	Ethiopia	46.7abcd	PI533792	Unknown	0d
PI665169	Ethiopia	45.0abcd	PI665166	Ethiopia	0d
PI533923	Ethiopia	45.0abcd	PI570841	Sudan	0d
PI668723	Ethiopia	40.0abcd	BTx635	USA	0d
PI576379	Ethiopia	40.0abcd	PI609251	Mali	0d
PI576431	Ethiopia	36.7abcd	PI665168	Ethiopia	0d
RTX7078	USA	35.0abcd	I665165	Ethiopia	0d
PI564776	Ethiopia	33.3abcd	PI570726	Sudan	0d
SA281	USA	31.7abcd	PI148101	Ethiopia	0d
PI669702	Ethiopia	31.7abcd	PI267588	Ethiopia	0d
PI267624	Ethiopia	30.0abcd			
PI668726	Ethiopia	25.0abcd			
PI660638	Ethiopia	25.0abcd			
PI661148	Ethiopia	23.3abcd			

[1]Acessions were planted at the Texas A&M AgriLife Research Farm, Burleson County, Texas during the 2021 growing season.
[2]Least square means for the accessions followed by the same letter(s) are not significantly different at the 5% probability level based on Tukey-Kramer

Figure-1. Zonate leaf spot with the characteristic symptoms: roughly circular to semicircular with alternating bands of different colors depending on the host variety, giving it a concentric or zonate appearance