Screening for shoot fly resistance in sorghum (*Sorghum bicolor* (L.) Moench)

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ABSTRACT

The present study was carried out with 26 derived lines for shoot fly resistance and three checks, to estimate the various variability parameters and heritability. Two sets of planting were done, first planting was done to record observations on yield and yield contributing traits. Second planting was done for screening of shoot fly reaction under artificial epiphytic conditions; late planting technique and infector row technique were used for creating sufficient shoot fly pressure. The analysis of variance revealed that significant difference among genotypes for all the traits, suggesting presence of wide range of variation among the genotypes for all the characters under study. Mean values for the lines AKENT - 101, AKENT - 104, AKENT - 107, AKENT - 117, AKENT - 123, AKENT – 125 and IS 18551, showed shoot fly reaction, these lines exhibiting comparatively low number of eggs per plant, minimum dead heart count, low chlorophyll content index and high trichome density per mm2. High heritability (broad sense) was recorded for trichome density per mm2 due to high additive gene action.

Key words: *Atherigona soccata*, *Sorghum bicolor*, sorghum shoot fly, variability, heritability, genetic advance

Sorghum (*Sorghum bicolor* (L.) Moench) is one of the most important cereal crops in the semi-arid tropics. The yield penalties to sorghum are very high starting from seedling stage to harvest, and are allotted maximally to biotic stresses. Deshpande *et al.* (2011) reported that more than 150 species of insects have been recorded as pests of sorghum, of which sorghum shoot fly, *Atherigona soccata* (Rondani) is an important pest in Asia, Africa, and the Mediterranean Europe.

The insect pests being one of the major biotic constrain that limits sorghum production. Worldwide, the yield losses were estimated to be 274 million US dollars. Insect pests are the major biotic constraints for production and productivity of sorghum causing economic losses over US $ 1 billion annually in the (SAT) Semi Arid Tropics. In India, nearly 32.1 percent of actual produce is lost due to insect pest damage (Borad and Mittal, 1983).

Sorghum shoot fly causes an average loss of 50% in India (Jotwani, 1982), but the infestations at times may be over 90% (Rao and Gowda, 1967). The adult fly lays white, elongated, cigar shaped eggs singly on the undersurface of the leaves, parallel to the midrib. After egg hatch, the larvae crawl to the plant whorl and move downward between the folds of the young leaves till they reach the growing point. They cut the growing tip resulting in dead heart formation. Host plant resistance is one of the most effective means of keeping shoot fly population below economic threshold levels, as it does not involve any cost input by the farmers.

A number of genotypes with resistance to shoot fly have been identified, but the levels of resistance are low to moderate (Jotwani, 1978; Taneja and Leuschner, 1985 and Sharma *et al.*, 2003). Plant resistance to sorghum shoot fly appears to be complex character and depends on the interplay of number of componential characters, which finally sum up in the expression of resistance to shoot fly (Dhillon, 2004).

Hence, it is important to identify genotypes with different mechanisms to increase the levels and diversify the bases of resistance to this insect. Therefore, the present studies were carried out on a diverse array of sorghum genotypes to identify plant characteristics influencing resistance/susceptibility to *A. soccata*.

MATERIALS AND METHODS

Twenty six derived lines (named as AKENT number) were selected to study the variability for shoot fly resistance. These lines have been derived from involvement of at least one resistant parent in their crossing programme and these lines are supposed to be with resistant blood for shoot fly reaction. In addition to these 26 lines, one resistant line (IS 18551), two susceptible lines (AKMS 14B, DJ 6514) were used in the present study, tested at sorghum research station, Dr. PDKV, Akola during *kharif* 2013. The experiment was conducted in randomized block design, replicated thrice with a spacing 45 cm between rows and 15 cm between plants. Most of the entries were having good agronomic background , study was conducted to evaluated for shoot fly resistance characters i.e. Number of Eggs per plant at 14, 21, 28 DAE, Chlorophyll content index , Trichome density per mm^2, Seedling vigour, Leaf Glossiness, Dead heart count at 14, 21, 28 DAE.

RESULTS AND DISCUSSION

Considerable genetic variability among 29 derived lines was observed for Characters are present in (Table 1) under study. Analysis of variance revealed highly significant differences among genotypes for all the characters under study. This indicated presence of considerable genetic variability between the genotypes.

Table 1. ANOVA for various characters

Sr. No.	Characters	Mean Sum of Squares		
		Replications	Genotypes	Error
1	Seedling vigour	0.054138	1.042**	0.0791
2	Leaf Glossiness	0.0996	1.0189**	0.1079
3	Chlorophyll content index	0.4557	48.575*	1.6306
4	Trichome Density/mm^2	0.0031	24.11**	0.0435
5	No. of eggs/plant at 14 DAE	0.009	0.253*	0.0097
6	No. of eggs/plant at 21 DAE	0.0537	0.3213*	0.019
7	No. of eggs/plant at 28 DAE	0.050	0.472**	0.046
8	Dead heart count at 14 DAE (%)	0.1642	53.806**	0.8616
9	Dead heart count at 21DAE (%)	5.644598	132.41**	2.230
10	Dead heart count at 28 DAE (%)	18.1208	21.805**	8.854

* Significant at 5% level of significance, * * Significant at 1% level of significant

Table 2. Mean performance of genotypes for characters related to shoot fly resistance

Sr. No.	Genotypes	Seedling Vigour (1– 5)	Leaf Glossiness (1 – 5)	Chlorophyll content index	Trichome Density /mm^2	No. of eggs /plant at 14 DAE	No. of eggs /plant at 21 DAE	No. of eggs /plant at 28 DAE	Dead heart count at 14 DAE (%)	Dead heart count at 21 DAE (%)	Dead heart count at 28 DAE (%)
		1	2	3	4	5	6	7	8	9	10
1	AKENT 101	2.33	3.00	17.94	6.30	1.06	1.76	2.49	13.54 (21.57)	53.91 (47.23)	59.08 (50.27)
2	AKENT 102	2.46	3.13	17.06	2.10	0.93	1.23	2.00	10.70 (19.10)	48.93 (44.37)	54.33 (47.50)
3	AKENT 103	3.3	3.10	18.53	1.06	0.77	1.16	1.99	9.76 (18.20)	25.33 (30.20)	44.28 (41.63)
4	AKENT 104	2.26	3.63	14.96	5.67	0.96	1.03	2.33	8.59 (17)	28.59 (32.30)	45.78 (42.57)
5	AKENT 105	2.16	4.17	15.88	6.23	0.93	1.43	1.88	6.15 (14.33)	28.09 (31.97)	44.83 (42)
6	AKENT	2.96	4.17	15.03	6.23	1.16	1.55	2.33	7.14	46.49	50.82

	106								(15.50)	(42.97)	(45.47)
7	AKENT 107	1.83	5.00	14.66	9.23	0.76	0.93	1.44	0.276 (9.966)	12.5 (20.7)	38.11 (38.12)
8	AKENT 108	2.53	3.93	15.99	2.90	0.88	1.26	1.44	12.71 (20.87)	23.70 (28.97)	53.72 (47.17)
9	AKENT 109	1.22	3.80	10.22	0	0.56	1.33	2.00	6.23 (14.50)	18.43 (25.40)	58.51 (49.90)
10	AKENT 110	3.20	3.40	12.50	1.06	0.8	0.83	1.80	7.93 (16.40)	21.96 (27.80)	49.27 (44.6)
11	AKENT 111	4.06	2.60	20.50	2.10	0.96	1.20	1.80	12.37 (20.40)	28.36 (32.17)	44.77 (42)
12	AKENT 112	3.10	4.17	18.20	0	1.36	1.43	1.90	9.90 (17.50)	44.82 (42.03)	53.64 (47.10)
13	AKENT 113	3.46	3.53	10.56	3.00	0.96	1.23	1.63	24 (29.30)	28.88 (32.53)	54.97 (47.93)
14	AKENT 114	2.80	3.80	9.23	1.7	0.93	1.16	1.90	5.93 (14.10)	35.18 (36.40)	46.53 (43)
15	AKENT 115	2.80	3.20	14.67	1.3	0.93	1.16	1.66	8.56 (16.97)	32.38 (34.67)	48.38 (44.07)
16	AKENT 116	3.13	3.53	9.00	0	0.83	1.1	2.06	8.91 (17.33)	37.21 (37.60)	48.05 (43.90)
17	AKENT 117	1.46	4.57	13.12	6.83	0.86	0.93	1.40	5.36 (13.40)	17.48 (24.7)	43.61 (41.33)
18	AKENT 118	3.56	4.07	20.38	0.94	0.86	1.06	2.50	7.64 (16.03)	22.52 (28.33)	44.80 (42)
19	AKENT 119	3.30	3.53	16.08	0.33	0.90	0.93	1.53	7.38 (15.80)	47.25 (43.40)	52.35 (46.37)
20	AKENT 120	3.20	3.60	8.62	3.10	0.80	1.00	1.80	9.30 (17.73)	25.45 (30.27)	49.58 (44.73)
21	AKENT 121	3.33	3.47	14.88	0	0.63	1.33	1.77	7.69 (16.10)	42.14 (40.50)	50 (45)
22	AKENT 122	3.06	3.33	16.46	4.03	1.23	1.23	2.2	7.53 (15.90)	27.19 (31.40)	49.38 (44.63)
23	AKENT 123	2.53	4.43	19.14	0	0.56	1.33	1.88	7.48 (15.87)	34.59 (36)	49.38 (44.63)
24	AKENT 124	3.00	3.30	16.70	0.94	0.83	1.66	1.76	9.93 (18.37)	30.54 (33.50)	51.49 (45.87)
25	AKENT 125	2.66	4.77	14.28	1.06	0.77	0.73	1.88	6.163 (22.266)	27.3 (31.50)	49.38 (44.63)
26	AKENT 126	2.66	4.40	15.26	0	1.43	1.60	1.88	9.74 (18.20)	24.70 (29.80)	50.12 (45.07)
27	AKMS - 14B	2.36	3.30	20.73	0.94	1.11	1.60	2.00	4.80 (12.63)	26.43 (30.93)	46.23 (42.83)
28	DJ-6514	2.66	3.30	26.36	1.06	0.56	0.66	1.83	6.47 (14.70)	30.61 (33.60)	48.38 (44.07)
29	IS – 18551	1.56	4.60	11.21	9.33	0	0.22	0.44	0.78 (5.10)	13.41 (21.4)	43 (40.966)
	Range	1.46-4.02	2.60-5	8.62-26.36	0-9.3	0-1.43	0.2-1.76	0.4-2.49	5.1-22.26	21.4-47.23	38.13-50.26
	Mean	**2.786**	**3.75**	**15.44**	**2.67**	**0.8839**	**1.1517**	**1.8237**	**17.008**	**32.766**	**44.46**
	CV	**10.096**	**11.133**	**8.2652**	**7.812**	**11.1967**	**12.0154**	**11.768**	**5.457**	**4.5576**	**6.692**
	SE (m±)	0.1624	0.34192	0.7373	0.1205	0.0571	0.0799	0.1239	0.5359	0.8622	1.718
	CD 5%	0.4601	0.9711	2.0887	0.3413	0.1619	0.2263	0.351	1.5183	2.4426	4.8671
	CD 1%	0.6125	1.2941	2.7802	0.4543	0.2155	0.3013	0.4673	2.021	3.2514	6.4786

Genotypic and Phenotypic co-efficient of variation

Perusal of data presented in table 3 all characters showed low genotypic variance and high phenotypic variance. It clearly showed that Environmental effect was more for expression of all characters, These findings also agree with findings of Godbharle *et al.* (2010) .The present study revealed that all the characters under study exhibited higher phenotypic and genotypic estimates of variance than environmental variance. This result corroborate with findings of Ahmed *et al.* (2012) .The research findings showed that there were small differences between GCV and PCV for all the characters studied in the experiment. Thus, all the characters studied in the experiment exhibited low ECV than other coefficient of variations. Low GCV and PCV is observed for days to 50 per cent flowering (GCV (7.96 %), PCV (10.94%), grain yield per plant. (GCV (13.94%), PCV (15.24%), Similar results were observed by Kjein and Rosenow (2006) and Mahajan *et al*. (2011). This showed that substantial genetic variability existed among the genotypes for character related to shoot fly resistance.

Heritability and Expected genetic advance

The genotypic coefficient of variation is not sufficient to determine the amount of variation which is heritable. Burton (1952) also made clear that the heritable variation cannot be estimated through genetic coefficient of variation and as such the genotypic coefficient of variation together with heritability would furnish the most reliable information on the magnitude of genetic advance to be expected from selection. In the light of this explanation, heritability was calculated to assist the breeder in choosing the characters that can be relied upon for selection. In the present study it was observed that most of the characters showed high heritability accompanied with low genetic advance which indicated non-additive gene action. The high heritability was being exhibited due to favourable influence of environment rather than genotype Singh and Narayanam (2006). The present study revealed higher heritability in broad sense for Trichome density (99.6 %), chlorophyll content index (90 %), fodder yield per plant (96 %).dead heart count at 14 DAE (95.3 %).Medium heriatblity was noticed in case of plant height (77.9%), and leaf glossiness (73.7 %).Low percentage of heritability was recorded for dead heart count at 28 DAE (32.7 %) followed by panicle breadth (50.9%). The study revealed that the high heritability estimates coupled with high genetic advance were found for trichome density per mm^2,(heritability (99.4 %), EGA (217 %), 1000 seed weight (heritability (89.4%), EGA (49.35%). The above were in conformity with Bello *et al*. (2007), Deepalakshmi and Ganeshmurthy (2007), and Shinde *et al*. (2010), and found promising in shoot fly resistance programme.

Table 3. Estimates of Genotypic, Phenotypic variance and Genotypic, Phenotypic, Environmental coefficient of variation, Heritability and Expected Genetic Advance over mean characters related to shoot fly resistance in sorghum .

Sr. No	Characters	Mean	Range		σ^2G	σ^2P	GCV (%)	PCV (%)	ECV (%)	h^2 (%)	EGA (%)
			Min	Max							
1	Seedling vigour	2.78	1.46	4.06	0.32	0.40	20.34	22.71	10.11	80.22	37.53
2	Leaf Glossiness	2.95	1.66	4.26	0.30	0.41	18.67	21.74	11.13	73.70	33.03
3	Chlorophyll content index	1.54	8.62	6.36	15.64	17.27	25.60	26.90	8.27	90.50	50.19
4	Trichome Density/mm2	2.67	0	9.30	8.02	8.06	106.06	106.35	7.81	99.40	217.89
5	No. of eggs/plant at 14 DAE	0.88	0	1.60	0.08	0.09	32.28	34.16	11.22	88.30	62.81
6	No. of eggs/plant at 21 DAE	1.15	0.20	1.76	0.100	0.11	27.56	30.06	12.02	84.00	52.03
7	No. of eggs/plant at 28 DAE	1.82	0.40	2.49	0.14	0.18	20.65	23.77	11.77	75.48	36.95
8	Dead heart count at 14 DAE (%)	17.00	5.10	2.26	17.64	18.55	24.70	25.30	5.46	95.30	49.68
9	Dead heart count at 21 DAE (%)	32.76	21.40	7.23	54.06	56.29	22.44	22.90	4.56	96.00	45.30
10	Dead heart count at 28 DAE (%)	44.46	38.10	0.26	4.31	13.17	4.67	8.16	6.69	32.70	5.51

Genetic variance (σ^2g), Phenotypic variance (σ^2p), Genotypic Coefficient of Variation (GCV), Phenotypic Coefficient of Variation (PCV), broad sense heritability ($h^2(bs)$) and Genetic advance (GA) , ** significant P= 0.05

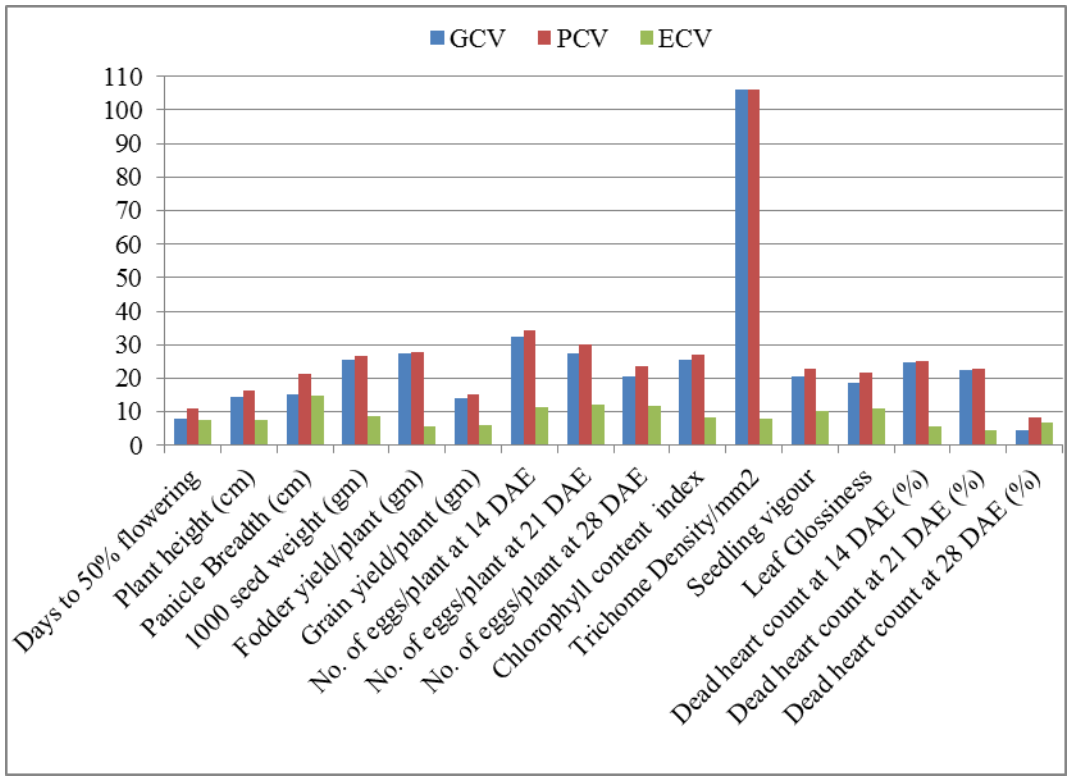

Fig 1. Genotype , phenotype and environmental co-efficient of variation

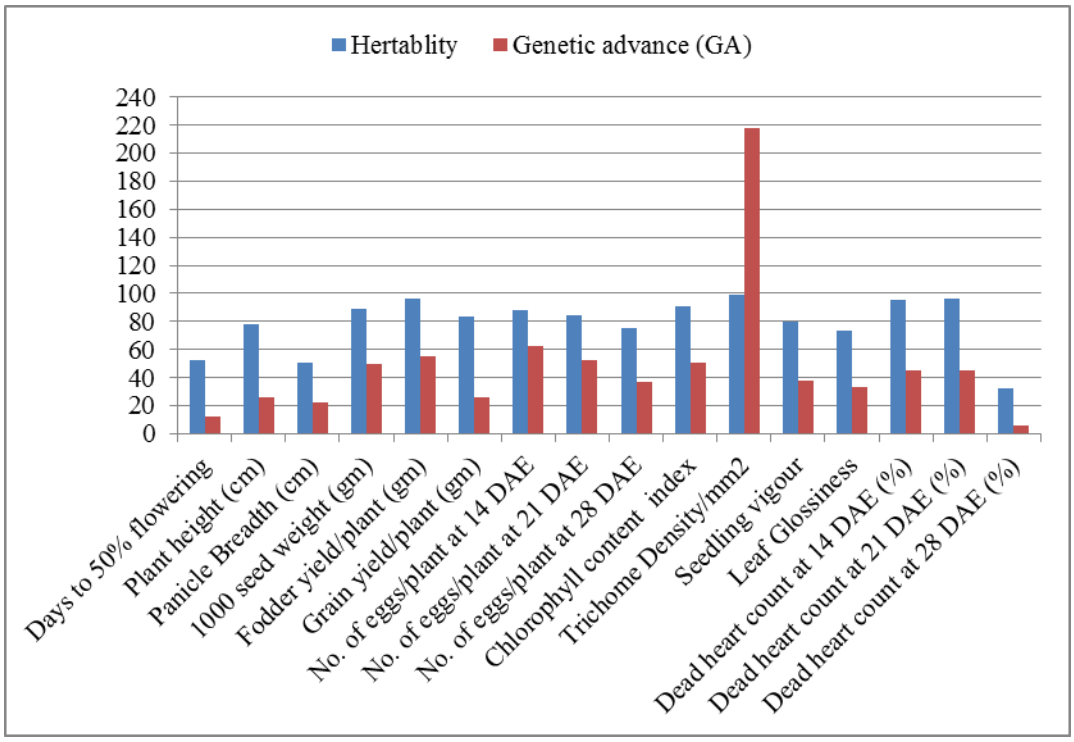

Fig 2. Heritability and Genetic Advance estimates of various characters in Sorghum.

CONCLUSION

The overall results indicated that there is adequate genetic variability present in the material studied. Hence, The Variability studies, and heritability analysis suggested that dead hearts, plants with eggs, leaf glossiness, trichomes on the abaxial surface of the leaf, and leaf sheath pigmentation can be used as marker traits to select for resistance to shoot fly,A. soccatain . Therefore, due emphasis is to be paid on above mentioned characters for improving the productivity during selection. Moreover, these traits are also having high heritability and genetic advance on grain yield also.

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