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National Academy of Agricultural Science (NAAS)
Rating : 3. 03

Host Plant Resistance in Sorghum Germplasms Against Shoot Fly: Morpho-physiological Characters

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Abstract: *The investigation entitled "Host plant resistance in different sorghum germplasms against shoot fly, Atherigona soccata Rondani" was conducted on the farm of Sorghum Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during kharif season of 2014-15. The experiment was laid in randomized block design with twenty two treatments, replicated thrice. The screening programme was carried out with sorghum germplasms viz.IS-2123, SPV-669, ICSV-705, ICSV-93046, ICSB-413, ICSV-12002, ICSV-12003, ICSV-25022, ICSB-435, IS-2146, ICSV-12004, IS-40615, ICSV-25026, ICSV-12001, AKSV-181, AKENT-73, IS-2205, AKENT-61-1, ICSB-444, Swarna, susceptible check DJ-6514 and resistant check IS-18551. All germplasms were raised under the recommended agronomical practices in open field condition. The observations were recorded on number of eggs per plant at 14 and 21 DAE; dead hearts at 14 and 28 DAE. Similarly, the data on morpho-physiological traits like seedling vigour, leaf glossiness and trichome density at abaxial surface of leaf were also recorded on 14 DAE. Finally simple correlation was performed to understand the association between morphophysiological traits and various parameters used to measure resistance (oviposition and deadhearts) to sorghum shoot fly.*

The significantly minimum number of eggs was observed on entries IS-2146, IS-2123 and ICSB 435 followed by resistant check IS-18551. Whereas, maximum eggs were noticed on susceptible check DJ-6514 and Swarna at 14 DAE. Similarly, the entries ICSV-93046, IS-2146, ICSB-435, ICSV-705, and resistant check IS-18551 indicated least oviposition preference at 21 DAE. Maximum oviposition preference was observed on susceptible check DJ-6514 and entry Swarna. The entries like IS-18551, IS-2123, ICSV-93046, ICSV-705, IS-2146, ICSV-25026 and ICSB-413 recorded minimum deadhearts percentage at 14 and 21 DAE. Whereas, maximum deadhearts incidence was noticed on susceptible check DJ-6514 and Swarna.

The studies on morpho-physiological traits at 14 DAE revealed maximum seedling vigour in IS-2123 which was at par with IS-18551 followed by ICSV-705. Whereas, maximum leaf glossiness was observed in entries IS-2123, IS-18551 and ICSV-25026. While, the density of trichomes measured at 14 DAE on abaxial surface of leaf blade were maximum in resistant check IS-18551 which was at par with IS-2146 and ICSB-435. Germplasms Swarna and DJ-6514 were non glossy, non trichomedand less vigorous.

However, morpho-physiological characters like seedling vigour and leaf glossiness were positively and significantly associated with shoot fly damage; while trichome density was significantly and negatively associated with shoot fly damage.

Keywords: *Germplasm, Host plant resistance, Morpho-physiological characters, Soybean, Atherigona soccata.*

INTRODUCTION

Sorghum is one of the most important cereal crop because of its good adaptation to a wide range of ecological conditions, low input cultivation and diverse uses as discussed by Aruna[2]. In India, area under sorghum was 7. 58 million hectares with annual production of 7. 18 million tonnes with 1163 kg/ha in the *kharif* and 677 kg/ha in the *rabi* season during 2013 as reported by Anonymous [1]. Insect pests are the major biotic constraints for production

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and productivity of sorghum. Among insects, shoot fly, *Atherigonasoccata* (Order: Diptera, Family: Muscidae) is a major grain yield limiting factor that causes damage when the sowing is delayed and late sown crop is most affected. It causes dead hearts in early seedling stage reducingplant population, resulting in heavy yield losses upto 75.60 per cent in grain and 68.90 per cent in fodder as discussed by Pawar *et al*. [9].

Normal sowing is recommended so that the available residual moisture can be utilized fully and hence reduction in shoot fly infestation. However, many times it is not possible to adhere to this period because of variability in rainfall, non availability of seeds of improved varieties/hybrids, fertilizers, sowing implements etc. in time. It causes staggered plantings which helps to increase the pest incidence. Adoption of chemical methods for control of shoot fly is not economically feasible for resource poor farmers. Use of resistant planting material in integrated pest management helps in minimizing the use of pesticides which results in conservation of natural enemies, prevention of environmental pollution and overcome the problem of development of insecticide resistant in insects. Host plant resistance combined with timely sowing is the most realistic approach to minimize the grain yield loss due to shoot fly.

Thus, present study was aimed to assess the shoot fly reaction in different sorghum germplasms by ascertaining the various morpho- physiological traits associated with sorghum shoot fly resistance/ susceptibility.

MATERIAL AND METHODS

The field investigation with a view to evaluate the divers germplasms of sorghum for resistant to shoot fly was carried out. The different morpho-physiological traits associated with sorghum to shoot fly resistance/susceptibility were ascertained.

Field experiment was laid out in Randomized Block Design with twenty two treatments replicated thrice. The gross plot size was 4.0 m × 0. 90 m. and spacing was 45 cm × 15 cm. Sowing was done on 5th August 2014 by dibbling. All recommended agronomic practices were followed.

The total numbers of eggs per plant were counted on 5 randomly selected plants in each plot at 14th and 21st days after emergence. The deadhearts caused by shoot fly were recorded at 14th and 28th days after emergence in each of the plot. The per cent deadhearts were computed. The observation on morpho-physiological characters like, seedling vigour and leaf glossiness were recorded at 14th days after emergence for each entry and measured on 1 to 5 scale, as suggested by Sharma *et al*. [11]. Whereas, the observations on number of trichomes per mm^2 were counted on abaxial surface of leaf on the sixth leaf from apical point as per Sharma *et al*. [11].

The data obtained from the field and laboratory experiment were converted to appropriate transformations and were subjected to statistical analysis to test the level of significance. Moreover, the data thus collected on morpho-physiological parameters associated with sorghum germplasms were correlated with shoot fly infestation.

RESULT AND DISCUSSION

Number of Shoot Fly Eggs at Fourteen Days After Emergence

The data on number of shoot fly eggs showed in Table 1 indicated that there were significant differences amongst the sorghum germplasms in respect of ovipositional preference by sorghum shoot fly. The number of eggs per plant at 14 DAE amongst all germplasm lines ranged from 0.33 to 1.86. Significantly minimum number of shoot fly eggs per plant was recorded on IS-2146, *i.e.* 0. 33 egg/plant, it was followed by the entry IS-2123 (0.53 eggs/plant).

The entries ICSB-435 (0. 60), ICSV-705 (0. 66), ICSB-413 (0. 73) and resistant check IS-18551 (0. 73) were found significantly superior over rest of the entries *viz*., ICSV-93046 ICSB-444, ICSV-25026, ICSV-12004, ICSV-12001, ICSV-25022, AKSV-181, IS-40615, AKENT-73, IS-2205, ICSV-12003, AKENT-61-1, SPV-669, ICSV-12002, Swarna and DJ-6514 in which 0.80, 0.86, 0.93, 0.93, 0.93, 1.00, 1.13, 1.20, 1.26, 1.26, 1.40, 1.40, 1.60, 1.80, 1.80 and 1.86 eggs per plant

Table 1
Field screening of sorghum germplasms against Shoot fly

Sr. No.	*Germplasms*	*Number of shoot fly eggs/plant 14 DAE*	*Number of shoot fly eggs/plant 21 DAE*	*Per cent deadheart due to shoot fly 14 DAE*	*Per cent deadhearts due to shoot fly 28 DAE*
1.	IS 2123	0. 53 (0. 72)*	0. 27(0. 50)*	15. 64(23. 21)**	21. 14(27. 29)**
2.	SPV 669	1. 60 (1. 26)	0. 60(0. 77)	47. 05(43. 30)	52. 12(46. 22)
3.	ICSV 705	0. 67 (0. 81)	0. 20(0. 44)	18. 09(25. 06)	22. 42(28. 23)
4.	ICSV 93046	0. 80 (0. 88)	0. 20(0. 44)	28. 54(32. 24)	35. 27(36. 41)
5.	ICSB 413	0. 73 (0. 85)	0. 33(0. 57)	21. 09(27. 27)	24. 33(29. 52)
6.	ICSV 12002	1. 80 (1. 34)	0. 40(0. 63)	41. 56(40. 13)	48. 14(43. 93)
7.	ICSV 12003	1. 40 (1. 18)	0. 53(0. 72)	45. 93(42. 66)	50. 67(45. 38)
8.	ICSV 25022	1. 00 (0. 99)	0. 40(0. 63)	24. 93(29. 91)	30. 76(33. 62)
9.	ICSB 435	0. 60 (0. 76)	0. 20(0. 44)	17. 39(24. 56)	21. 50(27. 59)
10.	IS 2146	0. 33 (0. 57)	0. 20(0. 44)	18. 79(25. 68)	21. 99(27. 94)
11.	ICSV 12004	0. 93 (0. 96)	0. 53(0. 72)	42. 50(40. 68)	48. 51(44. 14)
12.	IS 40615	1. 20 (1. 09)	0. 47(0. 67)	41. 16(39. 89)	46. 74(43. 12)
13.	ICSV 25026	0. 93 (0. 96)	0. 53(0. 72)	19. 81(26. 40)	25. 12(30. 04)
14.	ICSV 12001	0. 93 (0. 96)	0. 60(0. 77)	36. 49(37. 15)	42. 62(40. 75)
15.	AKSV 181	1. 13 (1. 06)	0. 67(0. 81)	39. 28(38. 80)	46. 72(43. 11)
16.	AKENT 73	1. 27 (1. 12)	0. 67(0. 81)	27. 56(31. 65)	34. 76(36. 06)
17.	IS 2205	1. 27 (1. 12)	0. 53(0. 72)	31. 36(34. 03)	35. 69(36. 68)
18.	AKENT 61-1	1. 40 (1. 18)	0. 53(0. 72)	49. 59(44. 76)	55. 34(48. 08)
19.	ICSB 444	0. 87 (0. 92)	0. 67(0. 81)	26. 24(30. 81)	32. 75(34. 89)
20.	SWARNA	1. 80 (1. 34)	1. 13(1. 06)	58. 83(50. 09)	67. 80(55. 46)
21.	DJ 6514 (S)	1. 87 (1. 36)	1. 13(1. 06)	59. 40(50. 43)	67. 86(55. 50)
22.	IS 18551 (R)	0. 73 (0. 85)	0. 27(0. 50)	15. 38(22. 92)	17. 78(24. 88)
'F' test		Sig.	Sig.	Sig.	Sig.
SE(m)±		0. 05	0. 04	0. 03	1. 32
CD at 5%		0. 14	0. 10	3. 77	4. 09

*Figures in parentheses are corresponding square root transformed values.

**Figures in parentheses are corresponding arc sine transformed values.

were recorded, respectively. Among all the germplasm lines, the maximum oviposition of shoot fly was observed on susceptible check DJ-6514 (1.86) and Swarna (1.80).

The present findings are in conformity with earlier worker Patel and Sukhani [8] screened twenty sorghum genotypes for oviposition preference and reported that resistant genotypes showed less number of eggs per plant indicating their non-preference for oviposition by shoot fly and opined that non-preference for oviposition appeared to be an important mechanism of resistance to shoot fly.

Number of Shoot Fly Eggs at Twenty One Days After Emergence

The results indicated that significantly minimum number of shoot fly eggs was noted in entries ICSV-93046, resistant check IS-18551 and entry IS-2123. All the remaining entries exhibited more or less equal number of egg per plant; overall range was 0.20 to 1.13 eggs per plant. Maximum number of eggs per plant was noticed on susceptible check DJ-6514(1. 13eggs/plant). The significant differences in number of eggs per plant were noticed during present investigation are in conformity with the earlier worker Khandare *et al.* [7] who reported 0.33

eggs per plant on genotypes IS-18551 and 1.63 eggs per plant on susceptible genotype CSH-9 at 21 DAE.

Per cent Shoot Fly Deadhearts at Fourteen Days after emergence

The data presented in Table 1 indicated significant differences in sorghum germplasms in respect to per cent deadhearts. The dead hearts percentage at 14 DAE, amongst all germplasms ranged from 15.38 to 59.40 per cent. The minimum percentage of deadhearts was noticed in resistant check IS-18551 (15.38%) and IS-2123 (15.64%). These were found at par with ICSB-435 (17.39%), ICSV-705 (18.09%), IS-2146 (18.79%), ICSV-25026 (19.81%). The latter treatments in turn found at par with ICSB-413 (21.09). The entries showed the deadhearts percentage in ascending order *viz.*ICSV-25022, ICSB-444, AKENT-73, ICSV-93046, IS 2205, ICSV-12001, AKSV-181, IS-40615, ICSV-12002, ICSV-12004, ICSV-12003, SPV-669 and AKENT-61-1 in which, 24.93, 26.24, 27.56, 28.54, 31.36, 36.49, 39.28, 41.16, 41.56, 42.50, 45.93, 47.05 and 49.59 per cent dead hearts were recorded, respectively. Whereas, the maximum percentage of deadhearts was recorded in susceptible check DJ-6514 (59.40) and Swarna (58.83). These results are in proximity with the earlier findings by Chamarthi *et al.* [3] who reported significant differences in dead hearts formation in resistant and susceptible cultivars of sorghum due to shoot fly.

Per cent Shoot Fly Dead hearts at Twenty Eight Days After Emergence

It is revealed from the data in Table 1 that there were significant differences within the treatments. The resistant check IS-18551 recorded significantly minimum of 17. 78% deadhearts due to shoot fly at 28 DAE. This was found at par with the entries IS-2123 ICSB-435, IS-2146 and ICSV-705 in which 21.14, 21.50, 21.99 and 22.42 per cent deadhearts were noticed, respectively. The germplasm *viz.* ICSB-413, ICSV-25026, ICSV-25022, ICSB-444, AKENT-73, ICSV-93046, IS-2205 and ICSV-12001 recorded deadhearts percentage within the range of 24.33 to 42.62 per cent. Whereas, maximum percentage of deadhearts was noticed in susceptible germplasms DJ-6514 and Swarna *i.e.* 67.86 and 67.80 per cent, respectively. These findings are on the line of research work carried out by Khandare *etal.* [7] who found resistant check IS-18551 with significantly minimum percentage shoot fly deadhearts on 28 DAE (20.10%) as compared to susceptible check with 86.36 per cent deadhearts.

MORPHO-PHYSIOLOGICAL BASES OF RESISTANCE OF SORGHUM GERMPLASMS

Seedling Vigour at Fourteen Days After Emergence

The data in Table 2 indicated that there were significant differences amongst the sorghum germplasms in respect of seedling vigour measured in 1 to 5 scale. Among the different germplasms, significantly maximum seedling vigour was noticed in IS-2123, *i.e.* 1.33, which was at par with IS-18551 in which 1.66 average seedling vigour was recorded. The resistant check IS-18551 was also found at par with ICSV-705 (2. 33). The entries *viz.*, AKENT-61-1, ICSV-25026, ICSV-12001, ICSB-413, ICSV-93046, ICSV-12002, ICSB-435, ICSV-12003, ICSV-12004, ICSB-444, IS-40615, SPV-669 and IS-2146 showed moderate seedling vigour with range of 2. 66 to 3.66. All these treatments found to be at par among themselves. The minimum seedling vigour was observed in the entries *viz.*AKENT-73, ICSV-25026, AKSV-181, IS-2205, Swarna and DJ-6514 in which 4.00, 4.00, 4.33, 4.66, 4.66 and 4.66 average seedling vigour was recordrd, respectively. The present results on seedling vigour find support in earlier research work carried out by Jayanthi *et al.* [6] who conducted studies on significance of early seedling vigour in sorghum for shoot fly resistance and reported that the resistant lines showed significantly high seedling vigour compared to susceptible parental lines.

Leaf Glossiness at Fourteen Days After Emergence

Glossy seedling expression could be used as a simple and reliable criterion for resistance. The data in Table 2 indicated that there were significant differences amongst the sorghum germplasms in respect of average leaf glossiness in 1 to 5 scale. Among the germplasms significantly maximum leaf glossiness was observed on IS-2123 (1.00) which was

Table 2
Evaluation of sorghum germplasms for shoot fly resistance in relation with morpho-physiological characters

Sr. No.	*Germplasms*	*Average seedling vigour (1 - 5 scale)*	*Average leaf glossiness (1 - 5 scale)*	*Average no. of trichomes/ mm²*
1.	IS 2123	1.33(1.13)*	1.00(1.00)*	3.88(2.08)**
2.	SPV 669	3.33(1.82)	3.66(1.91)	0.54(1.01)
3.	ICSV 705	2.33(1.52)	2.33(1.52)	4.45(2.22)
4.	ICSV 93046	3.00(1.73)	3.00(1.73)	2.41(1.70)
5.	ICSB 413	3.00(1.73)	3.33(1.82)	4.43(2.21)
6.	ICSV 12002	3.33(1.82)	4.00(1.98)	0.57(1.02)
7.	ICSV 12003	3.33(1.82)	4.33(2.07)	2.71(1.79)
8.	ICSV 25022	4.00(2.00)	3.33(1.82)	5.58(2.45)
9.	ICSB 435	3.33(1.82)	2.66(1.62)	6.21(2.58)
10.	IS 2146	3.66(1.91)	2.33(1.52)	6.64(2.67)
11.	ICSV 12004	3.33(1.82)	3.66(1.90)	1.67(1.45)
12.	IS 40615	3.33(1.82)	3.66(1.91)	0.83(1.15)
13.	ICSV 25026	3.00(1.71)	1.66(1.27)	3.86(2.08)
14.	ICSV 12001	3.00(1.71)	3.66(1.91)	0.79(1.13)
15.	AKSV 181	4.33(2.07)	4.33(2.07)	0.43(0.96)
16.	AKENT 73	4.00(1.98)	3.33(1.82)	0.82(1.14)
17.	IS 2205	4.66(2.15)	3.66(1.90)	0.92(1.19)
18.	AKENT 61-1	2.66(1.62)	3.66(1.91)	0.48(0.99)
19.	ICSB 444	3.33(1.82)	3.66(1.90)	5.67(2.48)
20.	SWARNA	4.66(2.15)	4.66(2.15)	0.36(0.92)
21.	DJ 6514 (S)	4.66(2.15)	4.33(2.07)	0.33(0.89)
22.	IS 18551 (R)	1.66(1.27)	1.66(1.27)	6.88(2.71)
'F' test		Sig.	Sig.	Sig.
SE(m)±		0.10	0.10	0.07
CD at 5%		0.29	0.31	0.21

*Figures in parentheses are corresponding square root transformed values.

**Figures in parentheses are corresponding $\sqrt{(x)+0.5}$ transformed values.

at par with IS-18551 and entry ICSV-25026 in which 1.66 average leaf glossiness was noticed. The entries IS-18551 and ICSV-25026 were in turn found at par with IS-2146 (2.33) and ICSV 705 (2.33). These were followed by ICSB-435, ICSV-93046, AKENT-73, ICSV-25022 and ICSB-413 with leaf glossiness of 2.66, 3.00, 3.33, 3.33 and 3.33, respectively. The entries *viz.*, ICSV-12004, ICSB-444, IS-2205, SPV-669, AKENT-61-1, IS-40615 and ICSV-12001 showed moderate leaf glossiness (3.66 each). The minimum leaf glossiness was recorded in Swarna (4.66) followed by DJ-6514 (4.33), AKSV-181 (4.33), ICSV-12003 (4.33) and ICSV-12002 (4.00). The research worker, Gomashe *et al.* [5] reported that leaf glossiness showed resistance to the sorghum shoot fly and noticed positive correlation with shoot fly oviposition and deadhearts and concluded that glossy seedling expression could be used as a simple and reliable criterion for resistance, which supports the present findings.

Leaf Trichome Density at Fourteen Days After Emergence

The data in Table 2 indicated that significantly maximum numbers of trichomes per mm^2 were recorded on the resistant check IS-18551, *i.e.* 6.88 trichomes/mm^2, was statistically at par with germplasms IS-2146 and ICSB 435 in which 6.64 and 6.21 trichomes per square millimeter were recorded, respectively. The latter entries found in turn at par with ICSB-444 (5.67) and ICSV-25022 (5.58). These were followed by ICSV-705, ICSB-413, IS-2123 and ICSV-25026 with trichome density within the range of 4.45 to 3.86 trichomes/mm^2 and found at par among each other. The entries *viz.*, ICSV-12003, ICSV-93046, ICSV-12004, IS-2205, IS-40615, AKENT-73, ICSV-12001, ICSV-12002, SPV-669, AKENT-61-1, AKSV-181 and Swarna recorded trichome density in descending order *i.e.* 2.71, 2.41, 1.67, 0.92, 0.83, 0.82, 0.79, 0.57, 0.54, 0.48, 0.43 and 0.36 trichomes/mm^2. Whereas, minimum numbers of trichomes were observed on susceptible check DJ-6514 *i.e.* 0.33. The results pertaining to trichome density are in accordance with Gomashe *et al.* [5] who revealed that leaf trichome density on abaxial leaf surfaces showed significant negative correlation with shoot fly dead hearts.

Correlation between Shoot Fly Resistance Contributing morpho-physiological Parameters

Correlation describes the interrelationship between different characters. In any biological entity the characters are generally associated with each other. Similarly, to find out the degree of association of shoot fly resistance and its contributing morpho-physiological characters, correlation coefficients among the different characters have been worked out.

The results in Table 3 revealed that seedling vigour recorded significant and positive association with number of shoot fly eggs at 14 DAE (0.536) and 21 DAE (0.613), deadhearts percentage at 14 DAE (0.494) and 28 DAE (0.551). As discussed by Jayanthi *et al.* [6] high early growth rate was associated with shoot fly resistance. The earlier worker Chamarthi *et al.* [3] also reported positive and significant association of seedling vigour with susceptibility to shoot fly.

Similarly, correlation studies revealed significant and positive relationship between leaf glossiness and number of shoot fly eggs per plant at 14 DAE (0.712) and 21 DAE (0.626). Moreover, simple correlation studies confirmed that there is a significant and positive relationship with leaf glossiness and shoot fly deadhearts at 14 DAE (0.688) and 28 DAE (0.798). The results of present studies on correlation of leaf glossiness with eggs per plant and deadhearts finds support in the work carried out by Dhillon *et al.* [4] who reported that correlation coefficient of leaf glossiness was significant and positive for shoot fly eggs per plant and deadhearts.

The results on leaf trichome density on abaxial surface recorded negative and significant association with number of eggs per plant at 14 DAE (–0. 772), 21 DAE (–0.614) and deadhearts percentage at 14 DAE (–0. 621), 28 DAE (–0. 813). Trichomes may contribute to the expression of antibiosis to shoot fly in sorghum as trichomed cultivars hinder the movement of newly hatched larvae to the base of the whorl. Trichomes can act as insect resistance mechanism by limiting the insect contact with plant. Sandhu *et al* [10] also observed that number of trichomes per unit area was negatively correlated with number of eggs per plant and deadhearts percentage. Similarly, Shekharappa [12] also observed negative and significant correlation between number of trichomes on the lower surface and mean per cent deadhearts.

Table 3
Correlation between shoot fly resistance contributing morpho-physiological parameters

	No. of eggs/plant		*Deadheart (%)*	
Traits	*14 DAE*	*21 DAE*	*14 DAE*	*28 DAE*
Seedling vigour	0. 536*	0. 613*	0. 494*	0. 551*
Leaf Glossiness	0. 712*	0. 626*	0. 688*	0. 798*
Trichome density	–0. 772*	–0. 614*	–0. 621*	–0. 813*

* Correlation coefficients significant at $P = 0.05 (r = 0.423)$.

CONCLUSION

Finally it is concluded that sorghum germplasms *viz.*IS-18551, IS-2123, ICSB-435, ICSV-705, IS-2146, ICSB-413 and ICSV-25026 proved effective to combact the menace of shoot fly, *Atherigona soccata* resulted into lower shoot fly damage. Moreover, these germplasms also showed the association of the various morpho-physiological traits regulating the resistance in sorghum to shoot fly.

Thusgerm plasm lines *viz.*IS-18551, IS-2123, ICSB-435, ICSV-705, IS-2146, ICSB-413 and ICSV-25026 could be used in breeding programme for shoot fly resistance. The morpho-physiological characteristics conferring resistance to shoot fly, which could be used to select shoot fly resistant lines from the breeding materials for use in sorghum improvement.

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