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EVALUATION OF SORGHUM GENOTYPES FOR MULTIPLE RESISTANCE AGAINST SHOOT FLY [*ATHERIGONA SOCCATA* (RONDANI)] AND SPOTTED STEM BORER [*CHILO PARTELLUS* (SWINHOE)]

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SUMMARY

Six field trials were conducted to evaluate seventy five sorghum genotypes for multiple resistance against shoot fly and spotted stem borer along with commercial checks, resistant checks, susceptible checks, local check and improved lines for resistance at Hisar during *Kharif*, 2017. Per cent dead hearts caused by shoot fly and stem borer were recorded at 28 and 45 days after emergence, respectively under natural field conditions. Fourteen genotypes namely, SPH 1838, SPV 2444, SPV 2388, SPV 2387, SPV 2522, SPV 2521, SPH 1895, SPV 2530, SPV 2533, SPV 2532, SPV 2383 and SPV 2385 including two commercial checks (SSG 59-3 and CSV 30F) were found to be resistant against shoot fly and stem borer as these genotypes showed less than 45 and 15 per cent dead hearts caused by *A. soccata* and *C. partellus*, respectively.

Key words : Sorghum, Screening, Insect-pest resistance, Dead heart

Sorghum bicolor (L.) Moench commonly known as sorghum is one of the most important cereal crops in the semi-arid tropics. During 2016, 63.93 million tons of sorghum grains were produced all around the world over the acreage of 44.77 million hectares. In India, a total of 4.41 million tons of sorghum grains were produced over the acreage of 5.65 million hectares during 2016 (FAO, 2018). The productivity of sorghum in the world and India are 1427.94 and 781.91 kg ha^{-1}, respectively indicating that the productivity in India is well below the world's average. Additionally in north Indian states, this crop is also cultivated for the purpose of fodder which added further significance of the crop in animal feed. Worldwide 150 insects are recorded on sorghum, which are major factors in reducing the yield. Among these, shoot fly *Atherigona soccata* (Rondani) (Diptera: Muscidae) and spotted stem borer, *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae) are major pests on sorghum which affect the quality and quantity of this fodder crop.

In India, *A. soccata* alone is reported to cause grain yield losses to the tune of 80-90 per cent and up to 68 per cent loss of fodder yield (Balikai and Bhagwat, 2009; Kahate *et al.*,2014). The losses caused by *C. partellus* in maize and sorghum ranged from 18-25 per cent in Asia (Dhaliwal *et al.*, 2015).

The host-plant resistance, if available is one of the most effective means of managing insect pests. It is environment-friendly, compatible with other methods of pest management, does not involve any extra cost of cultivation and has often been used for the successful management of several insect pests in sorghum (Huang *et al.*, 2013). Therefore, the present study was undertaken to screen sorghum genotypes for resistance against *A. soccata* and *C. partellus* under different All India Coordinated Research Project (AICRP)trials namely, initial advanced varietal and hybrid trial- multi cut (IAVHT-MC), advanced varietal and hybrid trial-single cut (AVHT-SC), initial varietal and hybrid trial-single cut (IVHT-SC), initial advanced varietal and hybrid trial-sweet sorghum (IAVHT-SS), high biomass sorghum (HBM) and shoot pest nursery (SPN) during *Kharif*, 2017 under natural field conditions.

MATERIALS AND METHODS

A total of seventy five genotypes of sorghum along with commercial checks (CSH 13, CSV 21F, CSV 30F, CSV 32F, CSH 22SS, CSV 19SS and CSV 24SS), local check (HC 136), resistant checks (IS 18551 and IS 2205), susceptible checks (DJ 6514 and Swarna) and improved lines for resistance (CSV 33MF,

ICSV-1, ICSV 700 and ICSV 93046) constituting six different trials namely, IAVHT-MC, AVHT-SC, IVHT-SC, IAVHT-SS, HBM and SPN were screened for their resistance against *A. soccata* and *C. partellus* at Experimental Farm of Forage Section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar (29°10'N, 75°46'E and 215.2 m above mean sea level) during *Kharif*, 2017 under natural field conditions. Under each trial, two rows of two meters length of each genotype including checks were sown in three replications under randomized complete block design (RBD) on 18 July, 2017. In order to maintain optimum plant population, the thinning was done at 10 days after emergence.

The data on shoot fly and stem borer infestation were recorded in terms of dead hearts (DH) at 28 and 45 days after emergence (DAE) of plants, respectively and expressed in percentage. The data was analyzed as per the methods suggested by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The genotypes of sorghum were screened for resistance against shoot fly and stem borer at Hisar location, which is identified as hot spot for stem borer. Dead heart has been reported as a stable parameter to ascertain resistance against these pests (Singh *et al.*, 1968). Therefore, the data on dead hearts were recorded at peak activities of the shoot fly (28 DAE) and stem borer (45 DAE). The genotypes showing less than 45 and 15% dead hearts caused by shoot fly and stem borer were considered as resistant against *A. soccata* and *C. partellus*, respectively (Anonymous 2018).

Perusal of data in terms of per cent dead hearts revealed that the shoot fly infestation varied from 18.4 to 62.0%, whereas stem borer infestation ranged from 10.9 to 37.1% under IAVHT-MC trial (Table 1). Genotypes namely, CSV 33MF, SPH 1838, 1877, 1840, 1880, 1807, 2492, SSG 59-3**,** SPH 1879 and 1841 were statistically at par in terms of shoot fly infestation with resistant check (IS 18551). Genotypes namely, SPH 1838, SSG 59-3, SPH 1807, 1840, 1877, 1880 and IS 2205 (RC) were found statistically at par with resistant check (IS 18551) in terms of stem borer infestation. The performance of genotypes namely, SPH 1807, 1838, 1877 and 1880 in terms of stem borer resistance are in conformity with those of Anonymous (2018) at national level. However, SPH 1838 and SSG 59-3 showed multiple resistance against both the pests (<45 and <15% DH by shoot fly and stem borer, respectively) in present study.

The per cent dead heart infestation due to shoot fly and stem borer ranged from 19.3 to 65.8% and 9.8 to 37.7%, respectively under AVHT-SC trial (Table 2). Except the genotype SPV 2449, all the tested genotypes were statistically at par with resistant check (IS 2205) in terms of shoot fly infestation. Genotype SPV 2444 was found statistically superior over resistance check in terms of resistance against shoot fly. In case of stem borer, except HC 136, SPH 1822, SPV 2454, 2452 and 2449, all the tested genotypes were statistically at par with resistant check (IS 2205) in terms of per cent dead heart infestation. However, SPV 2444, 2388 and 2387 showed resistance (<45 and <15% DH by shoot fly and stem borer, respectively) against both the pests and the results are in conformity with the reports of Anonymous (2018) across the AICRP (Sorghum) centers on overall basis.

TABLE 1
Screening of genotypes for insect pest resistance under IAVHT-MC trial during *Kharif*, 2017

Genotype	Shoot fly dead hearts (%)	Stem borer dead hearts (%)	Genotype	Shoot fly dead hearts (%)	Stem borer dead hearts (%)
SPH 1807	24.9	16.7	SPH 2492	25.0	25.6
SPH 1838	20.1	14.2	CSH 24MF (CC)	44.8	34.8
SPH 1840	24.1	22.2	SSG 59-3 (CC)	26.2	14.7
SPH 1841	34.7	33.3	CSV 33MF (CC)	19.9	33.2
SPH 1876	42.0	26.3	HC 136 (LC)	29.3	31.8
SPH 1877	20.4	23.1	IS 18551 (RC)	18.4	10.9
SPH 1878	39.7	25.2	IS 2205 (RC)	18.8	13.7
SPH 1879	28.8	26.5	DJ 6514 (SC)	59.9	36.4
SPH 1880	24.5	24.0	Swarna (SC)	62.0	37.1
SPH 1881	38.3	25.6	Mean	31.8	25.2
SPH 2491	35.0	27.9	C.D. (5%)	16.3	13.7

CC : Commercial check; LC: Local check; RC: Resistant Check; SC: Susceptible Check.

TABLE 2
Screening of genotypes for insect pest resistance under AVHT-SC trial during *Kharif*, 2017

Genotype	Shoot fly dead hearts (%)	Stem borer dead hearts (%)	Genotype	Shoot fly dead hearts (%)	Stem borer dead hearts (%)
SPH 1822	29.7	29.1	CSV 30F (CC)	23.8	19.3
SPV 2316	31.0	22.4	CSV 21F (CC)	25.6	17.2
SPV 2387	26.7	12.3	HC 136 (LC)	28.3	29.9
SPV 2388	26.8	12.0	IS 18551 (RC)	35.7	11.5
SPV 2444	19.3	11.0	IS 2205 (RC)	32.6	9.8
SPV 2445	24.9	15.2	DJ 6514 (SC)	65.8	37.1
SPV 2449	52.5	24.1	Swarna (SC)	65.8	37.7
SPV 2452	32.6	25.9	Mean	31.8	21.3
SPV 2454	22.0	26.2	C.D. (5%)	12.9	13.8
CSH 13 (CC)	38.1	21.0			

CC : Commercial check; LC: Local check; RC: Resistant Check; SC: Susceptible Check.

In IVHT-SC trial, the infestation due to shoot fly and stem borer varied from 20.7 to 63.7% and 7.1 and 37.7% dead hearts, respectively (Table 3). The genotypes namely, CSV 21F, SPV 2513, 2522, SPH 1890, SPV 2521, 2511, CSV 30F, 32F and SPH 1891 were found statistically at par with resistant check (IS 2205) in terms of shoot fly infestation. In case of stem borer infestation, SPV 2522, CSV 30F, SPV 2521, 2513 and SPH 1890 were found statistically at par with resistant check (IS 2205) in terms of per cent dead heart formation. However, SPV 2522, CSV 30F and SPV 2521 were observed to exhibit resistance (<45 and <15% DH by shoot fly and stem borer, respectively) against shoot fly and stem borer infestation. The findings on SPV 2522 are in line with the results of Anonymous (2018).

The dead hearts caused by shoot fly and stem borer varied from 25.2 to 61.6 and 10.0 to 38.9 per cent, respectively in IAVHT-SS trial (Table 4). Six genotypes namely, CSV 19SS, SPH 1895, SPV 2530, SPH 1892, SPV 2531 and CSH 22SS were found statistically at par with resistant check (IS 2205) in terms of dead hearts caused by shoot fly. In case of stem borer infestation, except CSH 22SS, CSV 19SS, SPH 1798, SPV 2527, SPH 1894, SPV 2526, SPH 1893 and 1825, all the tested genotypes were statistically at par with resistant check (IS 2205) in terms of dead heart formation. However, two genotypes namely, SPH 1895 and SPV 2530 were recorded as resistant against shoot fly and stem borer (<45 and <15% DH by shoot fly and stem borer, respectively). Anonymous (2018) also reported SPH 1895 to be resistant against shoot fly and stem borer.

In HBM trial, the infestation in terms of dead

TABLE 3
Screening of genotypes for insect pest resistance under IVHT-SC trial during *Kharif*, 2017

Genotype	Shoot fly dead hearts (%)	Stem borer dead hearts (%)	Genotype	Shoot fly dead hearts (%)	Stem borer dead hearts (%)
SPH 1890	25.6	19.9	SPV 2522	25.6	10.4
SPH 1891	30.3	25.2	SPV 2523	35.6	24.1
SPV 2511	25.7	24.5	CSH 13 (CC)	37.1	27.9
SPV 2512	34.8	20.6	CSV 30F (CC)	28.1	13.5
SPV 2513	23.8	17.0	CSV 32F (CC)	30.2	25.9
SPV 2514	48.6	30.4	CSV 21F (CC)	23.2	22.1
SPV 2515	41.2	28.6	HC 136 (LC)	29.3	31.8
SPV 2516	53.7	27.8	IS 18551 (RC)	23.2	8.8
SPV 2517	42.0	35.1	IS 2205 (RC)	20.7	7.1
SPV 2518	46.1	25.4	DJ 6514 (SC)	61.6	35.1
SPV 2519	38.1	23.1	Swarna (SC)	63.7	37.7
SPV 2520	32.5	33.8	Mean	35.3	23.8
SPV 2521	25.7	14.2	C.D. (5%)	10.5	13.3

CC : Commercial check; LC: Local check; RC: Resistant Check; SC: Susceptible Check.

TABLE 4
Screening of genotypes for insect pest resistance under IAVHT-SS trial during *Kharif*, 2017

Genotype	Shoot fly dead hearts (%)	Stem borer dead hearts (%)	Genotype	Shoot fly dead hearts (%)	Stem borer dead hearts (%)
SPH 1798	40.5	31.7	SPV 2528	44.5	22.9
SPH 1825	39.3	25.5	SPV 2529	41.7	17.1
SPH 1858	43.7	19.9	SPV 2530	35.3	14.1
SPH 1892	36.6	17.0	SPV 2531	36.7	19.2
SPH 1893	41.2	25.7	CSH 22SS (CC)	37.5	34.8
SPH 1894	41.6	28.1	CSV 19SS (CC)	29.8	33.7
SPH 1895	30.8	10.0	CSV 24SS (CC)	50.3	21.2
SPV 2324	48.2	20.5	IS 18551 (RC)	26.9	13.7
SPV 2458	47.9	21.3	IS 2205 (RC)	25.2	10.9
SPV 2462	39.4	21.8	DJ 6514 (SC)	61.0	38.9
SPV 2524	39.2	21.8	Swarna (SC)	61.6	36.4
SPV 2525	46.2	22.9	Mean	41.0	23.5
SPV 2526	38.9	26.4	C.D. (5%)	12.7	13.4
SPV 2527	42.1	31.2			

CC : Commercial check; LC: Local check; RC: Resistant Check; SC: Susceptible Check.

TABLE 5
Screening of genotypes for insect pest resistance under HBM trial during *Kharif*, 2017

Genotype	Shoot fly dead hearts (%)	Stem borer dead hearts (%)	Genotype	Shoot fly dead hearts (%)	Stem borer dead hearts (%)
SPH 1798	31.9	19.4	CSH 22SS (CC)	32.5	19.5
SPV 2531	34.0	20.1	IS 18551 (RC)	22.3	14.0
SPV 2532	29.5	14.9	IS 2205 (RC)	26.2	11.5
SPV 2533	27.9	11.4	DJ 6514 (SC)	61.7	34.8
SPV 2534	38.4	22.8	Swarna (SC)	63.3	37.0
SPV 2535	40.1	20.9	Mean	38.3	21.3
CSH 13 (CC)	51.5	29.8	C.D. (5%)	17.3	12.7

CC : Commercial check; LC: Local check; RC: Resistant Check; SC: Susceptible Check.

hearts caused by shoot fly and stem borer ranged from 22.3 to 63.3 and 11.4 to 37.0 per cent, respectively (Table 5). All the genotypes except CSH 13 and SPV 2535 were statistically at par with resistant check (IS 18851) in terms of per cent dead hearts caused by shoot fly. In case of stem borer, all the genotypes except CSH 13 showed statistically at par resistance with resistant check (IS 2205). However, two genotypes namely, SPV 2533 and 2532 were observed to possess resistance against both the pests (<45 and <15% DH by shoot fly and stem borer, respectively). The finding on SPV 2533 and 2532 in terms of stem borer infestation are in conformity with those of Anonymous (2018).

The dead hearts caused by shoot fly and stem borer varied from 16.1 to 60.0 and 10.4 to 32.2 per cent, respectively under SPN trial (Table 6). All the tested genotypes were found statistically at par with resistant checks in case of shoot fly infestation. In case of stem borer, the per cent dead heart infestation was non-significant among the tested genotypes. However, two genotypes namely, SPV 2383 and 2385 showed resistance (<45 and <15% DH by shoot fly and stem borer, respectively) against both the pests. Anonymous (2018) also reported SPV 2385 to be resistance against shoot fly infestation at national level. Some biochemicals such as malic acid, phenolic compounds, cellulose, hemi cellulose, lignin, free amino acids etc of crops could be responsible for resistance to insect pests (Jakhar *et al.*, 2018)

CONCLUSION

It is inferred from the trials conducted at Hisar that a total of fourteen genotypes namely, SPH 1838, SPV 2444, SPV 2388, SPV 2387, SPV 2522, SPV 2521, SPH 1895, SPV 2530, SPV 2533, SPV 2532,

TABLE 6
Screening of genotypes for insect pest resistance under SPN trial during *Kharif*, 2017

Genotype	Shoot fly dead hearts (%)	Stem borer dead hearts (%)	Genotype	Shoot fly dead hearts (%)	Stem borer dead hearts (%)
SPV 2296	24.4	19.4	BNV 349	23.0	21.1
SPV 2317	34.2	29.3	BNV 364	30.6	31.3
SPV 2383	19.6	10.4	CSV 33MF (ILR)	16.1	16.2
SPV 2385	17.8	12.1	ICSV-1 (ILR)	22.0	25.9
SPV 2398	25.1	16.7	ICSV 700 (ILR)	38.4	28.1
SPV 2437	24.7	24.8	ICSV 93046 (ILR)	23.6	27.2
SPV 2438	36.6	22.8	IS 18551 (RC)	24.0	13.9
SF-I-195	33.5	28.7	IS 2205 (RC)	25.8	11.8
SF-II-28	21.9	31.6	DJ 6514 (SC)	60.0	29.2
SF-I-1	31.7	29.4	Swarna (SC)	54.9	32.2
SH 1532	19.2	15.4	Mean	28.3	22.3
SH 1507-2	20.1	13.9	C.D. (5%)	17.8	NS
S 652	23.5	20.5			

ILR : Improved line for resistance; LC : Local check; RC : Resistant Check; SC : Susceptible Check.

SPV 2383 and SPV 2385 including commercial checks namely, SSG 59-3 and CSV 30F were found to possess multiple resistance against *A. soccata* and *C. partellus* under natural field conditions.

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