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Evaluation of *Sorghum* genotypes against stem borer (*Chilo partellus* Swinhoe) in Madhya Pradesh-India

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Abstract
Field trials were carried out during Kharif 2014-15 to evaluate resistance for stem borer in 25 genotypes of *Sorghum*. Based upon hierarchical clustering considering parameters of stem borerper cent plant infestation, dead heart caused by stem borer, stem tunneling, peduncle tunneling, number of larvae/plant and number of tunnel per plant eleven genotypes viz; Gird-36, CMSxS-654, Gird-36, CMSxS-633, CMSxS-654, CMSxS-633, DSSV-37 x NSSV-14, NSSV-04 x DSSV-196, CSH-2255 DSSV-37 x NSSV-14, NSSV-04 x DSSV-196 and CSH-2255 were found less susceptible to stem borer and genotype IS-25298 was found highly susceptible to stem borer.

Keywords: triclosan, TCS, determination, detection, sensor

Introduction
Sorghum *Sorghum bicolor* (L.) Moench is one of the main staple food for the world's poorest and most food insecure people across the semi-arid tropic sand insect pests are one of the major yield-reducing factors. A number of stem borer species have been reported as serious pests of *Sorghum* in Asia and Africa, of which spotted stem borer, Chilo partellus (Swinhoe) is the predominant species in Indian subcontinent, and South and eastern Africa, causing serious damage to *Sorghum*, maize and pearl millet. It causes 18-25% yield loss in *Sorghum* and maize. Chilo partellus attack in *Sorghum* starts from two weeks old seedlings, affects all plant parts except the roots and persists up to crop harvest. The neonate larvae scrap the leaf chlorophyll, and the early instar larvae while feeding in the whorl cause irregular shaped pinholes which later convert to elongated lesions on the leaves. The older larvae leave the whorl, bore into the stem where it cuts the growing point resulting in "dead heart" symptom. In older plants, the larva feeds inside the stem causing extensive tunneling. Feeding and stem tunneling by C. partellus larvae cause huge crop losses due to interference with translocation of metabolites and nutrients, thus resulting in poor development of grains, stem breakage, lodging, direct damage to panicles and loss in grain yield. Several control strategies such as crop rotation, field sanitation, introduction of parasitoids and use of synthetic pesticides have been employed for the control of C. partellus but their deployment have not given satisfactory control particularly when the larvae are feeding inside the stalks. In such a scenario, host plant resistance could be exploited as one of the most effective mean of minimizing losses due to insect pests and sustainable *Sorghum* production. Several *Sorghum* germ plasm accessions have been screened, and a number of C. partellus resistance sources have been identified. However, resistance reaction to C. partellus has been noticed highly variable across climatic conditions which could be due to variability in feeding potential or varying insect pressure at different locations. Thus, the effect of stem borer damage on grain yield may reflect in multiple traits, such as non-preference for oviposition, reduced feeding by the first instars on young leaves, low dead heart formation, reduced tunneling, and tolerance to leaf damage and stem tunneling. A number of biochemical factors, such as low sugar content, amino acids, total sugars, tannins, total phenols, neutral detergent fiber, acid detergent fiber and lignins have also been reported to be associated with resistance to stem borer in *Sorghum*. Thus, selection for resistance to stem borer based on individual parameter is difficult as *Sorghum* genotype identified resistant to leaf feeding damage and/or dead hearts may be susceptible to stem tunneling and vice versa.

Therefore, in the present study we explored biochemical interactions in diverse *Sorghum* genotypes with biological and damage parameters to understand their role in plant defense against *C. partellus*

Material and Methods

The experiment was carried out during *kharif* season, 2014-15 at the Research Farm, College of Agriculture, RVSKVV-Gwalior (M.P.). The material was planted in a randomized block design with three replications in 08th July 2014 and screening was done under natural infestation. The crop was sown in rows to row 0.5 m and plant to plant 0.24m distance. Plot consisted of parallel four rows 4 m long. One week after seedling emergence, thinning was carried out to maintain a spacing of 10 cm between the plants. All the agronomic practices were followed to raise the crop successfully with recommended dose of fertilizers (80 kg N_2: 40 kg P_2O_5: 40 kg K_2O / ha). The following 25 *Sorghum* genotypes were sown in this investigation.

1. CMSxS-633
2. CMSxS-654
3. Gird-36
4. Gird-8
5. HBM-B-1071
6. IS-17248
7. IS-13349
8. IS-18542
9. IS-25278
10. IS-25301
11. ICSV-93046
12. IS-25302
13. IS-27206
14. IS-27246
15. IS-38024
16. N-610
17. Sel-B-Pop
18. DSSV-34xNSSV-14
19. NSSV-04 x DSSV-
20. NSSV-04 x DSSV-196
21. NSSV-14 x RSSV-24
22. NSSV-258 x DSSSV-13
23. NSSV-015A x DSSV-165
24. CSH-2255
25.SSG-59

Methods of observations

Following observation was recorded to evaluate the advanced *Sorghum* resistant genotypes against *Chilo partellus* Swinhoe. During growth period two types of observations viz., leaf injured plants and dead heart formation were recorded at 30 and 45 days after emergence to work out the per cent plant infestation and per cent dead heart caused by stem borer. The five plants were randomly selected to record the stem tunneling, peduncle tunneling, number of larvae/pupae present in stem and peduncle at harvesting time. Number of holes in stem and peduncle were also recorded in selected plants. On the basis of observed data, per cent stem tunneling and per cent peduncle tunneling were calculated. The data obtained from a set of observations for each character were tabulated and analyzed by the method of "Analysis of variance" as suggested by Fisher and Yates (1938).

Results and Discussion

The incidence of *Chilo partellus* Swinhoe is given in Table 1&2.

Plant infestation by *Chilo partellus*

Result showed that significantly less plant infestation (3.28%) and (7.0%) was observed in genotype CMSxS-654 at 30 DAE & 45 DAE among the genotypes except CMSxS-633, Gird-8, HBM-B-1071, IS-13349, DSSV-37xNSSV-14 and NSSV-015AxDSSV-165 at 30 Days After Emergence (DAE) and NSSV-04xDSSV-108,HBM-B-1071 and Gird-36 at 45 DAE (Table 1). Whereas, significantly higher plant infestation (14.62% & 23.96%) was recorded in genotype SSG-59 than all the tested genotypes except IS-18542 at 30DAE and 45 DAE. Bhadviya (1995) [2] reported 1.63 to 4.98% infestation, Gour (1995) [3] reported 3.60 to 24.45% infestation and Kishore (2005) [4] was also reported 5.6 to 7.0% plant infestation by stem borer in different genotypes of *Sorghum*.

Per cent dead heart by *Chilo partellus*

Results revealed that dead hearts were not formed by C. partellus in genotypes Gird-36, IS-13349, IS-25298, IS-25301, IS-27206, IS-34024, NSSV-04 x DSSV-108, NSSV-04 x DSSV-196 and NSSV-14 x RSSV-24 (Table 1). These genotypes showed tolerance and free from dead hearts. Minimum dead heart (0.33%) was recorded in genotypes CMSxS-633, Gird-8, IS-27246 and SSG-59 and maximum dead heart (1.70%) was recorded in IS-18542 at 30 DAE. Whereas 45 DAE minimum dead heart (2.17%) was recorded in genotypes DSSV-37 x NSSV-14, which found at par with IS-25301, Gird-36, IS-25298, CMSxS-654, NSSV-015A x DSSV-165 and IS-18542. On the other hand maximum dead heart (12.10%) was recorded in SSG-59, which found significantly higher than rest of the genotypes except ICSV-93046, N-610, CSH-2255 and NSSV-14 x RSSV-24. Teli *et al.* (1983) reported 19.99 to 84.78% dead heart in different cultivars. The variation in per cent dead heart formation caused by stem borer might be due to different genotypes evaluated by various workers and variation in climatic condition of the tested centers. Similar results was also obtained by Kishore (1991) [3], Bhadviya (1995) [2] and Gour (1995) [3].

Stem tunneling by *Chilo partellus*

Stem tunneling caused by *Chilo partellus* at the harvest found significant difference among the genotypes (Table 1). The minimum stem tunneling (3.00%) was recorded in genotype IS-25298, except IS-25301. Whereas, maximum stem tunneling (31.60%) was recorded in IS-27246 except ICSV-93046 and N-610. Kishore (1991) [3] also reported 22.3 to 28.2% stem tunneling in *Sorghum* genotypes. Bhadviya (1995) [2] reported 2.00 to 35.50% and Gour (1995) [3] recorded 0.51 to 12.71% stem tunneling in different genotypes of *Sorghum*.

Table 1: Performance of *Sorghum* genotypes against stem borer (*Chilo partellus* Swinhoe)

S. No	Genotype	Plant Infestation (%)		Dead Heart (%)		Stem tunneling (%)*	Peduncle tunneling (%)*
		30 DAE*	45 DAE*	30 DAE*	45 DAE**		
1	CMSxS-633	4.44 (12.05)	9.26 (17.69)	0.33 (0.88)	5.78 (13.87)	8.95 (17.40)	10.50 (18.89)
2	CMSxS-654	3.28 (10.04)	7.00 (15.32)	0.67 (1.00)	3.74 (11.03)	17.05 (24.34)	10.85 (19.22)
3	Gird- 36	5.59 (13.47)	8.68 (17.12)	0.00 (0.71)	2.73 (9.39)	11.60 (19.90)	13.45 (21.50)
4	Gird- 8	5.38 (13.35)	10.20 (18.58)	0.33 (0.88)	4.73 (12.51)	24.80 (29.86)	16.85 (24.20)
5	HBM-B-1071	5.02 (12.50)	8.56 (16.84)	0.59 (0.98)	6.65 (14.74)	9.75 (18.15)	32.45 (34.71)
6	IS-17248	8.07 (16.25)	13.92 (21.78)	0.67 (1.00)	5.79 (13.54)	17.00 (24.33)	9.85 (18.28)
7	IS-13349	3.44 (10.42)	9.44 (17.81)	0.00 (0.71)	8.48 (16.89)	15.20 (22.93)	13.20 (21.29)
8	IS-18542	11.40 (19.61)	18.50 (25.42)	1.70 (1.36)	4.03 (10.79)	20.20 (26.70)	16.50 (23.85)
9	IS-25298	9.14 (17.55)	12.00 (20.25)	0.00 (0.71)	3.15 (10.08)	3.00 (9.88)	13.95 (21.90)
10	IS-25301	7.18 (15.53)	13.01 (21.08)	0.00 (0.71)	2.30 (8.64)	4.50 (11.90)	15.70 (23.33)
11	IS-25302	8.00 (16.39)	13.71 (21.71)	0.64 (0.99)	7.07 (15.38)	25.00 (29.99)	19.60 (26.27)

12	IS-27206	8.03 (16.45)	10.53 (18.92)	0.00 (0.71)	7.19 (15.54)	19.10 (25.90)	17.50 (24.66)
13	IS-27246	6.61 (14.89)	12.71 (20.84)	0.33 (0.88)	4.64 (12.40)	31.60 (34.18)	16.80 (24.18)
14	IS-34024	6.85 (15.15)	11.05 (19.39)	0.00 (0.71)	5.72 (13.66)	6.10 (14.26)	19.80 (26.41)
15	N-610	7.48 (15.85)	11.04 (19.39)	0.67 (1.00)	10.25 (18.65)	29.10 (32.63)	11.95 (20.17)
16	Sel-B-Pop	7.65 (15.87)	12.11 (20.32)	0.69 (1.01)	7.73 (16.11)	21.20 (27.40)	12.70 (20.86)
17	DSSV-37xNSSV-14	5.42 (13.42)	9.70 (18.13)	0.67 (1.00)	2.17 (8.36)	9.95 (18.37)	17.40 (24.64)
18	NSSV-04 x DSSV-108	7.01 (15.34)	7.78 (16.19)	0.00 (0.71)	5.67 (13.71)	20.50 (26.91)	2.55 (9.14)
19	NSSV-04 x DSSV-196	7.61 (15.88)	14.56 (22.31)	0.00 (0.71)	6.73 (15.02)	10.30 (18.71)	12.05 (20.30)
20	NSSV-14 x RSSV-24	6.54 (14.79)	11.77 (19.99)	0.00 (0.71)	10.13 (18.51)	12.00 (20.25)	13.44 (21.48)
21	NSSV-258 x DSSSV-13	7.06 (15.13)	15.47 (23.09)	0.94 (1.15)	8.15 (16.48)	12.10 (20.35)	15.19 (22.93)
22	NSSV-015A x DSSV-165	4.20 (11.71)	9.42 (17.76)	0.60 (0.98)	3.75 (11.11)	16.50 (23.88)	19.09 (25.90)
23	CSH-2255	6.39 (14.63)	13.25 (21.32)	1.31 (1.28)	10.23 (18.58)	9.80 (18.24)	16.99 (24.29)
24	ICSV-93046	6.23 (14.42)	12.16 (20.39)	1.21 (1.15)	11.51 (19.81)	30.80 (33.70)	16.29 (23.79)
25	SSG-59	14.62 (22.46)	23.96 (29.22)	0.33 (0.88)	12.10 (20.32)	22.53 (28.26)	19.29 (26.04)
	SE(m)±CD at 5%	(1.20) (3.42)	(0.80) (2.29)	(0.22) (NS)	(1.09) (3.11)	(0.80) (2.27)	(0.65) (1.86)

* Figures in parenthesis are arc signvalues

** Figures in parenthesis are $\sqrt{n+0.5}$ values

Table 2: Host plant resistance of *Sorghum* genotypes against stem borer (*Chilo partellus* Swinhoe)

S. No.	Genotypes	Number of larvae/plant*	Number of pupa /plant**	Number of holes/plant*	Length of cob**	Weight of cob**
1	CMSxS-633	1.70 (7.49)	0.50 (1.00)	2.90 (9.80)	27.95 (5.33)	75.00 (8.69)
2	CMSxS-654	5.00 (12.91)	0.90 (1.18)	5.80 (13.93)	16.20 (4.09)	55.00 (7.45)
3	Gird- 36	4.00 (11.53)	0.80 (1.13)	3.70 (11.08)	21.40 (4.68)	60.50 (7.80)
4	Gird- 8	4.50 (12.24)	1.40 (1.38)	5.80 (13.90)	13.10 (3.69)	50.40 (7.13)
5	HBM-B-1071	3.80 (11.23)	0.90 (1.18)	3.30 (10.44)	0.00 (0.71)	0.00 (0.71)
6	IS-17248	4.30 (11.84)	1.40 (1.38)	4.80 (12.64)	0.00 (0.71)	0.00 (0.71)
7	IS-13349	2.85 (9.62)	0.80 (1.14)	4.60 (12.37)	11.70 (3.49)	71.20 (8.47)
8	IS-18542	4.40 (12.00)	1.20 (1.30)	6.10 (14.29)	5.70 (2.45)	25.00 (5.03)
9	IS-25298	0.90 (5.44)	0.00 (0.71)	0.80 (5.13)	21.90 (4.68)	60.40 (7.80)
10	IS-25301	2.70 (8.99)	0.10 (0.77)	1.20 (6.23)	21.50 (4.69)	65.20 (8.10)
11	IS-25302	4.80 (12.65)	1.50 (1.41)	6.50 (14.74)	0.00 (0.71)	0.00 (0.71)
12	IS-27206	5.40 (13.41)	1.50 (1.41)	6.70 (14.99)	5.90 (2.52)	37.40 (6.15)
13	IS-27246	6.30 (14.51)	1.70 (1.48)	7.90 (16.32)	19.00 (4.42)	63.40 (7.99)
14	IS-34024	1.90 (7.87)	0.40 (0.95)	2.50 (8.94)	11.80 (3.51)	60.00 (7.77)
15	N-610	5.90 (14.01)	1.90 (1.55)	8.10 (16.52)	0.00 (0.71)	0.00 (0.71)
16	Sel-B-Pop	6.10 (14.22)	1.40 (1.38)	6.70 (14.95)	20.70 (4.60)	25.00 (5.03)
17	DSSV-37xNSSV-14	2.40 (8.86)	0.40 (0.95)	3.70 (11.07)	21.00 (4.64)	37.00 (6.11)
18	NSSV-04 x DSSV-108	3.70 (11.07)	0.90 (1.17)	6.00 (14.13)	23.70 (4.92)	65.00 (8.09)
19	NSSV-04 x DSSV-196	2.70 (9.43)	0.40 (0.95)	3.50 (10.76)	9.50 (3.16)	55.20 (7.46)
20	NSSV-14 x RSSV-24	3.40 (10.62)	0.60 (1.05)	3.40 (10.62)	22.40 (4.79)	55.00 (7.45)
21	NSSV-258 x DSSSV-13	4.05 (11.60)	0.80 (1.13)	4.20 (11.80)	18.35 (4.33)	47.00 (6.89)
22	NSSV-015A x DSSV-165	3.90 (11.24)	0.90 (1.18)	3.90 (11.34)	21.40 (4.68)	75.00 (8.69)
23	CSH-2255	2.90 (9.80)	0.20 (0.84)	2.90 (9.79)	21.40 (4.68)	71.00 (8.45)
24	ICSV-93046	5.20 (13.14)	1.10 (1.26)	7.00 (15.34)	0.00 (0.71)	0.00 (0.71)
25	SSG-59	5.00 (12.91)	0.75 (1.09)	5.50 (13.48)	22.45 (4.79)	30.00 (5.51)
	SE(m)±CD at 5%	(0.70) (2.00)	(0.06) (0.18)	(0.54) (1.53)	(0.13) (0.38)	(0.09) (0.26)

* Figures in parenthesis are arc signvalues

** Figures in parenthesis are $\sqrt{n+0.5}$ values

Peduncle tunneling by *Chilo partellus*

Results of peduncle tunneling caused by stem borer at harvest indicated that genotype NSSV-04 x DSSV-108 was found minimum peduncle tunneling (2.55%) among the tested genotypes (Table 1). The maximum peduncle tunneling (32.45%) were recorded in genotype HBM-B-1071. Bhadviya (1995) [2] was also reported 5.20 to 35.00% peduncle tunneling caused by stem borer during investigation. Similar trends was also obtained by Gour (1995) [3] who's reported 5.46 to 57.6% peduncle tunneling among different varieties. The stem and peduncle tunneling might be associated with the presence of silica content and stem hardening in the genotypes.

Number of larvae of stem borer

Results indicated that minimum *Chilo partellus* larvae (0.90) was found in genotype IS-25298 (Table 2). The maximum no of larvae (6.30) was recorded in IS-27246 which was at par with genotype Sel-B-Pop, N-610, ICSV-93046, CMSxS-654, SSG-59, IS-27206 and IS-25302.

Number of pupa of stem borer

Present studies showed that genotype IS-25298 was found free from pupal stage (Table 2). The lowest number of pupa (0.10) was recorded in genotype IS-25301, but was at par to CSH-2255, IS-34024, DSSV-37 x NSSV-14 and NSSV-04 x DSSV-196. Whereas, highest number of pupa (1.90) was recorded in N-610, but at per with IS-27246, IS-25302, IS-27206, Gird-8, IS-17248 and Sel-B-Pop.

Number of holes caused by stem borer

Number of holes caused by *chilo partellus* in *Sorghum* plants revealed that less number of holes (0.80) was recorded in IS-25298, which was found significantly lowest amoug the genotypes except IS-25301 (Table 2). Whereas, higher number of holes (8.10) was recorded in genotype N-610.

Length of cob

The Cob was not formed in genotype HBM-B-1071, IS-17248, IS-25302, N-610 and ICSV-93046 due to infestation of C. partellus (Table 2). The lowest length of cob (5.70 cm) was recorded in genotype IS-18542 among the genotypes, but was at par to IS-27206. Whereas, highest cob length (27.95 cm) was recorded in CMSxS-633 followed by NSSV-04 x DSSV-108, SSG-59 and NSSV-14 x RSSV-24. The results showed that length of the cob was also reduced due to infestation of C. partellus.

Weight of cob

Minimum weight of cob (25.00 g) was recorded in Sel-B-Pop followed by DSSV-37 x NSSV-14, SSG-59 and IS-27206 (Table 2). The maximum weight of cob (75.00 g) was recorded in CMSxS-633 and NSSV-015A x DSSV-165. The weight of the cob reduced due to infestation of C. partellus.

Conclusions

Basis on various damaging symptoms caused by *chilo partellus* in *Sorghum* cultivars viz, plant infestation, dead heart, stem tunneling, peduncle tunneling, number of larvae and pupa/plant genotypes Gird-36, CMSxS-654, CMSxS-633, CMSxS-654, CMSxS-633, DSSV-37 x NSSV-14, NSSV-04 x DSSV-196, CSH-2255 DSSV-37 x NSSV-14, NSSV-04 x DSSV-196 and CSH-2255 were found tolerant to C. partellus. And genotype IS-25298 was found highly susceptible to C. partellus.

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