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EVALUATION OF MULTICUT FODDER SORGHUM GERMPLASM FOR RESISTANCE TO MAJOR DISEASES AND INSECT-PESTS

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SUMMARY

Foliar diseases (anthracnose, grey leaf spot, zonate leaf spot) and insect-pests (sorghum shoot fly, stem borer) are major restraints in the cultivation of forage sorghum. Host plant resistance is one of the alternative components to manage sorghum shoot fly, stem borer and foliar diseases. In the present study, sixty-one sorghum genotypes were screened for varied levels of resistance during *Kharif* 2021 to 2023. Eleven genotypes *viz*., SPH 1967, SPH 1993, SPH 1994, SPH 1996, SPV 2861, SPH 1997, SPH 2018, SPH 2042, SPH 2043, SPH 2045 and SPV 3045 showed highly resistant disease reaction against sorghum anthracnose and grey leaf spot. Multi-resistance to both shoot fly and stem borer as observed in the entries SPV 2861 and SPV 2955. Entries SPH 1997 and SPV 3046 were found promising against shoot fly, while SPH 1934 and SPH 2047 had least stem borer dead heart formation.

Key words: Sorghum, screening, resistance, foliar diseases, shoot fly, stem borer

Sorghum [*Sorghum bicolor* (L.) Moench] is an important fodder as well as grain crop grown in India and worldwide. In Punjab, sorghum is mainly cultivated as fodder crop by the dairy farmers. Inspite of its adaptability to arid, semi-arid and tropic climatic conditions and good quality fodder production, this crop is prone to foliar diseases like grey leaf spot, anthracnose and zonate leaf spot causing significant yield losses across all its growing areas (Tesso *et al.*, 2012). Sorghum grey leaf spot is caused by *Cercospora sorghi* Ellis and Everhart & Edgerton ex Deightonis, anthracnose, incited by *Colletotrichum sublineolum* Hann. Kabát et Bub. (syn. *C.graminicola* (Ces.) G.W. Wilson) and zonate leaf spot is caused by *Gloeocercospora sorghi* D.C. Bain & Edgerton ex Deighton. These foliar pathogens could infect all aboveground parts of the plant and cause significant economic losses in terms of green fodder and grain yield (Aruna *et al.*, 2011). Many strategies like chemical are used for management of diseases and pests, control, agronomic practices and host plant resistance, however, these strategies are not always feasible.

Sorghum shoot fly (*Atherigona soccata* (Rondani) that belongs to the order Diptera and family Muscidae and spotted stem borer (*Chilo partellus* Swinhoe) that belongs to order Lepidoptera and family Crambidae are the major pests that adversely affect fodder sorghum in terms of quality and productivity. In India, yield losses due to attack of shoot fly and stem borer varies from 50 to 90% (Dhaliwal *et al.*, 2015). Shoot fly attacks sorghum 5–25 days after emergence and spotted stem borer attacks the crop from two weeks after germination till harvesting. Up to 80% damage is caused by *Chilo partellu*s (Panwar *et al.,* 2000).

Hence, host plant resistance is the key method to protect the sorghum fodder crop against foliar diseases and insect pests. To achieve this objective, the present studies were undertaken to screen the multicut sorghum germplasm for resistance to grey leaf spot, anthracnose, zonate leaf spot, shoot fly and stem borer in different trials under AICRP on Sorghum for three *Kharif* seasons of 2021 to 2023.

MATERIALS AND METHODS

Experimental details

The experiments were conducted at Forage, Millet and Nutrition Farm, Department of Plant Breeding and Genetics, Ludhiana (Punjab) during *Kharif* season for the evaluation of different germplasm lines against foliar diseases and insect pests as part of All India Coordinated Research Project (AICRP) on Sorghum. The field trials were conducted for three years during *Kharif* season from 2021 to 2023. The trial viz., Initial and Advanced Varietal and Hybrid Trial – Multicut (IAVHT MC) sorghum was conducted every season separately one for diseases and another for insect-pests for three years. A total of sixty-one sorghum germplasm lines were evaluated along with national checks (CSH 13, CSV 30F, CSV 21F, CSV 32F, CSV 33MF & CSH 24 MF), resistant checks (insects) (IS 18551, IS 2312 & IS 2205), susceptible checks (insects) (Swarna and DG 6514) and local checks PSC 4 (shoot fly and stem borer) and SL 44 (foliar diseases). The experiments were laid out in a Randomized Complete Block Design (RCBD) with three replications per genotype with two rows of two meter length each. The crop was sown during last week of June as per the recommended agronomic practices (Anonymous, 2021) and thinning was done at 10 days after emergence to maintain the optimum plant stand. During the cropping season, the mean temperature ranged from 22.0 to 39.3°C, while the relative humidity ranged from 61 to 92%. A total of 535.4 mm of annual average rainfall was recorded (Department of Climate Change and Agricultural Meteorology) (Fig. 1).

Disease data recording

Disease severity was assessed at 40 and 70 days after emergence and the ratings were based on visual estimate of percent leaf area infected with leaf spots. Disease severities foliar diseases (percentage of leaf area covered by lesions) were recorded on a 1-to-9 rating scale (Xu *et al*., 2020). Five classes of reaction were considered: HR = highly resistant reaction, infection type 1; R = resistant reaction, including infection types as 2, 3; MR = moderately resistant reaction, including infection types 4, 5; S = susceptible reaction, including infection types 6 and 7; HS = highly susceptible reaction, including infection types 8 and 9.

Shoot fly and stem borer

Moist fish meal was broadcasted evenly at 5 days after germination to ensure uniform infestation of sorghum shoot fly in the test material (Nwanze, 1997). The intensity of glossiness was recorded at 10 days after emergence (DAE) on a scale of 1–5, where 1 is high intensity of glossiness and 5 is non-glossy. At the same time, seedling vigour was also scored as per scale of 1–10, where 1 represents high vigour (plants showing maximum height, leaf expansion and robustness) and 10, low vigour (plants showing minimum growth, less leaf expansion and poor adaptation). The observations on shoot fly eggs (from 5 randomly selected plants) were recorded from all the test entries at 2-3 weeks after germination (Prasad *et al*., 2015). Dead heart incidence caused by shoot

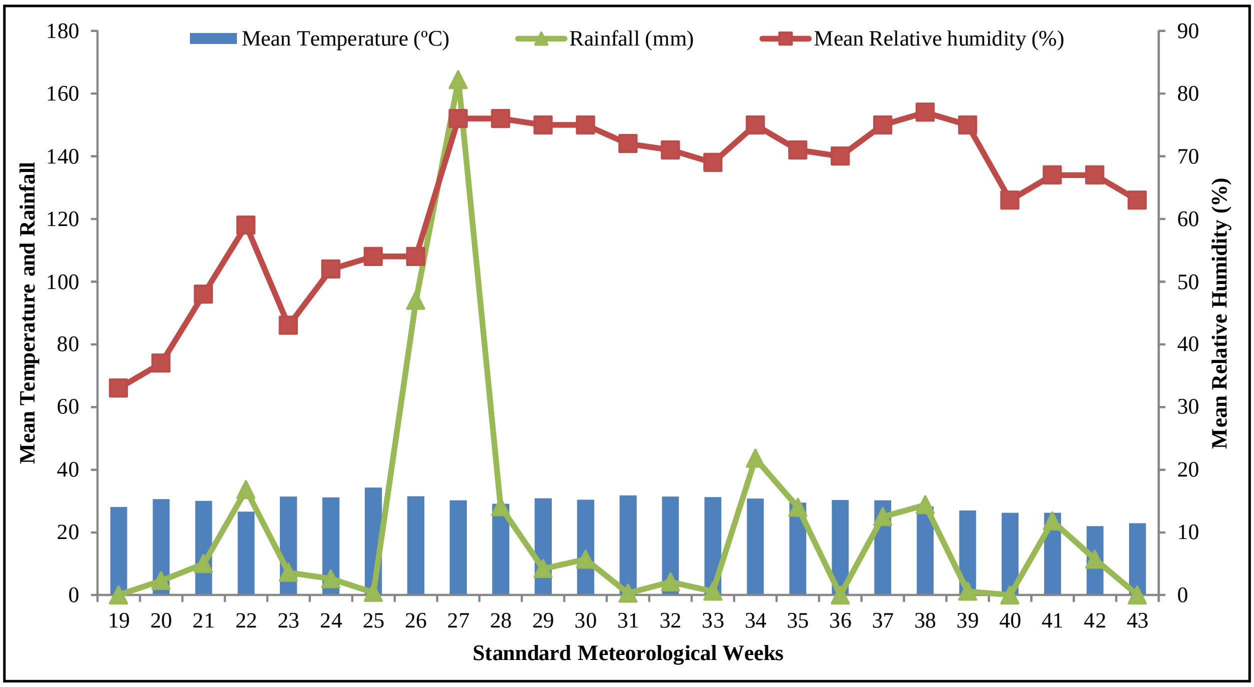

Fig. 1. Mean weekly weather data prevailed during the study period.

fly was also recorded. The leaf feeding by *C. Partellus* larvae was assessed, five weeks after emergence on a 1 to 9 scale (Sharma *et al.*, 1992). Dead heart formation was recorded at 45 DAE.

Data analysis

All experimental data were analyzed with SAS software (version 9.3). Analysis of variance (ANOVA) was used to assess effect of trial to determine the significant difference between the experimental repeats ($p \leq 0.05$).

RESULTS AND DISCUSSION

Diseases

Sorghum germplasm lines were screened for disease resistance against grey leaf spot, anthracnose and zonate leaf spot from *Kharif* 2021 to 2023 under IAVHT Multicut trials. In IAVHT Multicut trial, during *Kharif* 2021disease pressure of grey leaf spot on sorghum was moderate to high (4.7 to 6.3) followed by anthracnose (1.0 to 6.0) and less than 2.0 in case of zonate leaf spot. All the entries were found susceptible to diseases except SPH 1967, 1993, 1994 1996, 1997 and SPV 2861 with highly resistant reaction to diseases (Table 1). One line SH 1935 showed moderately resistant reaction to grey leaf spot. During 2022, the disease pressure of anthracnose and grey leaf spot was ranged between 1.7 to 4.3 and 3.0 to 8.0 in a 1-9 scale respectively (Table 2). Among all the lines, only one entry SPH 1966 exhibited resistant reaction to grey leaf spot and anthracnose out of 15 lines. Rest of the lines were found susceptible to grey leaf spot. In *Kharif* 2023, lines were screened for diseases like grey leaf spot, anthracnose and leaf blight. The disease score was ranged from 1.3 to 5.0 for anthracnose, 1.0 to 7.0 for grey leaf spot and 1.0 to 5.0 for leaf blight (Table 3). Among eighteen lines, SPH 2042, 2043, 2045 and SPV 3045 showed highly resistant disease reaction to grey leaf spot and anthracnose respectively. Rest of the entries were susceptible to diseases.

All the entries showed variation in disease reactions towards foliar diseases infecting forage sorghum (Fig. 2) in the present study. These findings justify the findings of other researchers (Thakur *et al.*, 2007; Cuevas *et al.*, 2017; Anitha *et al.*, 2020). A plenty of sorghum genetic diversity is available globally

TABLE 1

Evaluation of genotypes for shoot fly, stem borer and diseases in IAVHT (Multi cut) trial during *Kharif* 2021

S. No.	Entries	No. of eggs/5 plants at 14 DAE	Seedling vigour (1-5)	Seedling glossiness (1-5)	Shoot fly dead-hearts (%) 28 DAE	Stem borer leaf injury score (1-9) 35 DAE	Stem borer dead-hearts (%) 45 DAE	Anthracnose (1-9)	Grey leaf spot (1-9)
1.	SPH1933	4.3	2.3	4.0	39.9	1.7	5.2	1.0	1.0
2.	SPH1934	4.3	3.0	2.7	33.5	1.0	3.4	1.0	1.0
3.	SPH1935	4.3	2.7	4.0	43.0	1.0	6.8	2.3	4.7
4.	SPH1966	5.7	3.3	3.0	59.9	1.3	5.6	1.0	1.0
5.	SPH1967	4.3	2.7	3.0	48.6	1.7	7.8	1.0	1.0
6.	SPH1970	5.0	3.3	4.0	58.1	2.0	6.7	3.7	6.3
7.	SPH1993	6.3	3.3	3.3	79.9	1.3	5.3	1.0	1.0
8.	SPH1994	4.0	2.7	3.3	51.1	1.3	4.9	1.0	1.0
9.	SPH1995	4.3	2.7	3.0	49.4	1.7	6.5	1.0	1.0
10.	SPH1996	5.7	2.7	3.7	66.6	1.7	5.6	1.0	1.0
11.	SPH1997	2.3	3.0	3.0	23.7	1.3	5.2	1.0	1.0
12.	SPH1998	4.3	3.3	4.0	57.4	1.3	5.2	1.0	6.3
13.	SPV2861	1.7	3.3	3.0	19.0	1.0	3.0	1.0	1.0
14.	CSH 24MF	3.7	3.3	2.7	39.6	1.3	4.1	1.0	1.0
15.	CSV 33MF	2.7	3.0	3.0	31.9	1.0	3.0	1.0	4.0
16.	CSH 43MF	4.7	3.0	3.0	53.6	1.0	3.2	1.0	1.0
17.	Local check	3.3	3.0	2.0	37.7	1.0	4.2	6.0	6.7
18.	IS 18551 (RC)	1.3	3.0	1.7	12.3	1.0	6.4	-	-
19.	IS 2312 (RC)	2.0	3.0	2.3	17.0	1.0	3.7	-	-
20.	IS 2205 (RC)	2.0	3.3	1.7	15.0	1.0	3.4	-	-
21.	Swarna (SC)	4.7	3.3	4.0	56.7	1.7	4.1	-	-
	C.D. (5%)	1.4	0.7	0.9	9.5	0.7	3.9	1.303	1.786

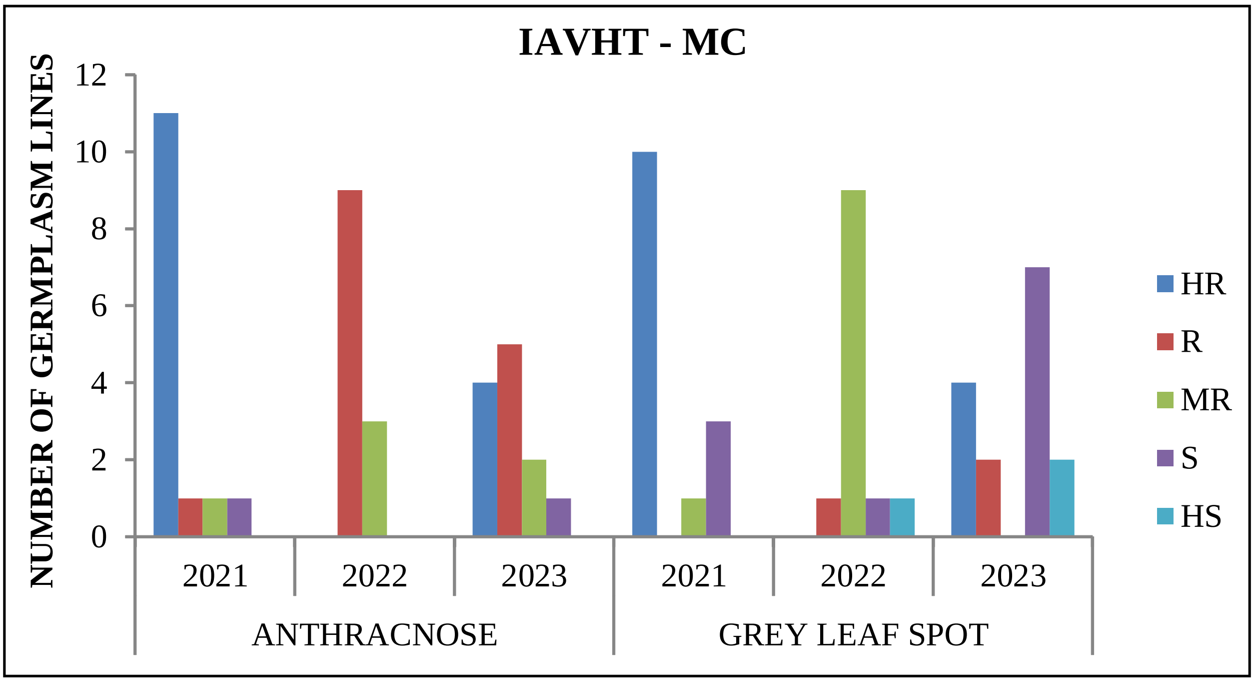

Fig. 2. Categorization of different germplasm lines into various disease reaction groups against anthracnose and grey leaf spot in IAVHT-MC trial.

that has an utmost significance in sorghum breeding program aimed to improve resistance against diseases in sorghum (Upadhyaya *et al.*, 2016; Cuevas *et al.*, 2017; Mengistu *et al.*, 2020). For the identification of novel sources of resistance within vast sorghum germplasm collection, various resistance-screening programs have identified several resistant genotypes which can be used in sorghum breeding. A total of 97 genotypes from Mali were evaluated for anthracnose response and about 46% of genotypes exhibited resistant response to anthracnose infecting sorghum crop (Erpelding, 2010). Likewise, 68 accessions were screened against diseases in sorghum and nine showed variable disease reactions from highly resistant to resistant and 34 were found susceptible (Cuevas *et al.*, 2014). Similarly, 167 accessions of sorghum were screened under field conditions during 2015 and 2016 and among them 27 and 38 accessions were showed highly resistant to resistant diseases reaction to anthracnose respectively (Xu *et al.*, 2020). Among 43 germplasm lines screened for foliar diseases and shootfly resistance, eleven lines were reported resistant to anthracnose and four were resistant to shoot fly (Atri *et al.*, 2021).

Insect-pests

During *Kharif* 2021, the total number of eggs per 5 plants was in range of 1.7- 6.3 in test entries as compared to 1.3- 2.0 in resistant checks and 4.7 in susceptible checks. The egg count per 5 plant was least in SPV 2861 (Table 1). The seedling vigour and glossiness in test entries ranged from 2.3 to 3.3 and 1.7 to 4.0, respectively. The per cent dead-hearts inflicted due to shoot fly damage across all test entries varied significantly from 19- 79.9 per cent with significantly lesser number of dead-hearts observed in SPV 2861 followed by SPH 1997 which was on par with it. The highest number of shoot fly dead-hearts were recorded in SPH 1993. There was moderate incidence of stem borer *C. partellus* in the form of leaf injury rating (1.0 – 2.0) and dead-hearts (3.0 – 7.8%). Entry SPV 2861 and SPH 1934 had low incidence of stem borer.

In 2022, the total number of shoot fly eggs per 5 plants were in range of 1.3 – 5.7 in test entries as compared to 1.0-1.7 in resistant checks and 4 in susceptible check. The egg count per 5 plants was lesser in CSV 33 MF followed by SPV 2955 (Table 2). The seedling vigour and glossiness in test entries ranged from 2.0 to 3.0 and 2.0 to 3.7, respectively. The dead hearts due to shoot fly damage varied significantly from 12.3- 79.2 per cent with significantly lesser number of dead hearts observed in CSV 33 MF followed by SPV 2955, and highest number of shoot fly dead hearts were recorded in SPH 1996. There was moderate damage of stem borer *C. partellus* in the form of leaf injury rating (1.0- 2.0) and dead hearts

TABLE 2

Evaluation of genotypes for shoot fly, stem borer and diseases in IAVHT (Multi cut) trial during *Kharif* 2022

S. No.	Entries	No. of eggs/5 plants at 14 DAE	Seedling vigour (1-5)	Seedling glossiness (1-5)	Shoot fly dead-hearts (%) 28 DAE	Stem borer leaf injury score (1-9) 35 DAE	Stem borer dead-hearts (%) 45 DAE	Anthracnose (1-9)	Grey leaf spot (1-9)
1.	SPH1966	4.0	3.0	3.3	60.4	1.3	4.5	1.7	3.0
2.	SPH1967	4.7	2.3	3.3	66.9	2.0	7.4	2.0	4.3
3.	SPH1970	5.3	2.0	3.7	67.8	2.0	8.1	3.3	5.0
4.	SPH1994	4.3	2.3	3.0	55.0	1.7	6.9	1.7	4.3
5.	SPH1996	5.7	2.3	3.7	79.2	2.0	8.9	3.0	5.3
6.	SPH1998	5.3	2.0	3.7	78.9	1.3	6.1	1.3	3.3
7.	SPH2018	3.7	2.3	3.3	46.5	1.7	7.0	2.3	4.3
8.	SPH2019	4.0	2.3	3.3	59.2	1.3	7.9	2.7	5.0
9.	SPH2020	2.7	2.7	3.0	37.9	1.7	6.9	2.0	3.3
10.	SPV2954	3.0	2.3	2.7	39.9	1.0	4.7	2.0	4.3
11.	SPV2955	1.7	3.0	2.0	19.0	1.3	4.4	2.3	3.3
12.	CSH 24MF	2.7	2.7	3.0	36.1	1.3	3.6	1.7	2.0
13.	CSV 33MF	1.3	3.0	2.7	12.3	1.0	2.8	2.0	5.0
14.	CSH 43MF	2.0	3.0	2.7	24.9	1.3	3.6	3.0	4.7
15.	Local Check	2.0	2.7	2.0	29.3	1.3	5.0	4.3	8.0
16.	IS 2205 (RC)	1.7	3.0	1.7	17.3	2.0	1.4	-	-
17.	IS 18551 (RC)	1.0	3.0	1.7	7.2	1.7	1.4	-	-
18.	Swarna (SC)	4.0	2.7	3.7	49.3	1.7	7.5	-	-
	C.D. (5%)	1.75	0.8	1.08	11.5	0.9	1.78	NS	2.647

TABLE 3

Evaluation of genotypes for shoot fly, stem borer and diseases in IAVHT (Multi cut) trial during *Kharif* 2023

S. No.	Entries	No. of eggs/5 plants at 14 DAE	Seedling vigour (1-5)	Seedling glossiness (1-5)	Shoot fly dead-hearts (%) 28 DAE	Stem borer leaf injury score (1-9) 35 DAE	Stem borer dead-hearts (%) 45 DAE	Anthracnose (1-9)	Grey leaf spot (1-9)	Leaf blight (1-9)
1.	SPH1998	4.3	3.0	2.0	44.3	2.7	13.6	2.0	6.7	1.0
2.	SPH2018	3.0	2.7	1.7	28.1	2.3	11.2	1.3	2.3	3.7
3.	SPH2019	4.0	2.7	3.0	51.3	2.7	12.7	2.3	7.0	1.0
4.	SPH2039	4.0	3.0	2.3	39.0	2.0	9.5	1.3	6.0	1.0
5.	SPH2040	4.0	3.0	2.7	50.0	2.3	10.6	2.7	7.3	1.0
6.	SPH2041	4.3	2.3	3.7	48.8	2.3	12.6	1.7	6.0	1.0
7.	SPH2042	3.0	2.3	3.3	33.0	1.7	7.9	1.0	1.0	4.0
8.	SPH2043	3.7	2.3	3.3	41.7	2.3	11.8	1.0	1.0	4.0
9.	SPH2044	4.7	2.3	3.0	52.7	2.3	12.9	1.0	3.3	4.0
10.	SPH2045	3.0	2.7	3.0	31.7	2.0	10.6	1.0	1.0	5.0
11.	SPH2046	2.7	2.7	3.0	30.4	2.3	12.5	3.0	7.0	1.0
12.	SPH2047	3.7	2.7	3.0	44.4	2.7	14.8	2.7	7.0	1.0
13.	SPV3045	3.3	3.0	2.0	38.3	2.3	13.6	1.0	1.0	5.0
14.	SPV3046	2.0	2.7	3.0	20.4	2.7	14.1	3.3	7.0	1.0
15.	CSH 24MF	2.3	2.7	3.0	24.0	2.7	12.5	1.0	1.0	5.3
16.	CSV 33MF	2.0	3.0	2.7	22.3	1.7	6.9	2.0	7.0	1.0
17.	CSH 43MF	3.3	2.7	2.7	37.8	2.7	11.7	1.0	1.0	5.0
18.	Local Check	2.3	3.0	2.0	29.1	2.0	9.8	5.0	6.8	4.0
19.	IS 18551(RC)	1.7	3.0	1.3	15.1	2.0	15.4	-	-	-
20.	IS 2205(RC)	1.7	3.0	1.7	15.8	2.7	14.2	-	-	-
21.	Swarna(SC)	4.7	1.7	4.0	52.2	3.3	14.7	-	-	-
22.	DJ 6514(SC)	3.7	2.0	3.7	43.8	3.7	9.4	-	-	-
	C.D. (5%)	1.3	0.9	1.2	9.8	1.2	NS	0.930	1.364	1.357

(2.8-8.9%). Entry CSV 33 MF had the lowest incidence of stem borer, and entries CSH 43 MF, SPV 2955, SPH 1966 and SPV 2954 were on par with it.

During *Kharif* 2023, in case of shoot fly, a total number of eggs per 5 plants were in the range of 2.0- 4.7 in test entries as compared to 1.7 in resistant checks and 4.7 in susceptible checks. The egg count per 5 plants was least in CSV 33 MF and SPV 2046 (Table 3). The seedling vigour and glossiness in test entries ranged from 2.3 to 3.0 and 1.7 to 3.7, respectively. The per cent dead hearts caused by shoot fly across all entries varied significantly from 20.4-52.7 per cent with significantly lesser number of dead hearts observed in SPV 3046, while maximum were observed in SPH 2044. There was moderate damage of stem borer *C. partellus* in the form of leaf injury rating (1.7 – 2.7) and dead hearts (6.9- 14.8%). Entries CSV33 MF and SPH 2042 had least incidence of stem borer whereas SPH 2047 had the highest.

Sorghum germplasm has been extensively screened for resistance to *Atherigona soccata* and *Chilo partellus* over the past several years and varying levels of resistance has been reported (Prem Kishore 2001, Deshpande *et al.* 2003, Aruna *et al.* 2011, Kumar *et al.*, 2024). Our findings are in accordance with those of Prasad *et al.* (2015) that identified morphological parameters as reliable indicators for distinguishing resistant and susceptible sorghum entries against shoot fly and stem borer. Earlier Dhillon *et al.* (2005) and later Mohammed *et al.* (2016, 2018) established positive correlation of high seedling vigour and leaf glossiness at seedling stage with resistance and negative with dead hearts. Thus, sorghum genotypes showing reduced shoot fly infestation had more plant vigour and glossy leaves, which agrees with work of Kumar *et al.* (2025).

CONCLUSION

It is concluded from the study that eleven genotypes *viz.*, SPH 1967, SPH 1993, SPH 1994, SPH 1996, SPV 2861, SPH 1997, SPH 2018, SPH 2042, SPH 2043, SPH 2045 and SPV 3045 showed highly resistant disease reaction against sorghum anthracnose and grey leaf spot. Entries viz., SPV 2861and SPV 2955 showed multi-resistance to both the insect pests. Entries SPH 1997 and SPV 3046 were found promising against shoot fly, while SPH 1934 and SPH 2047 had least stem borer deadheart formation. The genotypes exhibiting resistance to shoot fly, stem borer and fungal diseases across seasons can be effectively utilized in breeding program of forage sorghum.

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