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Evaluation of Grain Sorghum Entries against Spotted Stem Borer, C*hilo partellus* (Swinhoe)

K.J. Swathy* and S. Manimegalai
Department of Agricultural Entomology,
Tamil Nadu Agricultural University, Coimbatore - 641 003, Tamil Nadu, India

Stem borers are the major pest complex contributing to yield reduction in sorghum and stem borer, C*hilo partellus* is the important one among them. Identification of resistant genotypes is a contributing factor for releasing new varieties. In the present study, 11 sorghum entries along with one resistant (IS 2205) and susceptible (Swarna) checks were evaluated for stem borer resistance in *kharif* and *rabi* seasons considering leaf damage, dead heart, stem tunneling, yield plant $^{-1}$ and 1000 grain weight. The results revealed that sorghum entries TNS 664 and TNS 667 registered the lowest leaf damage score (2.9, 2.8 and 3.0, 3.5), dead heart (9.9%, 13.3% and 11.0%, 15.0%), stem tunnelling (5.7%, 5.1% and 6.6%, 5.5%) and yield loss (25.2%, 22.7% and 25.8%, 25.4%) and was on par with the resistant check, IS 2205 (2.3, 7.5%, 7.4%, 19.7% and 2.5, 9.0%, 8.2%, 26.9%) during *rabi*, 2016 and *kharif*, 2017, respectively.

Key words: Sorghum genotype, *Chilo partellus*, Screening, Dead heart, Yield/plant, Yield loss

Sorghum [*Sorghum bicolor* Moench (L)] is one of the main staple food for the world's poorest, holding fifth position in production in the world after wheat, rice, maize and barley and fourth position in India. Importance of sorghum is increasing day by day in India because of effective potential as poultry feed, flour for bread, ethanol production, grain alcohol, green and dry fodder for cattle and industrial raw materials like starch, adhesives and paper. One of the major biotic factors limiting sorghum yields is insect pests which cause an estimated loss of over one billion US $ annually worldwide (Sharma, 2003).

Among the pest complex reported in sorghum, stem borers are the major one (Sharma and Nwanze, 1997) of which the spotted stem borer *C. partellus* has been recorded as a serious pest in Indian and African subcontinent (Omoto and Seshu Reddy, 1985). Damages caused to sorghum include leaf feeding, dead heart, exit holes, stem tunnelling and chaffy grain (Dillon *et al.,* 2007).

The nocturnal habit of the adults and the cryptic behaviour of the larvae residing inside plant stems make stem borers difficult to control. The use of insecticides for stem borer control is often uneconomical and beyond the reach of resource poor farmers. Host plant resistance offers the best option for minimizing losses due to stem borers (Davies, 1981) and considered as the major contributing component in integrated pest management of stem borers in cereals. As future breeding efforts will largely focus on high yielding stem borer resistant lines, the study was conducted to identify the resistant lines by assessing morphological damage traits associated to *C. partellus* resistance.

*Corresponding author email: swathykjayan@gmail.com

Material and Methods

Field experiments were conducted at Tamil Nadu Agricultural University, Coimbatore (Latitude: 11.0151861, Longitude: 76.93261669999993, Elevation: 441 m), during 2016-2017 rabi and kharif seasons. The experiment was laid out in a Randomized Block Design (RBD) with 13 treatments and three replications. The experimental material consisted of 11 lines of sorghum entries along with resistant (IS 2205) and susceptible checks (Swarna). Each entry was sown in 2 row plots of 4 m row length, and the rows were 60 cm apart. The experimental plots were given a basal dose of NPK @ 45:45:45 kg/ha followed by split application of N 45 kg/ha @ 25:25 percentage rate at 15 and 30 days after sowing. All the agronomic practices were carried out based on the recommendation of Tamil Nadu Agricultural University Crop Production Guide, 2013. No insecticide was applied in the experimental plots. Intercultural and earthing up operations were carried out at 15 and 30 days after seedling emergence (DAE). Hand weeding was carried out as and when required.

Observations were made on plants with dead heart, leaf feeding, stem tunneling, normal and affected yield per plant and 1000 grain weight. Data on number of plants with dead-hearts were recorded at 45 DAE and expressed as percentage of the total number of plants. Leaf feeding by *C. partellus* larvae was assessed 35 DAE on a 1 to 9 rating scale (1= No visible injury or pin/shot hole injury on a few leaves, 2= Small amount of shot hole on a few leaves, 3 = Shot hole injury on several leaves, 4 = Several leaves with shot hole and elongated lesions, 5 = Several leaves with elongated lesions, 6 = Several leaves with elongated lesions (>2.5 cm), 7 = Long lesions common on about one-half of the leaves, 8 =

Long lesions common on about two-thirds of the leaves, and 9 = Most leaves with long lesions). At harvest, the main stems of plants infested with the larvae were split open from base to apex and the cumulative tunnel length (cm) was measured and expressed in percentage. At physiological maturity, the panicles were harvested from the borer-infested and uninfested plants separately and yield/plant and 1000 grain weight were taken as an average of five randomly selected plants from each replication. Grain yield loss was calculated on each genotype according to Walker (1983).

$$\text{Grain yield loss} = \frac{[\text{Grain yield (uninfested) - Grain yield (infested)}] \times 100}{\text{Grain yield (uninfested)}}$$

Results and Discussion

The data recorded respectively on damage and grain yield are presented in the Table 1(Rabi, 2016) and Table 2 (Kharif, 2017).

Leaf damage score

The leaf damage score on a scale of 1-9 indicated that there were significant differences among the entries. The damage score ranged from 2.3 – 8.0 in rabi season and 2.50 – 8.50 in kharif. The lines TNS 667, TNS 623, TNS 664 and TNS 672 contributed low damage and were on par with resistant check , IS 2205 in rabi (2.30) and kharif (2.50) seasons. The entries TNS 665, TNS 671 and TNS 666 registered high score ranging from 7.50 to 8.50 and were on par with the susceptible check, Swarna (5.80 and 6.50). Most of the genotypes were susceptible recording a damage score above four.

Dead heart

Significant difference in dead heart damage was observed in different sorghum entries, which varied from 7.5 to 29.4 per cent during rabi and 9.0 to 31.0 per cent in kharif. TNS 664 recorded the lowest dead heart (9.9 and 11.0 %) compared with the resistant

Table 1. Evaluataion of sorghum entries against Chilo partellus, (Rabi, 2016)

Entry	Leaf damage (score)	Dead heart (%)	Stem tunnelling (%)	Yield plant^{-1} (g)		Yield loss (%)	1000 grain weight (g)
				Uninfested	Infested		
IS 2205	2.25 a	7.5 a (15.94)	7.4 ab (15.78)	26.8 a	21.5 a	19.7	23.19 cd
SWARNA	5.8 de	29.4 g (32.83)	23 f (28.52)	17.8 b	11.5 bc	35.3	15.83h
TNS 667	2.8 ab	13.3 bcd (21.35)	5.1 a (12.96)	27.9 a	21.5 a	22.7	31.56 ab
TNS 665	6.8 ef	25.5fg (30.30	25f (29.99)	13.7 bcd	4.3 g	68.8	19.84 ef
TNS 671	7.9 f	21.4 ef (2.55)	8.6 ab (16.99)	15.6 bc	7.7 ef	50.8	21.38 de
TNS 648	4.8 cd	15.3 bcde (23.05)	8.5 ab (16.92)	7.5 d	5.9 f	21.6	16.61 gh
TNS 669	4.3 bcd	21.6 ef (27.62)	15.3 de (23.01)	10.0 cd	6.8 f	32.4	19.86 ef
TNS 623	3.8 ab	17.4 de (24.67)	19.8 ee (26.40)	25.8 a	13.0 b	49.5	22.99 d
TNS 664	2.9 ab	9.9 ab (18.33)	5.7 a (13.72))	28.1 a	21.0 a	25.2	25.97 c
TNS 668	4.1 bc	11.3 abc (19.60)	6.1 ab (14.27)	12.6 bcd	9.0 de	28.6	30.15 b
TNS 670	3.9 bc	17.8 de (24.87)	13.1 cd (21.21)	26.7 a	10.2 cd	61.6	34.14 a
TNS 672	2.9 ab	13.7 bcd (21.73)	9.4 bc (17.85)	18.6 b	11.4 bc	38.4	21.62 de
TNS 666	8.0 f	16.9 cde (24.23)	23.5 e (28.98)	16.1 bc	11.3 b	29.9	18.80 efg
SE (d)	0.74	2.38	1.86	0.90	0.89		1.65
CD(0.05)	1.61	4.98	4.05	1.88	1.96		2.92
C V	15.90	10.31	9.05	11.17	7.50		5.90

Figures in parantheses are arc sine transformed value
Mean of three replications.
Means followed by the common letter(s) are not significantly different at 5% level by LSD

IS 2205 (7.5 and 9.0 %) during rabi and kharif respectively. Dead heart damage of the genotypes *viz.,* TNS 667, TNS 648, TNS 669, TNS 623, TNS 670, TNS 668 and TNS 672 ranged from 13.3 to 17.8 per cent, while TNS 665 registered the highest dead heart damage among the entries in both seasons (25.5 % in rabi and 27.0 % in kharif) which was on par with the susceptible check, Swarna (29.4 and 31.0 %).

Swarna with 23.0 and 28.8 per cent tunnelling in respective seasons.

Screening based on a combination of traits will provide more accurate results for evaluation of genotypes. The association between various damage traits and grain yield is useful for selecting superior genotypes. A number of parameters have been reported to be associated with resistance to spotted stem borer in sorghum because resistance is a quantitative trait and selection based on a single parameter is not efficient (Singh *et al.,* 2011). In the present study sorghum genotypes showed difference in damage level in various damage traits and this results fall in line with findings of Sharma *et al*. (2006) who reported a great variation in resistance levels between resistant and susceptible entries.

Table 2. Evaluataion of sorghum entries against *Chilo partellus*, (Kharif, 2017)

Entry	Leaf damage (score)	Dead heart (%)	Stem tunnelling (%)	Yield plant -1 (g)		Yield loss (%)	1000 grain weight (g)
				Uninfested	Infested		
IS 2205	2.5 a	9.0 a (17.44)	8.2 a (16.60)	26.0 a	19.0 a	26.9	22.95 c
SWARNA	6.5 ef	31 f (33.80)	28.8 f (32.47)	16.0 c	9.5 bc	40.6	14.65 g
TNS 667	3.5 abc	15 bc (22.77)	5.5 a (13.55)	26.2 a	19.5 a	25.4	30.60 a
TNS 665	7.5 fg	27ef (31.27)	22 f (27.97)	11.9 de	2.25 g	81.1	17.49 f
TNS 671	8.5 f	23 de (28.61)	9 bcd (17.31)	15.0 cd	5.7 ef	61.9	20.85 d
TNS 648	5.5 de	17 bcd (24.34)	7.8 cd (16.24)	5.9 g	5.0 f	27.5	15.31 g
TNS 669	5.0 cde	23 de (28.61)	16.2 e (23.72)	8.3 fg	4.8 f	42.4	17.73 ef
TNS 623	4.5 bcd	19 cd (25.84)	20.7 (27.06)	23.0 ab	11.0 b	53.4	20.95 d
TNS 664	3.0 ab	11 ab (19.34)	6.6 ab (14.84)	26.3 a	19.5 a	25.8	23.84 c
TNS 668	4.5 c	13 abc (21.12)	7 abc (15.33)	10.8 ef	10.0 de	26.0	28.33 b
TNS 670	4.5 bcd	19 cd (25.72)	14 e (21.95)	22.9 b	7.0 cd	68.5	30.20 a
TNS 672	3.0 ab	15 bc (22.77)	10.3 d (18.68)	16.8 c	8.3 bc	50.6	19.41 de
TNS 666	8.5 f	19 cd (25.84)	22.0 f (27.95)	14.3 cde	9.5 bc	33.5	16.40 fg
SE (d)	0.76	3.52	1.33	1.63	0.89		0.87
CD(0.05)	2.31	7.27	2.90	3.57	1.89		1.89
C V	14.70	14.60	4.70	9.50	8.70		4.00

Figures in parantheses are arc sine transformed value
Mean of three replications.
Means followed by the common letter(s) are not significantly different at 5% level by LSD

Stem tunnelling

Stem tunneling due to borer was expressed as percentage of stem tunneled. Tunneling damage ranged between 5.1 to 25.0 per cent and 5.5 to 28.8 per cent in rabi and kharif seasons respectively. TNS 667 (5.1 and 5.5 %) showed lower stem tunnelling than resistant check while the entries TNS 671, TNS 664, TNS 668 and TNS 648 were on par with resistant check, IS 2205 which recorded 7.4 and 8.2 per cent tunnelling respectively during rabi and kharif. TNS 665 registered the highest tunnelling (25.0 and 22.0 %). TNS 665, TNS 666 and TNS 629 were highly susceptible and on par with susceptible check,

Muturi *et al*. (2014) evaluated 27 genotypes based on damage from leaf feeding, dead heart, exit holes, stem tunnelling, plant height, days to 50% flowering, total grain yield and hundred grain mass and reported significant differences in all the traits except leaf damage. The results showed a negative indirect effect on grain yield from dead heart, leaf feeding and stem tunnelling. Sorghum genotypes were evaluated by Bhagwat *et al.* (2011) for resistance to shoot fly and stem borer during kharif considering six parameters *viz.,* glossiness, seedling vigour, shoot fly dead heart, stem borer dead heart, tunnelling and exit holes/stalk due to borer. They reported that entries IS 2312, IS 18551 and IS 2205 were resistant and seven entries JJ1041, PVK 809, CO 28(S), CSV 15, SPV 1616 and CSV 17 were moderately resistant to shoot fly and stem borer. Forty seven sweet sorghum genotypes were evaluated by Prasad *et al*. (2011) during kharif against stem borer considering five damage parameters and suggested that dead hearts, stem tunnelling and exit holes per stalk were the most reliable parameters for characterization of resistance to *C. partellus* in sorghum and similar observations were made in present study.

Grain yield performance under infested and uninfested condition

Significant differences in grain yield were recorded among the entries during both season. The uninfested yield ranged from 7.5 to 28.1 g plant^{-1} in rabi and 5.9 to 26.3 g plant^{-1} in kharif. The highest yield was recorded in TNS 664 both during rabi (28.1 g plant^{-1}) and kharif (26.3 g plant^{-1}) followed by TNS 667 (27.9 g and 26.2 g plant^{-1}), TNS 670 (26.7 and 22.9 g plant^{-1}) and TNS 623 (25.8 and 22.9 g plant^{-1}) were on par with each other and with the resistant check, IS 2205 (26 and 28 g plant^{-1}) during both seasons. The entry TNS 648 observed a yield of 5.8 g plant^{-1} in kharif season which was the least among the entries. The entries *viz.,* TNS 665, TNS 669 and TNS 668 registered a yield lower than the susceptible check, Swarna (17.8 and 16 g plant^{-1}).

Significant yield reduction was observed in all entries under infested condition during kharif and rabi seasons. Under infested condition highest yield was recorded in TNS 667 (21.5 g and 19.5 g) with a yield loss of 22.7 and 25.4 per cent in rabi and kharif seasons followed by TNS 664 (21.0 and 19.5 g) with a yield loss of 25.2 and 25.8 per cent and both were on par with the resistant check, IS 2205 (21.5 and 19 g) with a yield loss of 19.7 and 26.9 per cent. The per cent yield loss recorded in TNS 648 was 21.6 and 27.5 per cent in rabi and kharif respectively. TNS 668 (28.6 and 26.0 %) and TNS 666 (29.9 and 33.5 %) were low but their yield potential under infested and uninfested condition was lower than the susceptible check, Swarna which recorded 17.8 and 11.5 g plant^{-1} during rabi and 16.0 and 9.5 g plant^{-1} during kharif.

In this study the entries selected as best registered lowest yield loss under infested and uninfested condition, which is on par with the resistant check, IS 2205 which was also supported by Singh *et al*. (2011) who suggested that selection of genotypes should be based on grain yield losses under borer-infested and uninfested conditions.

1000 grain weight

Highest grain weight was recorded in the entries TNS 667 (31.56 and 30.60 g) and TNS 670 (34.14 and 30.20 g) in respective seasons, which were higher than the resistant check (23.19 and 22.95 g) and the susceptible check (15.83 and 14.65 g) in both seasons. TNS 666 resulted in a weight of 16.60 and 16.40 g per 1000 grain which was least among the other entries. Lowest weight was shown by the susceptible check, Swarna (15.83 and 14.65g) in both seasons.

Conclusion

Evaluating 11 sorghum entries during rabi 2016 and kharif 2017 along with the resistant check, IS 2205 and susceptible check, Swarna against *C. partellus* based on leaf damage, dead heart, stem tunneling and yield loss showed a significant variation among the genotypes. The sorghum entries TNS 664 and TN 667 were found promising and on par with the resistant check, IS 2205. These two entries could be utilized in future breeding program as stem borer resistant sources to improve the resistance levels.

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