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CONTENTS

Effect of host genotypes on the severity of sorghum anthracnose

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ABSTRACT: Anthracnose, caused by *Colletotrichum graminicola* is one of the most damaging foliar diseases in the world. The most effective and eco-friendly method to control anthracnose is through the insertion of resistant genes. Twenty sorghum genotypes were screened to identify sources of resistance against the disease under field conditions. Out of twenty genotypes, two (PC 5 and ICSB 474) were moderately resistant while, rest were susceptible to highly susceptible during 2014 and 2015 crop seasons. Genotype PC 5 gave least per cent Disease Index (PDI) and AREA Under Disease Progress Curve (AUDPC) whereas, PC 23 showed maximum PDI and AUDPC during both the seasons.

Key words: Anthracnose, AUDPC, PDI, resistant genes

Sorghum [*Sorghum bicolor* (L.) Moench] stands fifth, among the world's cereal crops with wheat on the top followed by maize, rice and barley (Mabelebele *et al*., 2015). Plant diseases slow down the productivity of sorghum crop. The crop is attacked by various plant pathogens like fungi, bacteria, and viruses causing root, stalk, foliar, panicle, and caryopsis diseases (Prom *et al.,* 2005). Fungi causes many severe diseases, such as root and stalk rot caused by *Fusarium moniliforme, Fusarium thapsinum, or Colletotrichum* spp., seedling diseases induced by *Pythium* spp., foliar diseases such as leaf blight caused by *Exserohilum turcicum* , zonate leaf spot by *Gloeocercospora sorghi,* , Ergot by *Claviceps sorghi,* sooty stripe by *Ramulispora sorghi,* rust by *Puccinia purpurea* and head smut by *Sporisorium reilianum*, respectively (Waniska *et al.,* 2001; Prom *et al.,* 2005). The foliar diseases of fungal origin prevalent in India are downy mildew, anthracnose, zonate leaf spot, leaf blight, grey leaf spot, sooty stripe tar spot and rust (Sharma et *al.*, 1978). Anthracnose caused by *Colletotrichum graminicola* is one of the most important foliar diseases of sorghum in India. It is characterized by the presence of black, sunken lenticular symptoms on the infected part of the crop (Nicholson and Epstein, 1991). Sorghum anthracnose was reported for the first time in 1902 from Togo, West Africa (Sutton, 1980), and has since been reported from several regions of the world, where Sorghum is cultivated. This disease results into higher loss in tropical and semi-arid regions where the weather factors such as high temperature, relative humidity and total rainfall are conducive factors for *C. graminicola* growth, dispersal of propagules and sporulation (Tarr, 1962; Pastor-Corrales and Frederiksen, 1980). In India, anthracnose disease is severe in Andhra Pradesh, Maharashtra, Delhi, Madhya Pradesh, Uttar Pradesh, Tamil Nadu and Karnataka (Ravindranath, 1978; Hiremath and Lakshman, 1990). The loss caused by anthracnose disease varies from one region to another. It has been reported to be 50 per cent in Georgia (Harris *et al.*, 1964), 30 per cent in Pakistan (Hamid, 1978) and 1.2 to 16.4 per cent in India (Mishra and Siradhana, 1979). Several management strategies towards limiting the effect of anthracnose on sorghum have been used with different achievements on the basis of pathosystems. Breeding for resistance which has been found to be the most practical, economical and feasible method for plant disease management. Singh and Das (2019) studied the occurrence of pathogenic variability among *C. graminicola isolates*, which would be helpful for the disease management by screening resistant germplasm for breeding programme.

MATERIALS AND METHODS

Field experiments were conducted during the *Kharif* season 2014-2015 and 2015- 2016 at Livestock Research Centre, G.B. Pant University of Agriculture

and Technology, Pantnagar.

Evaluation of sorghum genotypes for resistance against the disease: Field experiment was conducted at Livestock Research Centre to evaluate sorghum lines for their resistance against anthracnose of sorghum. Twenty sorghum genotypes were screened to identify sources of resistance against the disease (Table1). Each line was sown in a row of six meter with the spacing dimension of 45 x15cm in three replications. The sowing was done on 24th June and 23rd June during *Kharif* season, 2014 and 2015 respectively. Weeding and irrigation were done from time to time, as and when required. Thinning was done to maintain the distance of 15cm between plant to plant at 25DAS. Two sprays of thiodan 35EC (0.1%) were done to protect the crop from insect damage, first at the appearance of the sorghum shootfly (*Antherigona soccata*) and then after 15 days of first spray. Infection rate and AUDPC was calculated by the below given formula (Shaner and Finney, 1977).

$$\text{AUDPC} = \left[\frac{\left(\frac{D_1 + D_2}{2} \times T\right) + \left(\frac{D_2 + D_3}{2} \times T\right) + \left(\frac{D_3 + D_4}{2} \times T\right)}{n-1}\right]$$

Where,

D = Per cent disease index at different dates (D_1, D_2, D_3 and so on)

T = Time interval (days) between two observations

n = Total number of observations

Disease observation

Observations on PDI of the disease was recorded in 1 to 9 scale proposed by All India Coordinated Sorghum Improvement Project.

1 = Highly resistant (0 to <1% disease intensity)

2 = Resistant (up to 5% disease intensity)

3 = Resistant (6-10% disease intensity)

4 = Moderately Resistant (11-20% disease intensity)

Table 1: List of sorghum genotypes

1.	ICSB654
2	ICSB2012
3	ICSB474
4	ICSB12015
5	ICSV467
6	ICSV12019
7	IS3089
8	ICSV12021
9	IS23586
10	PC5
11	IS23521
12	CSV21F
13	IS2095
14	SSG 59-3
15	IS10302
16	Kekri local
17	IS473
18	ICSB405
19	PC4
20	PC23

5 = Moderately Resistant (21-30% disease intensity)

6 = Susceptible (31-40% disease intensity)

7 = Susceptible (41-50% disease intensity)

8 = Highly Susceptible (51-75% disease intensity)

9 = Highly Susceptible (above75% disease intensity)

Following formula was used to calculate the per cent disease index.

$$\text{Per cent disease index (\%)} = \frac{\text{Sum of numerical rating}}{\text{Total no. of sample} \times \text{Maximum rating grade}} \times 100$$

Infection rate

Logarithmic infection rates were calculated by using following formula for weekly interval (Vanderplank, 1963).

$$r_1 = \frac{2.3}{t_2 - t_1} \log_{10} \frac{x_2}{x_1}$$

Apparent infection rate was calculated by using following formula at weekly interval (Vanderplank, 1963).

$$r = \frac{2.3}{t_2 - t_1} \log_{10} \frac{x_2 (1 - x_1)}{x_1 (1 - x_2)}$$

Where,

X_1 = Disease index at time T_1 (time of first disease rating)

X_2 = Disease index at time T_2 (time of second disease rating)
r_1 = Logarithmic infection rate
r = Apparent infection rate

RESULTS AND DISCUSSION

Evaluation of sorghum genotypes for their differential reaction to *C. graminicola*

Per cent disease index

Field experiment was conducted at Livestock Research Centre to evaluate sorghum genotypes for their resistance against anthracnose of sorghum. Twenty genotypes were screened to identify sources of resistance against the disease. The results revealed that the disease reaction of different genotypes was categorized into Resistant, Moderately resistant, Susceptible and Highly susceptible based on the disease rating. In 2014, two varieties/lines were moderately resistant (PC5 and ICSB474) while, three were highly susceptible (PC23, PV4 and SS459-3) rest all were susceptible to the disease (Table 2) whereas during 2015, two varieties/lines were moderately resistant (PC5 and ICSB 474) while, only one (PC23) was highly susceptible rest all were susceptible (Table 3).

During 2014, maximum PDI (89.67%) was observed in PC23 variety with infection rate 0.0075 unit-days followed by PC4 (80.93%), where infection rate was found 0.0063 unit-days. Minimum PDI was observed from PC 5 (47.36%) where infection rate was 0.0073 unit-days (Table 4). During 2015 crop season, maximum PDI (80.22%) was recorded in PC 23 with infection rate of 0.0057 unit-days followed by PC4 (76.01%) where infection rate was 0.0067 unit-days. Minimum PDI (45.11%) was recorded from PC5, where infection rate was 0.0085 unit-days (Table 5).

Area under Disease Progress Curve (AUDPC)

During 2014, minimum AUDPC was recorded by PC5 (622.3) followed by ICSB 474 (707.91) and IS23521 (736.70). Maximum AUDPC was recorded from PC23 (1144.64) followed by PC4 (1085.03) and ICSB405 (1023.61) (Table 2). During crop season 2015, minimum AUDPC was recorded from PC5 (594.99) followed by ICSB474 (691.10) and ICSV12021 (807.06) whereas maximum AUDPC was again recorded from PC23 (1095) followed by ICSB405 (1022.50) and PC4 (1011.22) (Table 3).

Infection rate

During 2014, PC 23 variety showed least infection rate with 0.0075 unit-days followed by PC 4, where infection rate was found 0.0063 unit-days. Minimum PDI was observed from PC5 (47.36%) where infection rate was 0.0073 unit-days (Table 4). During 2015 crop season, PC23 gave minimum infection rate of 0.0057 unit-days followed by PC4 (76.01%), where infection rate was 0.0067 unit-days. Minimum PDI (45.11%) was recorded from PC5, where infection rate was 0.0085 unit-days (Table 5).

Carlos *et al*. (2001) evaluated twelve sorghum lines under field conditions. High dilatory resistance was found in CMSXS169 and hybrid CMSXS373 in two experimental years whereas germplasm CMSXS202, CMSXS203, CMSXS206, CMSXS212, CMSXS214 and CMSXS157 showed low level of dilatory resistance. CMSXS201 and CMSXS178 were found highly resistant to *C. graminicola*. Da Costa *et al.* (2004) evaluated 18 hybrid lines for their differential reaction to *C. graminicola*. Hybrids with CMSXS169R as male progenitor had minimum AUDPC and were found to be highly resistant against anthracnose of sorghum. Li and David (2009) investigated three varieties against anthracnose of sorghum in Arkanas and observed that resistant variety Cargill 888 had significantly lower AUDPC compared to susceptible varieties ('BTx623' and 'Pioneer8313'). However, there was no significant difference in infection rate. Chala *et al.* (2010) evaluated PDI of anthracnose on different varieties where resistant line 2001 PWCollNo.022 had lowest PDI and AUDPC regardless of the growing season whereas susceptible genotype BTx263 showed highest severity of anthracnose. The use of resistant hybrid IG150 in the mixtures reduced PDI and AUDPC against anthracnose of sorghum. Varietal mixture having 75% of the resistant variety reduced

Table 2: Effect of sorghum genotypes on PDI and AUDPC recorded at fifteen days interval (2014)

S. No.	Genotypes	45 DAS (08 August)	60 DAS (23 August)	75 DAS (07 September)	90 DAS (22 September)	105 DAS (07 October)	AUDPC	Disease Reaction
1.	ICSB654	45.83	65.59	69.84	73.18	76.13	1010.97	S
2	ICSB2012	42.91	59.05	65.03	67.03	74.84	937.46	S
3	ICSB474	35.80	45.34	48.68	50.47	52.77	707.91	MR
4	ICSB12015	40.98	58.82	61.61	62.98	70.71	897.21	S
5	ICSV467	36.90	49.81	56.75	61.84	67.80	827.84	S
6	ICSV12019	34.50	48.60	54.38	59.04	66.60	797.14	S
7	IS3089	46.87	58.69	65.29	70.64	78.16	964.27	S
8	ICSV12021	42.06	57.10	63.00	69.14	73.51	926.37	S
9	IS23586	50.83	65.33	69.04	72.17	77.50	1015.15	S
10	PC5	30.52	38.60	42.80	44.60	47.36	622.3	MR
11	IS23521	30.50	46.80	50.50	52.08	60.50	736.70	S
12	CSV21F	41.49	53.39	62.62	63.27	72.31	885.67	S
13	IS2095	44.68	58.32	67.46	70.54	75.38	961.31	S
14	SSG 59-3	52.51	65.80	68.50	71.34	80.65	1020.85	HS
15	IS10302	42.50	59.76	62.83	63.30	71.71	911.20	S
16	Kekri local	40.77	50.90	59.89	68.92	73.12	887.43	S
17	IS473	37.97	55.15	57.37	63.09	67.24	855.79	S
18	ICSB405	54.74	66.84	68.74	70.57	78.89	1023.61	S
19	PC4	55.43	69.83	74.94	76.39	80.93	1085.03	HS
20	PC23	57.09	69.68	76.73	85.45	89.67	1144.64	HS

CD at 5% for genotype (A) =0.54, CD for time interval= 0.27, CD for A X B= 1.2 CV= 1.24 HS= Highly susceptible, S= Susceptible, MR= Moderately Resistant

Table 3: Effect of sorghum genotypes on PDI and AUDPC recorded at fifteen days interval (2015)

S. No.	Genotypes	45 DAS (07 August)	60DAS (22 August)	75 DAS (06 September)	90 DAS (21 September)	105 DAS (06 October)	AUDPC	Disease reaction
1.	ICSB654	38.68	50.70	57.12	66.95	70.877	861.28	S
2	ICSB2012	42.14	60.04	62.96	68.81	72.723	934.99	S
3	ICSB474	29.14	44.00	46.79	51.81	54.117	691.10	MR
4	ICSB12015	36.53	53.52	57.66	63.83	66.827	850.21	S
5	ICSV467	35.18	52.79	56.17	59.47	63.220	816.36	S
6	ICSV12019	33.05	56.85	60.06	63.81	69.857	870.94	S
7	IS3089	42.82	61.83	66.35	71.255	74.370	967.90	S
8	ICSV12021	37.03	52.17	55.18	57.87	62.963	807.06	S
9	IS23586	40.81	57.28	61.31	66.805	69.827	902.94	S
10	PC5	27.35	37.81	40.98	43.475	45.113	594.99	MR
11	IS23521	38.61	52.98	55.83	58.16	61.953	814.71	S
12	CSV21F	40.96	56.26	60.11	66.28	69.647	892.92	S
13	IS2095	35.40	53.05	55.44	59.64	66.853	822.37	S
14	SSG59-3	53.59	68.52	71.38	75.71	78.083	1055.73	S
15	IS10302	36.50	55.65	58.22	63.97	66.043	858.59	S
16	Kekri local	38.04	54.68	57.29	60.14	68.680	848.06	S
17	IS473	36.17	52.63	59.00	62.29	66.763	845.28	S
18	ICSB405	50.10	64.03	70.51	74.59	76.820	1022.50	S
19	PC4	51.00	65.17	68.37	72.47	76.013	1011.22	S
20	PC23	56.94	71.52	74.98	77.05	80.227	1095.70	HS

CD at 5% for genotypes (A) = 0.48 CD for time interval (B) = 0.24 CD for A X B= 1.09 CV=1.17 HS= Highly susceptible, S= Susceptible, MR= Moderately Resistant

the severity of the disease in the crops by63.81% (De Souza *et al.,* 2013). Guimaraes *et al.* (1998) observed that the plots with mixtures BR009B (susceptible), BR008 (moderately resistant) and CMSXS210B (resistant) reduced PDI by 78% and found that the use of resistant genotype reduced PDI

Table 4: Effect of sorghum genotypes on infection rate recorded at fifteen days interval (2014)

S.No.	Genotypes	Infection rate				"r" Value
		r_1	r_2	r_3	r_4	
1.	ICSB654	0.0239	0.0042	0.0031	0.0026	0.0085
2	ICSB2012	0.0213	0.0064	0.0020	0.0073	0.0093
3	ICSB474	0.0157	0.0047	0.0024	0.0030	0.0065
4	ICSB12015	0.0241	0.0031	0.0015	0.0077	0.0091
5	ICSV467	0.0200	0.0087	0.0057	0.0061	0.0101
6	ICSV12019	0.0228	0.0075	0.0055	0.0080	0.0110
7	IS3089	0.0150	0.0071	0.0052	0.0067	0.0085
8	ICSV12021	0.0204	0.0065	0.0062	0.0041	0.0093
9	IS23586	0.0167	0.0037	0.0030	0.0047	0.0070
10	PC5	0.0156	0.0069	0.0042	0.0025	0.0073
11	IS23521	0.0285	0.0071	0.00003	0.0100	0.0114
12	CSV21F	0.0168	0.0106	0.0007	0.0089	0.0093
13	IS2095	0.0177	0.0097	0.0030	0.0044	0.0087
14	SSG 59-3	0.0150	0.0027	0.0027	0.0082	0.0072
15	IS10302	0.0227	0.0033	0.0005	0.0083	0.0087
16	Kekri local	0.0148	0.0108	0.0094	0.0039	0.0097
17	IS473	0.0249	0.0026	0.0063	0.0042	0.0095
18	ICSB405	0.0133	0.0019	0.0017	0.0074	0.0061
19	PC4	0.0154	0.0047	0.0013	0.0038	0.0063
20	PC23	0.0133	0.0064	0.0072	0.0032	0.0075

r= infection rate

Table 5: Effect of sorghum genotypes on infection rate recorded at fifteen days interval (2015)

S.No.	Genotypes	Infection rate				"r" Value
		r_1	r_2	r_3	r_4	
1.	ICSB654	0.0180	0.0079	0.0106	0.0040	0.0101
2	ICSB2012	0.0236	0.0032	0.0059	0.0039	0.0092
3	ICSB474	0.0274	0.0041	0.0068	0.0031	0.0104
4	ICSB12015	0.0254	0.0050	0.0068	0.0031	0.0101
5	ICSV467	0.0270	0.0041	0.0038	0.0042	0.0098
6	ICSV12019	0.0361	0.0037	0.0040	0.0062	0.0125
7	IS3089	0.0245	0.0047	0.0048	0.0030	0.0093
8	ICSV12021	0.0228	0.0037	0.0032	0.0056	0.0088
9	IS23586	0.0226	0.0045	0.0057	0.0031	0.0090
10	PC5	0.0216	0.0054	0.0039	0.0030	0.0085
11	IS23521	0.0211	0.0035	0.0027	0.0042	0.0079
12	CSV21F	0.0211	0.0044	0.0065	0.0036	0.0089
13	IS2095	0.0269	0.0029	0.0049	0.0077	0.0106
14	SSG 59-3	0.0164	0.0027	0.0039	0.0022	0.0063
15	IS10302	0.0281	0.0030	0.0063	0.0018	0.0098
16	Kekri local	0.0242	0.0031	0.0032	0.0101	0.0102
17	IS473	0.0250	0.0076	0.0036	0.0047	0.0102
18	ICSB405	0.0163	0.0064	0.0037	0.0021	0.0071
19	PC4	0.0163	0.0032	0.0039	0.0034	0.0067
20	PC23	0.0152	0.0031	0.0018	0.0028	0.0057

r= Infection rate

against *C. sublineolum* and concluded that a greater proportion of the resistant genotype units gives greater reduction in PDI.

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