

## SCREENING OF SINGLE CUT FODDER SORGHUM GENOTYPES AGAINST 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, fifty three sorghum genotypes were screened for varied levels of resistance during *Kharif* 2021 to 2023. Twelve genotypes *viz.*, SPH1985, SPH 1905, SPV2704, SPV2705, SPV2797, SPV2800, SPV 2985, SPV 2587, SPV 2451, SPV 2881, SPV2886 and SPV 2887 showed resistant disease reaction to anthracnose and grey leaf spot of sorghum. Entries namely SPV2800, SPV2878, SPV 2801, SPV2886 and SPV 2804 showed least percent dead hearts caused by shoot fly, while entries SPV 2800, SPV 2801 and SPV 2886 were also promising against stem borer.

**Key words:** Sorghum, screening, resistance and foliar diseases

Sorghum [*Sorghum bicolor* (L.) Moench] is one of the widely cultivated and most important cereal crops after wheat, rice and maize in the world. It is an essential dietary staple of people in more than 30 countries (Smith and Frederiksen, 2000). It has great significance as a source of food, fodder, fiber and fuel across a range of environments and production systems. Sorghum is an annual crop that is capable of tolerating high temperatures and low rainfall conditions, thus, making it suitable option for dry areas (Costa *et al.*, 2012). In India, sorghum is one of the important fodder crops occupies 2.6 million hectare of area and grown in North Western, Hilly, Central and Southern regions of India (Anonymous, 2013). It meets primary need of fodder during *Kharif* and summer seasons. Apart from its ability to tolerate adversities of environment, various foliar diseases like anthracnose (*Colletotrichum sublineolum* Hann. Kabát et Bub. (syn. *C. graminicola* (Ces.) G.W. Wilson)) and grey leaf spot (*Cercospora sorghi* Ellis and Everhart & Edgerton ex Deighton) are the key impediments in the successful cultivation of sorghum. The impact of foliar diseases not only hampers the quality and nutritive value of fodder as well as grain yield (Pande *et al.*, 2003), but also results in the reduction of income from fodder sale and milk production (Rama *et al.*, 2000). Yield losses as high as 50% has been reported due to foliar diseases with prevailing high temperatures and wet weather (Tesso, 2012).

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 major pests that adversely affects the fodder sorghum in terms of quality, production and productivity. In India, yield losses due to attack of shoot fly and stem borer varies from 50 to 90% (Kahate *et al.*, 2014; 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 resulting in “deadheart” symptoms.

Management of diseases and pests infecting sorghum becomes a great challenge due to diversity within the species, adaptability to wide host range, diverse weather conditions and less availability of resistant sources further aggravates the challenge. Several approaches have been used to reduce the losses caused by foliar pathogens including fungicide application, biological control and host plant resistance (Kwodaga *et al.*, 2019; Xu *et al.*, 2020; Atri *et al.*, 2022). Although, number of chemicals have been found effective but reliance on chemical management is not always feasible due to number of problems like environment and soil health, human and animals (Sharma *et al.*, 2012). 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 single cut sorghum germplasm for resistance to grey leaf spot, anthracnose, shoot fly and stem borer in different trials under AICRP on Sorghum for three *Kharif* seasons from 2021 to 2023.

**MATERIALS AND METHODS**

**Experimental details**

The experiments were conducted at Ludhiana (Punjab) during *Kharif* season for the evaluation of different germplasm linesto foliar diseases 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 namely Advanced Varietal and Hybrid Trial - Single cut (AVHT SC) sorghum one for diseases and another for insect-pests were conducted every season separately for three years. A total of fifty three 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

meters 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 was 61 to 92%. A total of 535.4 mm of annual average rainfall was received (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

TABLE 1  
Evaluation of genotypes for shoot fly, stem borer and diseases in AVHT (Single cut) trial during *Kharif* 2021

S. No.	Entries	No. of eggs/5 plants at 14 DAE	Shoot fly dead-hearts (%) 28 DAE	Seedling vigour (1-5)	Seedling glossiness (1-5)	Stem borer leaf injury score (1-9) 35 DAE	Stem borer dead-hearts (%) 45 DAE	Anthracnose (1-9)	Grey leaf spot (1-9)
1.	SPH1985	4.3	45.8	3.0	3.7	1.3	6.6	2.3	3.0
2.	SPV2704	2.0	25.2	3.7	1.7	1.0	4.0	1.0	2.7
3.	SPV2705	4.3	54.2	3.3	2.0	1.3	6.9	1.0	2.3
4.	SPV2797	2.3	28.3	3.3	2.0	1.3	4.7	1.0	2.0
5.	SPV2800	1.0	18.7	3.0	2.7	1.0	3.5	1.0	2.3
6.	SPV2801	1.7	20.4	3.0	3.3	1.0	3.4	1.0	1.0
7.	CSH36F	2.0	29.8	3.0	2.7	1.3	6.7	1.0	1.0
8.	CSV 30F	3.0	29.1	3.0	2.7	1.0	5.6	1.0	2.7
9.	CSV 35F	1.7	25.5	2.7	3.0	1.3	4.8	1.0	1.0
10.	CSH 40F	2.7	31.2	3.0	2.7	1.7	6.4	1.0	4.3
11.	CSV 21F	2.7	23.2	3.0	1.7	1.3	4.9	1.0	3.0
12.	Local Check	1.3	26.9	3.0	2.3	1.0	3.4	5.0	8.0
13.	IS 18551 (RC)	2.3	16.5	3.0	1.7	1.0	3.6	-	-
14.	IS 2312 (RC)	1.7	12.5	3.3	2.3	1.3	4.5	-	-
15.	IS 2205 (RC)	2.7	20.0	3.3	1.7	1.0	3.8	-	-
16.	Swarna (SC)	4.7	44.7	3.3	4.3	1.0	4.0	-	-
	C.D. (5%)	1.5	10.4	NS	1.1	0.7	2.1	1.13	NS

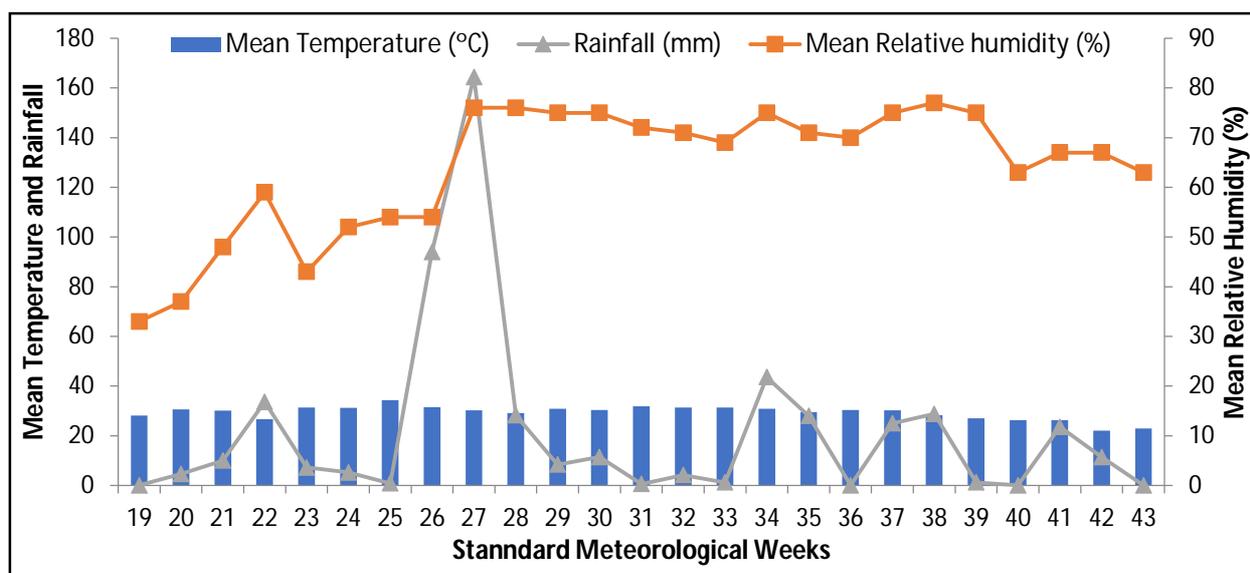


Fig. 1. Mean weekly data prevailing during the study period.

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. Seedling vigour was scored at 10 DAE on a 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) and per cent deadhearts were recorded from all the test entries at 2–3 weeks after germination (Prasad *et al.*, 2015). In case of stem borer, leaf feeding by larvae was assessed, five weeks after emergence on a 1–9 rating scale (Sharma *et al.*, 1992). Incidence of deadhearts was recorded at 45 days after emergence.

### 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 ( $p < 0.05$ ).

## RESULTS AND DISCUSSION

### Foliar diseases

Sorghum germplasm lines were screened for disease resistance against grey leaf spot, anthracnose and zonate leaf spot from Kharif 2021 to 2023 under

AVHT Single cut trials. In AVHT Single cut trials, during 2021, disease pressure of grey leaf spot and anthracnose was ranged from 1.0 to 5.0 and 2.0 to 8.0 on 1 – 9 scale. Germplasm line SPV 2801 was found highly resistant and SPH1985, SPV2704, 2705, 2797 and SPV2800 were resistant to grey leaf spot and anthracnose diseases (Table 1). During 2022, grey leaf spot and anthracnose were observed in the range of 2.2 to 7.7 on 1–9 scale. Entries SPH1985, 2006, SPV2797, 2800, 2801, 2828 and SPV2881 were found moderately resistant against both the diseases of sorghum (Table 2). In 2023, foliar diseases were ranged from 2.0 to 7.7 and other diseases like leaf blight and zonate leaf spot were noticed in traces. Entry SPV 2985 was grouped into highly resistant category, SPV 2881, 2886 and SPV 2887 were grouped into resistant category and remaining entries were found moderately resistant (SPV 2879, 2883 and SPV 2884) and rest were found susceptible to diseases (Table 3 & Fig. 2).

All the entries evaluated in the present study exhibited variation in their disease reactions to foliar pathogens infecting forage sorghum. These results corroborate earlier findings of Thakur *et al.* (2007), Cuevas *et al.* (2017) and Anitha *et al.* (2020). A substantial amount of sorghum genetic diversity is available globally, which holds great significance for breeding programs aimed at improving disease resistance (Upadhyaya *et al.*, 2016; Mengistu *et al.*, 2020). To identify novel sources of resistance within extensive sorghum germplasm collections, several resistance-screening efforts have reported promising

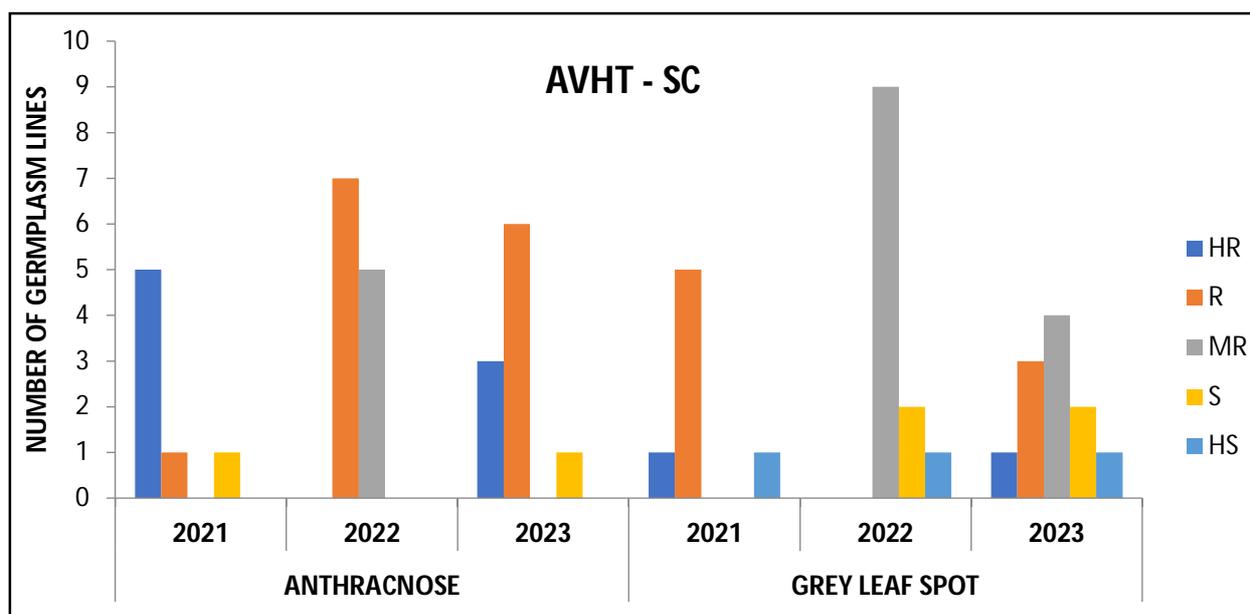


Fig. 2. Categorization of different germplasm lines into various disease reaction groups against grey leaf spot and anthracnose in AVHT-SC trial.

genotypes that can be utilized in sorghum improvement. For instance, 97 genotypes from Mali were evaluated for anthracnose resistance, of which about 46% showed resistant reactions (Erpelding, 2010). Similarly, Cuevas *et al.* (2014) screened 68 accessions and identified nine with disease reactions ranging from highly resistant to resistant, whereas 34 were susceptible. In another study, 167 sorghum accessions were screened under field conditions during 2015 and 2016, and 27 and 38 accessions, respectively, displayed highly resistant to resistant reactions to anthracnose (Xu *et al.*, 2020). Atri *et al.* (2021) evaluated 43 germplasm lines for two seasons and reported eleven lines resistant to anthracnose and four resistant to shoot fly.

### Shoot fly and stem borer

During *Kharif* 2021, the total number of eggs per 5 plants was in range of 1.7- 4.3 in test entries as compared to 1.3- 2.0 in resistant checks and 4.7 in susceptible checks. The egg count per 5 plants was least in SPV 2800 (Table 1). The seedling vigour and glossiness in test entries ranged from 2.7 to 3.7 and 1.7 to 3.7, respectively. The per cent dead-hearts inflicted due to shoot fly damage across all test entries varied significantly from 18.7- 54.2 per cent with significantly less number of dead-hearts observed in SPV 2800 followed by SPV 2801 and SPV 2704, which were on par with it. The highest number of shoot fly dead-hearts were recorded in SPV 2705. There was

moderate incidence of stem borer *Chilo partellus* in the form of leaf injury rating (1.0 – 1.7) and dead-hearts (3.4 - 6.9). Entry SPV 2800, SPV 2801 and SPV 2704 had low incidence of stem borer. In 2022, in case of shoot fly, the total number of eggs per 5 plants was in range of 1.7 – 3.0 in test entries as compared to 1.0-2.7 in resistant checks. The egg count per 5 plants was lesser in SPV 2800 and SPV 2878 (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 13.7- 39.6 per cent with significantly less number of dead hearts observed in SPV 2800 and SPV 2878, and highest number of shoot fly dead hearts were recorded in SPV 2884. There was moderate damage of stem borer *Chilo partellus* in the form of leaf injury rating (1.0- 1.3) and dead hearts (11.2-14.5%). Entry SPV 2879 had the lowest incidence of stem borer, and entries SPV 2885, SPV 2881, SPV 280 and SPV 2801 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 1.3- 4.0 in test entries as compared to 1.3-1.7 in resistant checks and 5.7 in susceptible checks. The egg count per 5 plants was least in SPV 2886 (Table 3). The seedling vigour and glossiness in test entries ranged from 2.0 to 3.3 and 1.3 to 4.0, respectively. The per cent dead hearts inflicted due to shoot fly damage across all entries varied significantly from 13.6- 39.7 per cent with significantly less number of dead hearts observed in SPV 2886 and SPV 2878, and highest number of

TABLE 2  
Evaluation of genotypes for shoot fly, stem borer and diseases in AVHT (Single cut) trial during *Kharif* 2022

S. No.	Entries	No. of eggs/5 plants at 14 DAE	Shoot fly dead-hearts (%) 28 DAE	Seedling vigour (1-5)	Seedling glossiness (1-5)	Stem borer leaf injury score (1-9) 35 DAE	Stem borer dead-hearts (%) 45 DAE	Anthracnose (1-9)	Grey leaf spot (1-9)
1.	SPH1985	1.7	23.4	3.0	3.0	1.3	14.2	2.3	3.7
2.	SPH2006	1.7	23.2	2.0	3.3	1.3	14.5	2.3	3.7
3.	SPV2797	1.7	20.7	2.3	2.7	1.0	12.8	2.0	3.7
4.	SPV2800	1.0	13.7	2.7	2.7	1.0	12.2	2.0	4.0
5.	SPV2801	2.0	28.0	2.7	2.7	1.0	12.4	2.7	4.7
6.	SPV2878	1.0	13.7	2.7	2.7	1.3	13.2	2.0	4.3
7.	SPV2879	1.7	20.0	2.3	3.0	1.0	11.2	3.0	5.7
8.	SPV2880	2.3	30.4	2.3	2.7	1.3	12.7	2.3	5.0
9.	SPV2881	2.0	26.7	2.7	2.7	1.0	11.9	2.3	4.7
10.	SPV2884	3.0	39.6	2.3	2.7	1.0	14.2	3.0	4.7
11.	SPV2885	2.0	25.4	2.0	3.3	1.0	11.6	2.3	5.0
12.	CSV 30F	1.0	18.2	2.7	2.3	1.0	14.2	2.3	4.7
13.	CSV 35F	1.7	24.0	2.7	2.7	1.0	14.4	2.7	5.3
14.	CSH 40F	2.7	33.9	2.7	3.3	1.0	13.1	2.7	4.7
15.	Local Check	2.0	28.3	2.7	2.0	1.0	13.9	4.3	7.7
16.	IS 2205 (RC)	1.0	12.0	3.0	2.0	1.0	8.1		
17.	IS 18551 (RC)	1.0	7.9	3.0	1.7	1.0	8.0		
18.	Swarna (SC)	3.3	43.8	2.7	3.7	2.0	16.6		
	C.D. (5%)	1.2	6.1	0.5	1.2	0.4	4.5	NS	NS

TABLE 3  
Evaluation of genotypes for shoot fly, stem borer and diseases in AVHT (Single cut) trial during *Kharif* 2023

S. No.	Entries	No. of eggs/5 plants at 14 DAE	Shoot fly dead-hearts (%) 28 DAE	Seedling vigour (1-5)	Seedling glossiness (1-5)	Stem borer leaf injury score (1-9) 35 DAE	Stem borer dead-hearts (%) 45 DAE	Anthracnose (1-9)	Grey leaf spot (1-9)
1.	SPV2878	2.0	19.7	2.7	3.0	2.7	12.9	2.7	5.7
2.	SPV2879	2.3	25.1	2.7	2.7	3.0	17.3	2.0	4.0
3.	SPV2881	3.0	31.6	3.0	2.7	2.3	11.2	1.7	3.0
4.	SPV2883	2.7	28.1	2.3	3.0	1.7	9.2	2.3	5.0
5.	SPV2884	2.7	33.9	2.7	3.3	1.7	7.9	1.3	3.7
6.	SPV2886	1.3	13.6	2.7	2.7	1.3	7.5	1.0	2.7
7.	SPV2887	4.0	37.1	2.3	3.3	2.0	9.4	1.3	3.0
8.	SPV2982	3.3	34.3	2.3	3.3	2.7	12.8	2.7	7.3
9.	SPV2983	2.3	23.8	3.0	2.3	2.0	10.1	2.3	5.3
10.	SPV2985	3.3	39.7	3.0	3.0	1.3	7.7	1.0	1.0
11.	SPV2998	2.3	26.5	2.7	3.0	1.3	5.9	2.3	4.7
12.	CSV 35F	2.7	28.1	3.3	2.3	1.7	7.9	1.3	4.3
13.	CSH 40F	2.3	22.9	2.0	3.3	1.7	8.8	1.7	3.3
14.	CSV 46	2.7	26.9	3.0	2.3	1.7	7.5	1.7	3.3
15.	Local Check	2.3	21.7	3.0	2.0	1.7	8.7	6.7	7.7
16.	IS 18551(RC)	1.7	14.1	3.0	1.3	1.3	10.1		
17.	IS 2205 (RC)	1.7	14.3	3.0	1.7	2.0	13.3		
18.	Swarna (SC)	5.7	50.3	2.0	4.0	3.0	12.6		
19.	DJ 6514 (SC)	3.7	34.3	2.3	3.7	2.3	9.2		
	C.D. (5%)	1.76	9.2	1.4	1.6	1.19	3.71	NS	NS

shoot fly dead hearts in SPV 2985. There was moderate damage of stem borer *Chilo partellus* in the form of leaf injury rating (1.0 – 3.0) and dead hearts (5.9-17.3%). Entries SPV 2998 had least incidence of stem borer followed by SPV 2886.

Several researchers have screened large numbers of sorghum genotypes against *Atherigona soccata* and *Chilo partellus* in fodder sorghum and have reported varying levels of resistance to these pests (Patil and Bagde, 2017; Kumar *et al.*, 2019). Kumar *et al.* (2024) also screened forty germplasm lines against shoot fly and reported fourteen genotypes with resistance, as indicated by the lowest percentages of dead hearts. Prasad *et al.* (2015) screened thirty-two sweet sorghum genotypes against *A. soccata* and *C. partellus* and identified morphological parameters as reliable indicators for distinguishing resistant and susceptible entries. Our findings are in agreement with those of Bhoge *et al.* (2017), who evaluated twenty sorghum genotypes against shoot fly and observed differential levels of resistance, which were attributed to traits such as high seedling vigour and leaf glossiness (Mohammed *et al.*, 2018). Likewise, Mohammed *et al.* (2016) evaluated thirty sorghum genotypes against *A. soccata* and reported positive correlations between resistance and traits such as leaf glossiness, seedling vigour, and trichome density. More recently, Sharma *et al.* (2023) assessed 115 elite sorghum genotypes for resistance to shoot fly and stem borer and identified thirteen genotypes with multiple-pest resistance.

### CONCLUSION

It is concluded from the study that twelve genotypes *viz.*, SPH1985, SPH 1905, SPV2704, SPV2705, SPV2797, SPV2800, SPV 2985, SPV 2587, SPV 2451, SPV 2881, SPV2886 and SPV 2887 showed resistant disease reaction to anthracnose and grey leaf spot of sorghum. Sorghum entries SPV2800, SPV2878, SPV 2801, SPV 2886 and SPV 2804 showed relatively lower percent dead hearts caused by shoot fly. Entries SPV 2800, SPV 2801 and SPV 2886 were also promising against stem borer. Therefore, genotypes exhibiting resistance to shoot fly, stem borer and fungal diseases across seasons can be effectively utilized in breeding program of fodder sorghum.

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