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REACTIONS OF SORGHUM GENOTYPES TO GRAY LEAF SPOT DISEASE UNDER SUDAN FIELD CONDITIONS IN NIGERIA

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ABSTRACT
Sixteen sorghum cultivars were evaluated for resistance to gray leaf disease in a randomized complete block design. The result indicated that cultivars showed significant effect on development and rate of progress of gray leaf disease. It was revealed that IS3443, IS9659, ICSV111, IS9890, ICSV400, ICSH89002NG, ICSH89009NG the local variety KSV4 were resistant to gray leaf spot with 20 to 40% severity of the disease than the other with 45 to 60% severity. It was further noted that none of the cultivars were immune. The resistant cultivars were also observed to have more genetic traits in reducing area under disease progress curves. Study has provided better information on the sixteen sorghum varieties in terms of their relative individual resistance to gray leaf spot disease incidence and severity, these varieties therefore can serve as test materials on which further work can be done to improve them.

KEY WORDS: *Cercospora sorghi*, sorghum varieties, incidence, severity, Area under disease progress curve, logistic infection rate.

INTRODUCTION

Sorghum (*Sorghum bicolor* L.) belongs to Poaceae family, Anchopogenae, which is native in Africa in the south of Sahara desert, where several closely related wild species are found. Sorghum (*Sorghum bicolor* (L.) Moench) is a very important food crop in West and Central Africa (WCA). It is well adapted to the semi-arid tropics, with production concentrated in three agro-ecological zones– Sahel (400-600 mm), Sudan (600-1000 mm) and Guinea (1000-1300 mm) annual rainfall that cut across the region. The total area sown to sorghum in WCA is estimated at 12.5-14.9 million hectares with average yields of 0.78 tons/ha, respectively. The total production of this crop is reported to be 10.2 million tons of which Nigeria is the major producer with an estimated total production of 8.5 million tons (ICRISAT/FAO, 1996; Marley and Ogungbile, 2002). Sorghum is known to adapt well to various environments, provided the most adaptable recommended varieties for specific locations are used. However, pests and diseases constitute serious constraints to sorghum production both in traditional and improved farming systems, of all diseases, foliar diseases are the most serious. This is because sorghum spends most of its growth period in the vegetative phase, thereby providing lush green vegetation for the pathogens (Horne and Berry, 1992). Fungal diseases are considered as the most serious of these diseases on mostly foliage. Amongst the foliar diseases of sorghum, Gray leaf spot induced by *Cercospora sorghi* Ellis and Everhart was seen to be one of the most common diseases with an incidence of more than 70% in all four savanna zones of Sahel, Sudan, Northern and Southern Guinea. Most of the local land races were susceptible to gray leaf spot disease (Pande *et al*., 1993). It is therefore eminent to test some sorghum cultivars (Open pollinated hybrids and landraces) for resistance to gray leaf disease, so that they may be recommended for cultivation or as sources of resistance for genetic improvement.

MATERIALS & METHODS

The experiment was conducted on the research farm of the Department of Crop Protection, University of Maiduguri (Lat 11º 15′ N 13º 05′ E), which is located in the Sudan Savanna of Nigeria and has an annual rainfall of 450 – 600 mm per annum. The trial was laid out on flat land; the plot size was 5 m x 2 m with inter- and intra-row spacing of 0.9 m x 0.4 m respectively. The experimental design was randomized complete block with three replicates. About six seeds were sown in each planting hole and at two weeks after planting, the emerging seedlings were thinned to two plants per stand. At land preparation compound fertilizer (NPK 15:15:15) was applied at the recommended rate of 259 $kgha^{-1}$ (BOSADP, 1989). This was followed by application of Urea at the rate of 100 $kgha^{-1}$ by side dressing at four weeks after planting. Weeding was done when necessary. Sixteen sorghum varieties recommended for Northern Guinea and Sudan Savanna and gray leaf spot susceptible check (Q-L INDIA (Anon. 1993) were used for the experiment. Agronomic characteristics of the cultivars tested here are shown in Table 1.

Inoculation procedure

Inoculation was done using natural inoculums. Experimental field had been under sorghum for five years before the trials were planted in 2000. To ensure uniform and adequate supply of inoculums in 2001 the residues of 2000 were uniformly left over the entire experimental field to serve as source of infection for the next cropping season. Apart from this no artificial inoculation was carried out.

TABLE 1. Names and agronomic characteristics of crop varieties used for the gray leaf spot study.

S/NO	Variety	Exotic or Local	Height (cm)	Seed colour	Days to 50% flowering	Days to 50% panicle formation	Days to harvest
	Hybrids						
1.	ICSH89002NG	E	69	Cream	84	100	205
2.	ICSH89009NG	E	67	Cream	86	112	183
	Inbreds						
3.	ICSV111	E	66	Cream	72	77	150
4.	ICSV400	E	69	Cream	74	79	140
5.	KSV8(SAMSORG-3)	L	80	Cream	67	84	130
6.	Yarwasha	L	83	White	97	140	228
7.	Ware-warebashi	L	67	Spotted white	60	67	229
8.	IS18760	E	74	Milky cream	91	112	200
9.	IS1006	E	54	White	67	98	175
10.	IS854	E	62	Cream			95
11.	Q-L INDIA	E	78	Reddish brown	97	140	215
12.	IS3443	E	76	Cream	72	104	170
13.	IS9659	E	68	Cream	84	100	195
14.	IS9890	E	71	Cream	90	120	200
15.	SC414-12E	E	75	White	60	66	120
16.	TX378	E	79	Reddish brown	69	95	188

TABLE 2: Combined mean incidence of Gray Leaf Spot Disease on 16 Sorghum Cultivars in 2000 and 2001

		% incidence of gray leaf spot in 50 – 80 Days after sowing			
S/No	Cultivars	50	60	70	80
1.	Q-L INDIA	98.33(85.92)^{1a2}	98.41(86.01)^{a}	100.00(90.00)^{a}	100.00(90.00)^{a}
2.	IS18760	97.00(84.35)^{a}	90.72(73.08)^{ab}	93.38(78.38)^{ab}	100.00(90.00)^{a}
3.	TX378	96.00(83.39)^{a}	100.00(90.00)^{a}	100.00(90.00)^{a}	100.00(90.00)^{a}
4.	SC414-12E	81.33(73.95)^{a}	97.22(84.59)^{a}	97.22(84.59)^{a}	98.00(85.48)^{a}
5.	IS1006	80.00(68.34)^{ab}	95.83(83.24)^{a}	95.83(83.24)^{a}	100.00(90.00)^{a}
6.	IS854	78.00(66.83)^{ab}	94.44(82.09)^{a}	97.22(84.59)^{a}	100.00(90.00)^{a}
7.	Yarwasha	47.67(43.85)^{bc}	72.15(59.33)^{bc}	72.15(59.33)^{bc}	75.49(61.42)^{b}
8.	KSV4	31.67(30.58)^{cd}	29.05(32.63)$^{d-f}$	29.05(32.63)$^{d-f}$	34.43(36.02)$^{c-e}$
9.	ICSV400	28.00(32.20)^{cd}	42.33(40.41)$^{c-e}$	42.33(40.41)$^{c-e}$	47.33(43.52)$^{b-d}$
10.	IS9659	27.33(30.97)^{cd}	10.26(14.04)^{f}	10.26(14.04)^{f}	11.93(15.05)^{f}
11.	ICSH89002NG	16.67(21.38)^{cd}	26.19(27.33)^{ef}	30.95(30.18)$^{d-f}$	33.53(34.23)$^{c-f}$
12.	Ware-ware bashi	12.33(20.57)^{cd}	59.59(50.97)$^{b-d}$	59.59(50.97)$^{b-d}$	63.33(53.28)^{bc}
13.	IS9890	7.33(12.14)^{d}	16.90(24.59)^{ef}	16.90(24.59)^{ef}	23.05(28.98)$^{d-f}$
15.	ICSH89009NG	7.33(12.14)^{d}	21.32(24.49)^{ef}	22.46(25.20)^{ef}	26.13(27.38)$^{d-f}$
16.	ICSV111	7.00(14.11)^{d}	8.21(14.90)^{f}	8.21(14.90)^{f}	14.88(22.31)^{ef}
	IS3443	0.00(4.05)^{d}	3.70(9.34)^{f}	7.04(14.29)^{f}	10.67(17.32)^{ef}
	Mean	25.00	28.75	29.66	31.61
	S.E (±)	8.80	6.90	7.00	6.10

1. Means on parentheses are arcsin transformed values

2. Means on the same column with the same letter(s) are not significantly (P0.05) different according to DMRT

Observations and data recording

Gray leaf spot disease incidence**:** The incidence of gray leaf spot disease was recorded by establishing the proportion of plants showing the symptoms in each plot and expressing the result in percentage. Incidence was assessed at 10 days intervals starting at 50 days after sowing (DAS) by calculating the percentage of plants developing it in each treatment.

Gray leaf spot disease severity: Assessment of severity of the disease was also done at 10 days intervals starting at 50 DAS. Ten plants were tagged in each plot on which disease severity (determining overall score according to percentage leaf area coverage) and yield related data were recorded. Severity was assessed using scale 1-5. The percentage leaf area covered as related to disease score is presented below:

1= 0 – 20% leaf area covered by gray leaf spot

2= 21 – 40 % leaf area covered by gray leaf spot

3= 41 – 60% leaf area covered by gray leaf spot

4= 61 – 80% leaf area covered by gray leaf spot

5= 81 – 100% leaf area covered by gray leaf spot

The incidences of resistance used in the present study are incidence and severity of gray leaf spot infection (Anahosur, 1992) where:

<40% incidence of leaf area covered by gray leaf spot was considered resistant.

41 – 60% incidence of leaf area covered by gray leaf spot was considered moderately susceptible

>60% incidence of leaf area covered by gray leaf spot was considered highly susceptible.

Logistic infection Rate

This was determined using the modified Vander plank's (1963) formula and according to Zadock and Scheim (1979) as follows:

$$R = \frac{1}{t_2 - t_1} \left[\text{logit } X_1 - \text{logit } X_2 \right]$$

Where:

X_1 and X_2 are the incidences of diseases at the days t_1 and t_2 respectively. This is expected to measure the speed of the epiphytotic process in each treatment.

Area under Disease progress curve (AUDPC)

$$DP = \sum_{i=1}^{n} \left(Di+1+\frac{X_1}{2}\right) \left(ti+1-t_1\right)$$

Where:

Di = Disease severity at the ith observation

X1 = Disease severity at the 1st observation

ti = Time in days at the ith observation

t1 = Time in days at the 1st observation

n = Total number of observation.

The main aim of computing AUDPC is to measure the amount of disease in each plot.

Grain yield

When matured, the sorghum heads from each plot were cut, sun dried, threshed and winnowed. The grains were weighed. The figures were later converted to kilograms per hectare.

Data analysis

The data obtained from disease incidences were transformed using Arc sine transformation (Gomez and Gomez, 1984). All data collected were statistically analyzed according to the Randomized complete block design and the means separated using Duncan's Multiple Range test (DMRT).

TABLE 3: Combined mean severity of Gray Leaf Spot Disease on 16 Sorghum Cultivars in 2000 and 2001

		% severity of gray leaf spot in 50 – 80 Days after sowing			
S/No	Cultivars	50	60	70	80
1.	Q-L INDIA	44.00^{a}	41.33 ^{a}	46.67^{a}	52.67^{a}
2.	IS18760	40.00^{ab}	40.00^{ab}	40.00^{a-c}	48.67^{ab}
3.	TX378	40.00^{ab}	40.00^{ab}	40.00^{a-c}	49.67^{ab}
4.	SC414-12E	35.00^{bc}	40.00^{ab}	40.00^{a-c}	45.33^{a-c}
5.	IS1006	40.00^{ab}	40.00^{ab}	40.00^{a--c}	53.67^{a}
6.	IS854	40.00^{ab}	40.00^{ab}	41.33^{ab}	52.00^{a}
7.	Yarwasha	32.00^{c}	37.33^{abc}	37.33^{b-d}	40.33^{b-d}
8.	KSV4	20.00^{d}	32.00^{bcd}	32.00^{c-e}	33.33^{d-f}
9.	ICSV400	22.67^{d}	30.67^{cd}	30.67^{de}	38.33^{c-e}
10.	IS9659	20.00^{d}	20.00^{e}	20.00^{f}	20.00^{g}
11.	ICSH89002NG	21.33^{d}	28.00^{de}	29.33^{d-f}	29.33^{e-g}
12.	Ware-ware bashi	21.33^{d}	36.00 ^{abc}	36.00^{b-d}	48.00^{a-c}
13.	IS9890	20.00^{d}	22.67^{de}	22.67^{ef}	26.67^{fg}
14.	ICSH89009NG	22.67^{d}	30.67^{cd}	30.67^{de}	38.33^{c-e}
15.	ICSV111	20.00^{d}	20.00^{e}	20.00^{f}	24.00 ^{fg}
16.	IS3443	22.33^{d}	20.00^{e}	20.00^{f}	20.00^{g}
	Mean	28.75	32.42	32.92	38.77
	S.E (±)	2.00	2.9	2.90	3.2

Means on the same column with the same letter(s) are not significantly (P0.05) different according to DMRT

RESULTS

The incidence of gray leaf spot disease on 16 sorghum varieties is presented in Table 2. Incidences of Gray leaf spot disease were significantly higher in Q-L INDIA, IS18760, TX378, SC414-12E, IS1006, IS854, Yarwasha and Ware-ware bashi than in other varieties at 50, 60, 70 and 80 DAS. Incidence of gray leaf spot was lowest on IS3443, IS9659 and ICSV111, while KSV4, IS9890, ICSV400, ICSH89002NG and ICSH89009NG had moderate incidences of gray leaf spot disease. Severity of gray leaf spot disease on 16 sorghum varieties is presented in Table 3 indicated that the disease was more severe on Q-L INDIA, IS854, IS1006, IS18760, TX378, SC414-12E, Ware-ware bashi and Yarwasha, while it was least severe on on IS3443, IS9659 and ICSV111, ICSH89002NG and KSV4. Other cultivars like, ICSV400 and ICSH89009NG were intermediate in reaction to the disease at 50, 60, 70 and 80 DAS. Though logistic infection rates calculated both from disease incidence and severity did't show any level of significant, the result presented on Table 4 indicated that there was a highly significant (P=0.01) differences in the amount of gray leaf spot disease amongst the 16 sorghum cultivars tested. The largest amount of gray leaf spot disease was obtained in Q-L INDIA, IS854, IS1006, IS18760, TX378 and SC414-12E while it was moderate in Yarwasha and Ware-ware bashi. Other cultivars like IS9659, IS3443, ICSV111, IS9890, ICSH89002NG, KSV4, ICSH89009NG and ICSV400, showed least amount of gray leaf spot disease. Grain yield of the 16 sorghum cultivars in Table 5 also presented a highly significant cultivar effect, which revealed that IS3443, IS9659, ICSV111, KSV4, IS9890, ICSV400, ICSH89002NG and ICSH89009NG which showed various levels of resistance to gray leaf spot disease produced more grain yields than the other varieties.

TABLE 4: Effect of cultivars on Combined mean infection rate and Area under disease progress curve (AUDPC) of Gray Leaf Spot Disease on 16 Sorghum Cultivars in 2000 and 2001

S/No	Treatment	Infection rate (r)[*1](68-80 DAS) A[2]	B[3]	AUDPC[5] (60-80 DAS)
1.	Q-L INDIA	0.049[a4]	0.027[a]	3294.30[a]
2.	IS18760	0.078[a]	0.017[a]	3152.70[a-c]
3.	TX378	0.00[a]	0.019[a]	3162.00[a-c]
4.	SC414-12E	0.005[a]	0.002[a]	3072.00[b-d]
5.	IS1006	0.032[a]	0.027[a]	3199.20[ab]
6.	IS854	0.026[a]	0.024[a]	3192.00[ab]
7.	Yarwasha	0.007[a]	0.006[a]	2979.60[c-e]
8.	KSV4	0.014[a]	0.003[a]	2735.10[gh]
9.	ICSV400	0.012[a]	0.019[a]	2795.40[e-g]
10.	IS9659	0.004[a]	0.000[a]	2496.00[i]
11.	ICSH89002NG	0.011[a]	0.003[a]	2789.10[fg]
12.	Ware-ware bashi	0.008[a]	0.025[a]	2954.10[ef]
13.	IS9890	0.020[a]	0.010[a]	2583.60[g-i]
14.	ICSH89009NG	0.054[a]	0.003[a]	2681.10[g-h]
15.	ICSV111	0.088[a]	0.011[a]	2533.20[i]
16.	IS3443	0.0037[a]	0.000[a]	2518.20[i]
	S.E (±)	0.022	0.0063	10.68

1. * Per unit per day.
2. A= Infection rate calculated from disease incidence.
3. B= Infection rate calculated from disease severity.
4. Means on the same column with the same letter(s) are not significantly (P=0.05) different, according to DMRT.
5. AUDPC= Area under Disease Progress Curve.

TABLE 5: Combined mean grain yields of 16 sorghum cultivars evaluated for resistance to gray leaf disease in 2000 and 2001.

Treatment	Grain Yield in (kg/ha)
	550.00[i-j]
Q-L INDIA	
IS18760	473.33[j]
TX378	643.33[h-i]
SC414-12E	633.33[h-i]
IS1006	781.67[g-h]
IS854	666.67[g-h]
Yarwasha	846.67[e-f]
KSV4	846.67[e-f]
ICSV400	1583.33[a]
IS9659	960.00[e]
ICSH89002NG	1166.67[c-d]
Ware-ware bashi	753.33[f-g]
IS9890	786.67[f-g]
ICSH89009NG	1346.67[b]
ICSV111	1036.67[c-d]
IS3443	970.00[d-e]
Mean	504.44
S.E (±)	45.9
C.V.(%)	9.1

Means within a column followed by the same letter(s) are not significantly different at 5% level using DMRT.

DISCUSSION

Combined means of the two year results showed that IS3443, IS9659, ICSV111, IS9890, ICSV400, ICSH89002NG and ICSH89009NG and even the local variety KSV4 were resistant to gray leaf spot with 20 to 40% severity of the disease than the other with 45 to 60% severity. Those cultivars observed to be resistant also had less AUDPC subsequently high grains yield. Wall *et al*., 1992 inferred that resistant cultivars have higher genetic traits to reduce severity and AUDPC of the disease than susceptible checks. Results obtained also revealed that logistic infection rate of gray leaf spot among cultivars were not significant. This indicated that though significant effect existed on incidence and severity of gray leaf spot among cultivars, the rate of spread of the disease from seedling to grain formation was the same in all the sorghum cultivars. This result also probably confirmed work of Anaso (1996) which indicated that the inoculation procedures adopted were successful in providing the conidiophores and conidial inoculums uniformly. The

result of the study has in a way provided better information on the sixteen sorghum varieties in terms of their relative individual resistance to gray leaf spot disease incidence and severity. These varieties therefore can serve as test materials on which further work can be done to improve them.

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