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EVALUATION OF SORGHUM GENOTYPES [SORGHUM BICOLOR (L.) MOENCH] FOR RESISTANCE AGAINST SHOOT FLY, *ATHERIGONA SOCCATA RONDANI*

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SUMMARY

Forty genotypes of sorghum were evaluated against shoot fly, *Atherigona soccata* Rondani during *Kharif*, 2020 at forage section Department of Genetics and Plant Breeding, CCS HAU, Hisar. Based on seedling vigor, leaf glossiness, plant height, number of eggs and percent dead heart, five genotypes *viz.,* IC-305927, HJ-541, HC-308, HC-136 and CSV-44F were categorized as highly resistant, and five as highly susceptible *viz.,* IS-9543, IC-352261, IS-11393, IS-6286 and IS-3023, whereas the remaining were categorized as moderately resistant. Correlation between the number of eggs and per cent dead hearts with plant stand, plant height, leaf glossiness and seedling vigor revealed that resistant genotypes were glossier with good seedling vigor, good plant height and showed maximum plant stand.

Key words : *Atherigona soccata,* correlation, dead heart, screening

Sorghum [*Sorghum bicolor* (L.) Moench] serves as the primary source of food and fodder for the world's poorest and most food-insecure people, especially in the semi-arid tropics (Rao *et al.,* 2010). It is primarily cultivated for fodder in Haryana (Satpal *et al*., 2016). From sowing to harvest, the crop is susceptible to more than 150 insect species (Sharma, 1985). Nearly 32 per cent of the sorghum crop loss is due to the insect pest damage (Borad and Mittal, 1983). Among these different insect-pests, sorghum shoot fly alone accounts for 5 per cent of the crop loss (Jotwani, 1983).

The sorghum shoot fly, *Atherigona soccata* (Rondani) (Diptera: Muscidae), attacks during the early stage (5-30 days after emergence), particularly in late-sown crop. The infestation can reach up to 80 per cent, resulting in yield losses of 80-90 per cent for grain and 68 per cent for fodder, respectively (Chikkarugi *et al*., 2009; Kahate *et al*., 2014). The shoot flies attack sorghum between 7 and 28 days after seedling emergence (Nwanze *et al.,* 1990).

Thorough research has been conducted to identify management strategies for this pest because of its effect on plant stand and grain. Agronomical practices, natural enemies, synthetic insecticides, and host plant resistance have all been proposed to mitigate losses incurred by shoot fly (Sharma, 1993 and Kumar *et al*., 2008). Given the economic value of the shoot fly, genetic resistance to this pest is a major target in India's sorghum breeding programs. As a result, genotypes widely found in the region were evaluated for shoot fly tolerance to find the most resistant genotype suiting to the local agro-climatic conditions.

MATERIALS AND METHODS

The study was conducted at the Research Area of Forage Section, Department of Genetics and Plant Breeding, Chaudhary Charan Singh Haryana Agricultural University, Hisar, during *Kharif* season. Geographically Hisar is located at 29.1492° N, 75.7217° E coordinates from 215 m above mean sea level. Forty sorghum genotypes were sown in last week of July, 2020 under natural conditions along with the resistant (IS-18551, IS-2205 and IS-2312) and susceptible checks (DJ-6514 and Swarna), to study for resistance against *Atherigona soccata* Rondani.

The entries were sown in two rows of two metre length and randomized in three replications with a spacing of 45 cm × 25 cm. Observations for different biophysical parameters were recorded at different crop stages which included plant stand, number of eggs at 7 and 14 days after emergence (DAE), dead hearts percentage at 21 and 28 DAE, glossiness at 12 DAE and seedling vigour at 12 DAE and plant height at the time of harvest.

The per cent dead heart formation and the number of eggs per five plants were correlated with the yield attributing characters *viz.,* plant vigour, leaf glossiness, plant height and plant stand and simple correlation was calculated by the Karl Pearson formula.

RESULTS AND DISCUSSION

During *Kharif* 2020, an assessment of forty sorghum genotypes was carried out in order to determine the relative resistance against the sorghum shoot fly, *A. soccata* under the natural infestation conditions. Observations on plant stand, leaf glossiness, seedling vigour at12 DAE; mean number of plants with shoot fly eggs at 7 and 14 DAE; mean number of plants with per cent dead heart at 21 and 28 DAE and plant height at the time of harvest were recorded. After subjecting the data to statistical

TABLE 1

Plant stand and various morphological characters of the various sorghum genotypes during the *Kharif* 2020

S. No.	Sorghum Genotypes*	Plant stand of two lines of 2m each	Leaf glossiness score in scale 1 to 5	Seedling vigor score in scale 1 to 5	Plant height (cm)
1.	IS-950	22.67	2.33	3.67	258.33
2.	IS-36	14.00	2.66	3.67	122.00
3.	IS-3023	10.67	4.66	4.33	102.09
4.	IS-2058	16.33	4.00	3.28	194.11
5.	IS-18388	11.33	2.00	4.00	103.78
6.	IS-5	16.67	4.33	3.21	116.44
7.	IS-40764	14.00	3.00	3.24	145.56
8.	IS-11393	11.67	4.33	4.48	101.22
9.	IS-8110	15.67	2.00	3.37	111.22
10.	IS-4496	11.00	1.66	4.33	100.89
11.	IS-106	20.00	1.00	2.33	286.57
12.	IS-6286	10.67	4.00	4.67	102.33
13.	IS-9543	10.00	2.33	4.67	99.85
14.	IS-3889	24.33	4.33	4.03	205.33
15.	IS-6012	29.00	1.00	2.33	291.44
16.	IS-2371	24.33	2.33	3.12	230.78
17.	IS-3124	25.67	3.34	2.88	192.67
18.	IS-352	28.33	1.00	1.88	285.67
19.	IS-3802	19.33	4.33	3.67	157.44
20.	IS-7675	16.33	1.00	2.47	181.33
21.	IS-4192	27.33	4.34	2.43	286.93
22.	IS-7999	28.33	3.00	2.67	286.37
23.	IS-2633	30.67	4.00	2.38	287.28
24.	IC-352551	17.00	5.00	3.43	117.33
25.	IC-305927	23.00	5.00	2.00	286.88
26.	IC-352430	14.00	2.33	3.93	106.67
27.	IC-352261	13.33	4.66	4.33	105.22
28.	IC-352410	26.33	4.00	3.00	284.32
29.	IC-352473	18.00	4.33	3.67	107.11
30.	IC-352264	22.33	2.00	3.44	209.44
31.	EC-532984	22.33	2.66	2.61	282.51
32.	HJ-541	30.00	1.00	1.78	297.36
33.	HC-308	31.00	1.66	1.57	294.00
34.	HC-136	31.33	1.33	1.78	298.33
35.	CSV-44F	29.00	1.33	1.67	294.00
36.	IS-18551(RC)	30.00	1.00	1.33	298.37
37.	IS-2205 (RC)	26.00	1.33	1.33	298.14
38.	IS-2312 (RC)	24.00	1.33	1.47	297.77
39.	DJ-6514 (SC)	15.00	4.66	4.67	100.00
40.	Swarna (SC)	14.67	5.00	4.67	86.55
	C. D. (P=0.05)	(2.77)	(0.74)	(0.95)	(16.09)
	S. Em±	(0.98)	(0.26)	(0.33)	(5.70)
	C. V. %	(8.25)	(15.73)	(18.81)	(4.94)

analysis, the experimental findings are discussed here under various headings.

Plant stand and morphological basis of resistance

Plant stand varied from 10.00 to 31.33 (plants/2m) in IS 9543 and HC 136 respectively in two lines at 12 DAE (Table 1). The results were in line with Sonalkar and Pagire (2017) who reported plant populations ranging from 20.33 to 27.33 in two rows of two metres each in nine genotypes and ten checks.

The observations on leaf glossiness in different sorghum genotypes were recorded at 12 days after germination on a 1-5 rating on visual basis and are presented in Table 1. The data revealed that there was a significant difference among the genotypes in terms of leaf glossiness. In the present study, the leaf glossiness range was 1.00 to 5.00; the lower the score higher was the glossiness and vice-versa. The lowest seedling leaf glossiness score of 1.00 was observed in the resistant check IS-18551, test lines *viz.,* HJ-541, IS-106, IS-6012, IS-352 and IS-7675. The highest score of 5.00 was observed in susceptible check Swarna, test lines IC-352551 and IC-305927. Sonalkar *et al.* (2013) also found that shoot fly damage was associated with seedling glossiness.

The results on the seedling vigour score indicate that the least seedling vigour score was observed in the resistant check IS-18551 and IS-2205with a score of 1.33 each, indicating that these are more vigorous. Apart from this, twelve lines, *viz.,* IS-2312 (RC), IC-305927, IS-106, IS-6012, IS-352, IS-7675, IS-2633, IS-4192, HJ-541, HC-136, HC-308 and CSV-44F showed less than 2.5 seedling vigour scores. The highest seedling vigour score of 4.67, was exhibited by the susceptible check Swarna and DJ-6514 and the test lines IS-2633 and IS-9543, indicating least vigorous seedlings. Prasad *et al.* (2015), observed that increased plant vigour in sorghum was responsible for conferring multiple resistance to *A. soccata.*

The maximum plant height of 298.37 cm was at par with that observed in resistant checks IS-2205 (298.14), IS-2312 (297.77) and test lines HC-136 (298.33), HJ-541 (297.36), CSV-44F (294.00), HC-308 (294.00), CSV-44F (294.23), IS-6012 (291.44), IS-2633 (287.28), IC-305927 (286.88), IS-106 (286.57), IS-4192 (286.92), IS-7999 (286.37), IS-352 (285.67) and IC-352410 (284.32).The minimum plant height of 86.55 cm was at par with the susceptible check DJ-6514 (100.00) and test lines IS-9543 (99.85), IS-18388 (100.22), IS-4496 (100.89),IS-11393 (101.22), IS-3023 (102.09) and IS-6286 (102.33). The difference in the plant height was observed due to the extent of damage caused by the shoot fly. Minimum height was observed in the lines, which were highly infested and had more number of side tillers.

Ovipositional preference of shoot flies

The eggs at 7 DAE on five plants in different genotypes ranged from 0.67 to 4.67 (Table 2). The susceptible check Swarna and entry IS-9543 recorded the maximum number of eggs *i.e*., 4.67. The resistant checks IS-18551 (0.67) and IS-2205 (1.00), as well as test line HC-136, had the least eggs (1.00). The current findings were in accordance with Khandare *et al.* (2013), who found that shoot fly eggs were laid at a low level when observed 7 DAE.

The eggs at 14 DAE on five plants varied from 2.33 to 11.33, with significant differences across the sorghum lines tested. Swarna (11.33) and DJ-6514 (10.33), the two susceptible checks with the maximum number of eggs, were statistically at par. IS-9543 (8.33) had the maximum number of eggs among the test entries. The resistant check IS-18551 (2.33) and test lines IS-3124 (2.33) and IC-352410 (2.33) recorded the least eggs.

Dead heart formation

The per cent dead hearts within the sorghum lines differ statistically, when observed at 21 DAE. The least dead hearts *i.e.* 4.52 were noted in check IS-18551; however these dead hearts were statistically on par with those observed in IS-2205 (4.87%), HC-136 (5.65%), HJ-541 (5.93%), HC-308 (5.92%), CSV-44F (6.98%), IS-2312 (7.36%), IC-305927 (7.51%) and IS-106 (7.91%). The susceptible check, Swarna, showed the highest (27.40%) dead hearts expressing susceptibility to shoot fly. The dead hearts in genotypes DJ-6514 (26.09%), IS-9543 (24.96 %), IC-352261 (24.35%), IS-6286 (24.17%) and IC-352473 (21.81%) were at par with dead hearts observed in susceptible check (Table 2). These findings were similar to those of Arora *et al.* (2021), who reported low shoot fly dead heart incidence in the resistant genotypes ICSB 84, ICSA/B 467, ICSB 487, ICSB 14024, and IS 18551.

The mean per cent of dead hearts at 28 DAE caused by shoot fly varied from 9.15 to 49.53 per cent in different genotypes (Table 2). The least dead hearts *i.e.* 9.15 per cent were noted in the resistant

TABLE 2

Ovipositional preference and percent dead hearts by shoot fly (*Atherigona soccata*) on different sorghum genotypes during the *Kharif* 2020

S. No.	Sorghum Genotypes	Shoot fly eggs per five plant**		Shoot fly dead hearts (%)**	
		7 DAE*	14 DAE*	21 DAE*	28 DAE*
1.	IS-950	3.67 (2.15)	4.00 (2.21)	11.87 (20.08)	17.50 (24.66)
2.	IS-36	2.67 (1.90)	4.33 (2.30)	12.35 (20.56)	20.64 (26.92)
3.	IS-3023	3.34 (2.07)	6.66 (2.75)	24.28 (29.48)	39.54 (38.94)
4.	IS-2058	2.67 (1.91)	4.33 (2.30)	12.15 (20.37)	24.38 (29.57)
5.	IS-18388	2.34 (1.82)	6.00 (2.64)	13.82 (21.79)	30.73 (33.38)
6.	IS-5	2.67 (1.91)	5.00 (2.44)	18.77 (25.63)	23.14 (28.58)
7.	IS-40764	2.66 (1.91)	4.66 (2.37)	16.21 (23.61)	24.15 (29.37)
8.	IS-11393	3.33 (2.07)	6.33 (2.70)	20.75 (27.02)	43.41 (41.18)
9.	IS-8110	3.67 (2.15)	4.66 (2.37)	14.34 (22.19)	21.97 (27.89)
10.	IS-4496	4.00 (2.23)	7.33 (2.87)	15.25 (27.87)	32.71 (34.68)
11.	IS-106	1.33 (1.52)	2.66 (1.88)	7.91 (16.18)	14.93 (22.67)
12.	IS-6286	4.34 (2.30)	7.66 (2.94)	24.17 (30.15)	44.61 (41.88)
13.	IS-9543	4.67 (2.37)	8.33 (3.04)	24.96 (31.18)	45.78 (42.55)
14.	IS-3889	3.00 (2.00)	5.66 (2.57)	14.24 (22.03)	22.70 (28.43)
15.	IS-6012	1.67 (1.62)	3.00 (2.00)	9.39 (17.77)	15.35 (23.04)
16.	IS-2371	2.00 (1.71)	4.66 (2.36)	16.28 (23.76)	22.29 (28.14)
17.	IS-3124	1.67 (1.62)	2.33 (1.82)	13.94 (21.84)	21.58 (27.59)
18.	IS-352	1.33 (1.52)	4.33 (2.30)	11.88 (20.08)	17.95 (24.75)
19.	IS-3802	2.67 (1.91)	5.33 (2.50)	17.55 (24.76)	25.27 (30.16)
20.	IS-7675	1.33 (1.52)	3.33 (2.06)	19.01 (25.79)	20.99 (27.23)
21.	IS-4192	1.33 (1.47)	4.33 (2.29)	17.18 (24.42)	24.17 (29.35)
22.	IS-7999	2.00 (1.71)	5.00 (2.42)	19.09 (25.82)	24.01 (29.32)
23.	IS-2633	1.67 (1.55)	3.33 (2.07)	10.46 (18.85)	16.27 (23.77)
24.	IC-352551	1.67 (1.62)	5.33 (2.51)	16.37 (23.81)	24.31 (29.50)
25.	IC-305927	2.33 (1.80)	3.33 (2.07)	7.51 (15.85)	14.25 (22.07)
26.	IC-352430	2.67 (1.91)	5.66 (2.58)	14.56 (21.87)	29.03 (32.38)
27.	IC-352261	3.33 (2.06)	7.66 (2.94)	24.35 (29.87)	45.41 (42.34)
28.	IC-352410	1.33 (1.52)	2.33 (1.80)	12.83 (20.95)	19.05 (25.86)
29.	IC-352473	1.67 (1.62)	4.66 (2.37)	21.81 (27.77)	23.99 (29.22)
30.	IC-352264	3.67 (2.15)	5.66 (2.58)	14.67 (21.80)	20.23 (26.70)
31.	EC-532984	3.00 (1.98)	4.00 (2.22)	10.73 (19.06)	17.54 (24.73)
32.	HJ-541	1.33 (1.52)	3.00 (1.98)	5.93 (14.08)	12.03 (20.22)
33.	HC-308	1.33 (1.48)	2.66 (1.88)	5.92 (14.04)	10.57 (18.92)
34.	HC-136	1.00 (1.41)	2.66 (1.90)	5.65 (13.73)	10.44 (18.77)
35.	CSV-44F	1.67 (1.62)	3.00 (1.95)	6.98 (15.30)	12.99 (21.04)
36.	IS-18551 (RC)	0.67 (1.27)	2.33 (1.82)	4.52 (12.23)	9.15 (17.56)
37.	IS-2205 (RC)	1.00 (1.41)	2.66 (1.90)	4.87 (12.61)	9.26 (17.70)
38.	IS-2312 (RC)	1.34 (1.52)	3.33 (2.07)	7.36 (15.65)	12.48 (20.61)
39.	DJ-6514 (SC)	4.34 (2.30)	10.33 (3.36)	26.09 (32.65)	45.81 (42.57)
40.	Swarna (SC)	4.67 (2.37)	11.33 (3.50)	27.40 (31.49)	47.65 (43.63)
	C. D. (P=0.05)	(0.36)	(0.41)	(4.07)	(4.70)
	S. Em±	(0.13)	(0.14)	(1.44)	(1.66)
	C.V. %	(10.20)	(10.63)	(11.33)	(10.06)

*Mean of three replications, **Figures in parentheses are corresponding square root transformed values, DAE= Days after emergence, RC= Resistant check, SC= Susceptible check.

check IS-1855 which was statistically at par with dead hearts in IS-2205 (9.26%), HC-136 (10.44%), HC-308 (10.57%), HJ-541 (12.02%), IS-2312 (12.48%), CSV-44F (12.99%) and IC-305927 (14.25%).The susceptible check Swarna (47.65%) showed the maximum dead hearts followed by DJ-6514 (45.81%). These were at par with dead hearts in test entries, IS-9543 (45.78%), IC-352261

(45.41%), IS-6286 (44.61%), IS-11393 (43.41%) and IS-3023 (39.54%).

Association of shoot flies with resistance contributing characters

In the present investigations, the correlation between the number of shoot fly eggs at 7 and 14 DAE and dead heart per cent at 21 and 28 DAE was done with plant stand, plant height, leaf glossiness and seedling vigour and Pearson coefficient values were obtained as shown in Table 3. The plant stand is influenced by oviposition of the shoot fly. Plant stand had a highly significant negative impact on eggs laying by shoot fly at 7th DAE (-0.69**) and 14th DAE (-0.69**) expresses the lines having good plant stand are not preferred for egg-laying.

TABLE 3

Simple Crelation analysis between shoot fly oviposition, dead hearts and various parameters in different genotypes during the Kharif 2020

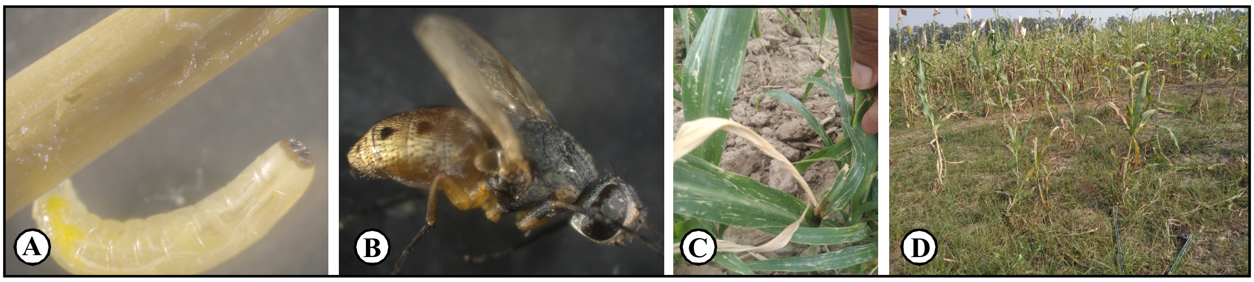
Parameters	R value			
	Nos. of eggs/ seedling		Plants with Dead hearts (%)	
	7 DAE	14 DAE	21 DAE	28DAE
Plant Stand	-0.69**	-0.69**	-0.69**	-0.77**
Plant height (cm.)	-0.65**	-0.74**	-0.77**	-0.80**
Leaf glossiness (1-5 rating scale)	0.46**	0.49**	0.62**	0.55**
Seedling vigour (1-5 rating scale)	0.82**	0.83**	0.83**	0.88**

**Correlation coefficients highly significant at P = 0.01.

Dead hearts caused by the shoot fly had a highly significant negative impact at 21st DAE (-0.69**) and 28th (-0.77**) DAE. The number of eggs laid by shoot fly on sorghum plants is influenced by plant height at maturity. Plant height had a highly significant negative impact on shoot fly egg-laying at the 7th (-0.65**) and 14th DAE (-0.74**), indicating that lines with faster growth are not favoured for egg-laying. Shoot fly dead hearts at 21st (-0.77) and 28th (-0.80) DAE were negatively and significantly associated with plant height at maturity. The results agreed with Anandan *et al*. (2009), who found that plant height is both very significant and adversely linked with shoot fly oviposition per plant. The egg count was correlated with seedling leaf glossiness on the 7th and 14th DAE. According to the correlation coefficient values (Table 3), seedling glossiness score was positively significant 7th (0.46**) and 14th (0.49**) DAE eggs number, showing that oviposition on glossy seedlings was not preferred. These results were similar to the findings of Dhillon *et al*. (2005), who discovered a significant positive relationship between oviposition and leaf glossiness. Shoot fly dead hearts were highly significantly correlated with leaf glossiness on the 21st (0.62**) and 28th (0.55**) DAE (Table 3). The shoot fly dead hearts are affected by the intensity of the leaf glossiness of sorghum lines. Seedling vigour score had a high positive and significant relationship with eggs on the 7th (0.82**) and 14th (0.83**) DAE, indicating that vigorous lines are not selected by shoot flies for egg-laying and also, it had highly significant positive effect on shoot fly dead hearts at 21st (0.83**) and 28th (0.88**) DAE, demonstrating that vigorous seedlings are less sensitive to shoot fly, resulting in fewer dead hearts. This reveals that shoot fly does not prefer robust lines for egg-laying. This was in close conformity with the findings of Gomashe *et al*. (2010), who found a substantial positive relationship between oviposition on 14 and 21 DAE and shoot fly dead hearts with seedling vigour.

CONCLUSION

Screening of forty genotypes was done on the basis of number of eggs per five plants; dead heart per cent, seedling vigour, leaf glossiness and plant height. The results revealed that five genotypes were highly resistant against shoot fly excluding the



Shoot fly attack in forage sorghum

resistant checks viz., IC-305927, HJ-541, HC-308, HC-136 and CSV-44F. Genotypes viz., IS-106, IS-950, IS-36, IS-2058, IS-18388, IS-5, IS-40764, IC-352551, IS-8110, EC-532984, IC-352430, IS-4496, IC-352264, IS-3889, IS-6012, IS-2371, IS-3124, IS-352, IS-3802, IS-7675, IS-4192, IC-352410, IS-7999, IC-352473 and IS-2633 were moderately resistant with dead hearts ranging from 14.93- 32.71 per cent. Five genotypes were highly susceptible, excluding the susceptible checks IS-9543, IC-352261, IS-11393, IS-6286 and IS-3023. Correlation between the number of eggs and per cent dead hearts with plant stand, plant height, leaf glossiness and seedling vigour revealed that resistant genotypes were glossier with good seedling vigour, good plant height and showed maximum number of plants. While, susceptible genotypes had non-glossy leaves, lower seedling vigour with low height and minimum plant stand.

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