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Akshatha S
Post Graduate Student, College of Agriculture, Vijayapura-586 101, University of Agricultural Sciences, Dharwad, Karnataka, India

Karabhantanal SS
Senior Scientist, Agricultural Entomology, AICSP, RARS, Vijayapur, College of Agriculture, Vijayapura-586 101, University of Agricultural Sciences, Dharwad, Karnataka, India

Jagginavar SB
Professor, Agricultural Entomology, College of Agriculture, Vijayapura, Karnataka, India-586 101, University of Agricultural Sciences, Dharwad, Karnataka, India

Corresponding Author:
Akshatha S
Post Graduate Student, College of Agriculture, Vijayapura-586 101, University of Agricultural Sciences, Dharwad, Karnataka, India

Shoot bug, *Peregrinus maidis* (Ashmead): A potential threat to *Rabi* sorghum

Akshatha S, Karabhantanal SS and Jagginavar SB

Abstract
Sorghum shoot bug, *Peregrinus maidis* (Ashmead) is one of the major sucking insect pests in *rabi* season, can able to cause direct loss by sucking nature of adults and nymphs from leaves, leaf sheaths and stem during exploratory feeding and indirect damage is by transmitting sorghum stripe virus disease and excretion of honey-dew, encourages sooty mould development resulted in reduction of both quality and quantity of plant biomass. Keeping these points in view, the present investigation was carried out at the Research Farm of Regional Agricultural Research Station, Vijayapura, Karnataka, India during *rabi,* 2019-20 to assess the sorghum yield loss due to the shoot bug, *P. maidis* under filed condition on three varieties. Results revealed that significantly highest per cent loss in grain and fodder yield of 24.25 and 33.28 over cage control was recorded in highly susceptible variety (Hathi kunta) as compared to 21.99 and 26.43 per cent in moderately susceptible variety (M 35-1) and 12.98 and 20.99 per cent in resistant variety (Y-75), respectively. The untreated control plot recorded highest per cent of avoidable loss of 31.85 and 33.53 per cent in grain and fodder yield, respectively, which was statistically equivalent to release of 20 shoot bugs per plant (25.98 & 37.24%, respectively). On the contrary, in complete control plot with calendar-based sprays treatment recorded significantly lowest avoidable loss of grain (4.93%) and fodder yield (19.25%), which was superior to rest of the treatments.

Keywords: Yield loss estimation, shoot bug, *Peregrinus maidis*, Sorghum, *Rabi*

Introduction

Sorghum [*Sorghum bicolour* (L.) Moench] acts as an important dietary staple for millions of people living in about 30 countries in Africa and Asian continents, Sorghum plays an important role in food as well as livelihood security for almost every household, more so in Northern Dry Zone of Karnataka. In India, the sorghum production primarily remains in Maharashtra and Karnataka states. Over the years area under sorghum cultivation is declining and on the contrary, productivity is increasing trend. Even then, there is lot of scope to enhance the yield through improved production and protection techniques. Among the several abiotic and biotic factors responsible for decline in the area under sorghum in India, insect pests have been considered as one of the important biotic factors. It has been reported that nearly 150 pests are known to attack the crop at various stages from the day of sowing to till harvest (Reddy and Davies [1] and Jotwani *et al.* [2]). The shoot bug, *Peregrinus maidis* (Ashmead) is the major sucking insect pest in sorghum in Northern districts of Karnataka and the direct loss is by sucking nature by the adults and nymphs from leaves, leaf sheaths and stem during exploratory feeding, which causes reduced vigour, stunting, yellowing of leaves. When severe, leaf damage spreads downwards resulting in complete death of the plant etc. The infestation prior to pre-boot leaf stage causes girdling and twisting of leaves, prevent panicle development and emergence. Excessive oviposition in the midrib causes eventual drying up of leaves and the tissue surrounding the oviposition site. Indirect damage is by transmitting sorghum stripe virus disease. Feeding punctures and wounds produced by shoot bug ovipositor predispose sorghum plants to fungal infections and excretion of honey-dew by the insect encourages sooty mould development and it indirectly reduces the quality and quantity of plant biomass (Padmaja *et al.* [3]. Considering these facts, the present experiment has been carried out to estimate the yield losses of *rabi* sorghum due to the shoot bug.

Materials and Methods

To assess the extent of loss caused by shoot bug, *Peregrinus maidis* (Ashmead) in *rabi* sorghum, the present investigation was carried out at the Research Farm of Regional Agricultural

Research Station, Vijayapura, Karnataka, India during *rabi*, 2019-20 under rainfed situation. The experiment was laid out in plot size of 2.0 x 2.7m by adopting split plot design with two replications. The totals of following three varieties were used as main treatments and differential release of shoot bug population, complete cage control, calendar based application of insecticides for shoot bug management and untreated was considered as sub treatments. The details of treatments are as follows.

Treatment details

Main treatments	Varieties
V_1	M 35-1 (Moderately Susceptible to shoot bug)
V_2	Y-75 (Resistant check to shoot bug)
V_3	Hathi kunta (Susceptible check to shoot bug)

Sub Treatment: Shoot bug population per plant

S_1	5 shoot bugs / plant
S_2	10 shoot bugs / plant
S_3	15 shoot bugs / plant
S_4	20 shoot bugs / plant
S_5	Complete control plot (calendar-based sprays)
S_6	Untreated control (Natural control)
S_7	Cage control

All three *rabi* sorghum varieties (M 35-1, Y-75 & Hathi kunta) were sown during second week of October, 2019 and soon after germination, four plants in each plot (size of plot 2m x 2.70m) were covered with muslin cloth to prevent carryover field infestation in the experiment plot. Later when crop was at 40 days known number of shoot bug were released in each cage as per the treatment detail (S_1 to S_4). In complete or calendar-based sprays (S6) treatment, to check the shoot bug multiplication, regular spray was imposed as per the RPP schedule (Anon.) [4].

The multiplication rate of shoot bug population in each variety was counted by recording the number of shoot bugs per plant from the caged plants at 90 days after sowing or 50 days after release of known number of freshly emerged nymphs in each variety as per the treatment details. The shoot bug population per plant was by tapping the whorl part of the plant and number of shoot bug adults or nymphs coming out of the whorl region. The data was averaged to population per plant.The collected data were subjected to square root transformations for statistical analysis.

When the crop was at maturity, cloth nets were removed and recorded data on the panicle length (cms) and breadth (cms), Panicle weight (gms), grain yield (kg/ha) and fodder yield (q/ha). The data obtained from a set of observations for each character were tabulated and analysed by the method of "Analysis of variance" (Gomez and Gomez [5]). Further Yield loss in respective treatment was worked out using following formula.

Formulas used for loss estimation of yield

$$\text{Yield loss in respective treatment} = \text{yield in completely protected - yield in respective treatment treatment}$$

$$\text{Per cent yield loss} = \frac{\text{Yield loss in respective treatment}}{\text{Yield in completely protected treatment}} \times 100$$

Results and Discussion

Shoot bug population

Variation in the occurrence of shoot bug population on different varieties is attributed to several morphological and biochemical characters of each genotype. In the present investigation, multiplication rate of shoot bug population on different varieties was differed significantly at 90 days after sowing (50 days after release of shoot bug nymphs/plant), Table 1.The resistant variety (Y-75) recorded significantly lowest shoot bug population (3.42/plant) over moderately susceptible M 35-1 variety (10.61/plant) and highly susceptible Hathi kunta variety (15.41/plant). The present investigation is in agreement with Indhusri *et al.* [6] who reported higher shoot bog population in *rabi* varieties *viz*., Phule Yashodha, M 35-1, DSV 4, DSV 5 and Muguti. Similarly Subbarayudu[7] also reported that the maximum number of shoot bugs per plant in M 35-1. Chinniprakash and Karabhantanal [8] noticed higher number of shoot bug population on Hathi kunta when it was used as susceptible check in evaluation of speciality grain type of *rabi* sorghum varieties. While, the entries, SLR 35, SLV 29, SLV 31, SLV 10, SLV 25 and Y 75 were found to be resistant to shoot bug (Chikkarugi [9]). Among sub treatments, multiplication rate of shoot bug population at 90 days after sowing was significantly highest in natural control (14.08/plant) due to continuous exposure of plant during the cropping period and was did not differ significantly from graded releases of shoot bugs i.e. 5, 10, 15 and 20 shoot bugs per plant, as they recorded shoot bugs ranged from 14.06 to 10.09 per plant. This no impact of graded releases of shoot bugs might be due to hiding nature of both nymphs and adults in whorl region of the plant leads to competition for food and shelter. The finding is in conformity with Anaji [10] who reported that, the treatments with release of 30 first instar nymphs per plant recorded significantly higher mean shoot bug population per plant (62.5) followed by treatments with release of 25, 20, 15, 10 and 5 first instar nymphs per plant with 49.3, 41.3, 35.6, 28.5 and 22.6, respectively.

In Interaction effect, the susceptible variety (Hathi kunta) with the release of 15 shoot bugs per plant in a cage recorded significantly highest shoot bug population (16.26 / plant), while it was lowest in resistant variety (Y-75) with 5 bugs per plant (0.91 /plant), Table 1. All the varieties in natural control treatment (4.38 in Y-75, 13.63 in M -35-1, & 18.42 in Hathi kunta) were recorded highest population of shoot bugs per plant. It is quite obvious that susceptibility of variety coincide with higher number of shoot bugs prone to higher multiplication than those with resistant variety with same number of release. The variation of shoot bug multiplication in different varieties is attributing to plant morphological characters and chemical composition of the plants. Chinniprakash [11] who reported, Hathi kunta (shoot bug susceptible variety) had higher trichome density (12.33/ mm^2), leaf glossiness (2.08 grade), seedling vigour (2.0 grade), lowest relative water content (77.33%), relative chlorophyll content (43.60) and leaf area index (2.95) as compared to resistant variety i.e. DJ-6514 with no trichomes on leaf, 4.83 grade of leaf glossiness and 4.67 grade of seedling vigour, higher relative water content (90.33%), relative chlorophyll content (53.07) and leaf area index (3.83).

Panicle length and breadth

The susceptible variety (Hathi kunta) with release of 20 shoot bugs per plant recorded significantly lowest panicle length

(11.63cm) and breadth (4.63cm) which was on par with un treated / natural control (13.38 & 4.98 cm) as well as with its lowest release of shoot bugs per plant treatments *Viz.,* 15 shoot bugs/plant (14.00 & 4.88cm), 10 shoot bugs per plant (15.00 & 5.38cm) and 5 shoot bugs per plant (15.48 & 6.13cm), respectively. In Moderately susceptible variety (M 35-1) and resistant variety (Y-75) also similar trend was observed but the length and breadth of panicle in these two varieties were significantly higher than the Hathi kunta variety (Table 1). The significant variation in the length and breadth of panicle in each genotype was in relation to the shoot bug population in each genotype. The infestation of shoot bugs prior to pre-boot leaf stage usually causes girdling / twisting of top leaves, which bend downwards and prevent panicle development and emergence which has resulted in reduction in ear head length and breadth in treatments with differential releases of shoot bugs as compared to cage and complete control plot. In the present investigation severity of shoot bug infestation was more in susceptible variety (Hathi kunta) than resistant variety (Y-75) and moderately susceptible variety (M 35-1). The presents findings are conformity with results of Mote and Shahane [12] who reported increased content of total phenols in infested plants that resulted in suppression of pest damage by hindering the food digestion particularly protein digestion in insects. Further, the investigation made by Chinniprakash[11] reported that, Hathi kunta (shoot bug susceptible variety) had higher trichome density (12.33/ mm^2), leaf glossiness (2.08 grade), seedling vigour (2.0 grade), lowest relative water content (77.33%), relative chlorophyll content (43.60) and leaf area index (2.95) as compared to resistant variety i.e. DJ-6514 with no trichomes on leaf, 4.83 grade of leaf glossiness and 4.67 grade of seedling vigour, higher relative water content (90.33%), relative chlorophyll content (53.07) and leaf area index (3.83) Further he also noticed a significant and negative correlation between shoot bug damage at 70 DAE and total phenol content of leaf at seedling stage (r =-0.201), vegetative stage (r =-0.956) and reproductive stage (r =-0.554). These are some possible reasons for highly susceptibility of Hathi kunta variety to shoot bug infestation compared to other verities.

Panicle weight (g)

Moderately susceptible variety (M 35-1) recorded significantly highest panicle weight (86.52 g/plant**)** and was differed significantly from Y-75 (Resistant check) and Hathi kunta (Highly susceptible) varieties as they recorded the weight of 50.20 g and 50.43 g per plant, respectively. During the study period, shoot bug population was high on Hathi kunta variety, which led to maximum loss in panicle weight (Table 1). On the contrary, panicle weight was significantly highest in M 35-1 variety though it is moderately susceptible to shoot bug compared to resistant variety (Y-75). The variation in the panicle weight is due to genetic character of each genotype. Variety, M 35-1 is inherent tolerant to drought, having narrow leaves, medium size with semi compact type of ear head it might be resulted in higher panicle weight.

The treatment with cage control recorded the highest panicle weight of 87.17 g per plant followed by complete control plot i.e. calendar based sprays (74.26 g/plant). On the contrary, untreated control (Natural control) recorded significantly lowest panicle weight (59.73 g/ plant). Further, interaction effects between sorghum varieties and differential release of shoot bug population per plant had significant impact on panicle weight. In M 35-1 variety, treatment without release of shoot bugs in cage had significantly highest panicle weight (111.74g) followed by calendar-based spray treatment (92.18g) and release of shoot bugs @ 5 per plant (86.80g). In susceptible (Hathi kunta) and resistant (Y-75) varieties also, similar trend was observed. From the study it can be concluded that irrespective of genotypes, the population of shoot bug at all graded level (5,10, 15 & 20 /plant) had equally reduced the panicle parameters. This might be due to the specific feeding nature of both nymphs and adults in the whorl region of the plant during peak growth stage, particularly prior to pre-boot leaf stage causes girdling and twisting of leaves prevent panicle development and emergence.

Sorghum grain and fodder yield

Sorghum grain and fodder yield was significantly highest in moderately susceptible variety, M -35-1 (1879 kg & 31.90 g/ha) followed by Y-75 variety (1200 kg & 24.67q/ha) and Hathi kunta variety (1050kg & 17.63q/ha), respectively (Table 1). The highest sorghum in M 35-1 is due to highest panicle length breadth, weight and semi compact nature of ear head as compared to Y-75 and Hathi kunta. The present investigation is in agreement with Indhusri *et al.* [6]. Among different sub treatments, treatment with cage control without release of shoot bug was significantly superior over all other treatments by recording highest grain and fodder yield (1779 kg/ha & 32.97 q/ha), followed by complete control plot i.e. calendar based sprays (1612 kg/ha & 28.82 q/ha), respectively. While, it was lowest in natural control (1297 kg/ha & 20.82 q/ha) and was on par with the treatment comprising of release of 20 shoot bugs per plant (1124 kg/ha & 21.33 q/ha), respectively. As the numbers of released insects were increased, the lowest grain and fodder yield was obtained. This is due to fact that adults and nymphs of shoot bug pierces the vascular tissues and suck sap from whorl region of plant, which causes leaf yellowing, reddening, reduced vigour, stunting, and least ear head emergence which causes significant reduction in grain and fodder yield both in terms of quality and quantity. These findings are in line with Anaji [10] who reported that, the control treatment with no infestation recorded significantly higher grain and fodder yield 42.7 g per plant and 60.3 g per plant, respectively as compared release of shoot bugs at 30 nymphs per plant (20.70 g/plant). Present investigation is also in conformity with [13] Shivamurthappa *et al.* [13] who estimated yield loss in sorghum under greenhouse condition and recorded the highest grain weight in un infested plants (43.25 g) than the infested plants with 34.96, 18.08, 14.72, 12.74 and 3.93 g per plants in 5, 10, 15, 20 and 25 first instar nymphs, respectively.

The interaction effects between sorghum varieties and differential release of shoot bug population per plant had significant impact on grain and fodder yield per ha (Table 1). In M 35-1 variety, treatment without release of shoot bugs in cage had significantly highest grain (2245 kg/ha) and fodder yield (43.33 q/ha) and was superior to rest of the treatments. Untreated plot recorded significantly lowest grain yield and fodder yield of (1677 kg & 27.46 q/ha), respectively. Similar trend was also noticed in highly susceptible (Hathi kunta) and resistant (Y-75) varieties.

Significantly highest per cent loss in grain and fodder yield over cage control was recorded in highly susceptible variety i.e. Hathi kunta (24.25 & 33.28%) as compared to moderately susceptible i.e., M 35-1 (21.99 and 26.43%) and resistant variety i.e. Y-75 (12.98& 20.99%), respectively (Table 1). Whereas, the highest per cent of avoidable loss in grain and fodder yield was recorded in untreated control with (31.85 & 33.53%) and was on par with the release of 20 shoot bugs per plant (25.98 & 37.24%), respectively. Further, the loss was gradually decreased with reduced release of first instar shoot bug nymphs 15, 10 and 5 per plant. In complete control plot with calendar-based sprays treatment recorded significantly lowest avoidable loss of grain (4.93%) and fodder (19.25%) yield, which was superior to rest of the treatments. The results are in conformity with Anaji [10] who reported that the highest yield loss of 51.5 and 43.3 per cent was recorded in the treatments with the release of 30 and 25 first instar nymphs per plant, respectively. The present finding is also corroborating with the reports of Chavan *et al.* [14], Shivamurthappa [13]. Raja sekhar *et al.* [15] who reported 13.82, 25.46 and 14.1 per cent reductions in grain yield, respectively due to shoot bug infestation.

Conclusion

Significantly highest per cent loss in grain and fodder yield was recorded in highly susceptible variety (Hathi kunta) as compared moderately susceptible variety (M 35-1) and resistant variety (Y-75). The release of shoot bugs @ 20 per plant had caused equivalent yield loss as that of untreated control in all three varieties. Whereas, in complete control plot with calendar-based sprays treatment for shoot bug management recorded significantly lowest per cent of avoidable loss in grain and fodder yield and was superior to rest of the treatments in all three varieties.

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Table 1: Effect of differential release of shoot bug population on panicle characters in different *rabi* sorghum varieties

Treatments	Shoot bug population per plant at 45 days after shoot bugs release (90 DAS)				Panicle length (cms) at harvest				Panicle breadth (cms) at harvest				Panicle weight (gms)			
	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean
S_1	9.60 (3.18)	3.10 (1.90)	17.58 (4.25)	10.09 (3.25)	17.58	18.48	15.48	17.18	6.75	7.13	6.13	6.67	86.8	49.63	35.49	57.31
S_2	13.85 (3.79)	4.15 (2.16)	16.75 (4.15)	11.58 (3.48)	16.58	17.85	15.00	16.48	6.13	6.55	5.38	6.02	84.34	45.13	33.88	54.45
S_3	13.00 (3.67)	5.75 (2.50)	17.88 (4.29)	12.21 (3.56)	15.50	17.00	14.00	15.50	5.75	6.00	4.88	5.54	82.25	42.06	33.11	52.47
S_4	16.00 (4.06)	5.75 (2.50)	20.43 (4.57)	14.06 (3.82)	14.88	16.50	11.63	14.33	5.13	5.75	4.63	5.17	79.58	43.93	30.42	51.31
S_5	7.26 (2.79)	2.37 (91.69)	11.44 (3.45)	7.02 (2.74)	20.00	19.25	17.13	18.79	7.38	8.63	6.25	7.42	92.18	57.47	73.13	74.26
S_6	15.56 (4.01)	4.84 (2.31)	21.84 (4.73)	14.08 (3.82)	14.25	15.68	13.38	14.43	5.13	5.38	4.98	5.16	68.76	50.88	59.55	59.73
S_7	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	22.85	21.00	18.75	20.87	8.38	9.38	7.63	8.46	111.74	62.33	87.45	87.17
Mean	10.61 (3.33)	3.42 (1.98)	15.41 (3.99)	9.82 (3.21)	17.38	17.96	15.05	16.80	6.38	6.97	5.69	6.35	86.52	50.20	50.43	62.39
For Comparison			C.D. @5%	S.Em.±	C.D. @5%		S.Em.±		C.D. @5%		S.Em.±		C.D. @5%		S.Em.±	
Varieties (V)			0.70	0.12	1.93		0.33		0.77		0.13		12.34		2.04	
Shoot bug population (S)			0.61	0.21	3.01		1.01		1.60		0.53		6.16		2.06	
'S' at same 'V'			0.65	0.23	2.85		0.96		1.68		0.55		7.92		2.65	
Interaction 'S' x 'V'			0.67	0.24	2.91		0.98		1.89		0.64		8.99		3.03	

Varieties: V_1 – M 35-1, V_2– Y-75, V_3 - Hathi kunta
Release rate of shoot bug population: S_1 - 5 shoot bugs/plant, S_2 –10 shoot bugs/plant, S_3 - 15 shoot bugs/plant, S_4 - 20 shoot bugs/plant
S_5 - Complete control plot (calendar-based sprays), S_6 -Untreated control (Natural control), S_7 -Cage control without release of shoot bug
Figures in the parenthesis are arc sine transformed value

Table 2: Effect of differential release of shoot bug population on grain and fodder yield in different *rabi* sorghum varieties

Treatments	Grain yield (kg/ha)				Per cent loss in grain yield per plant over cage control (S7)				Fodder yield (q/ha)				Per cent loss in fodder yield per plant over cage control (S7)			
	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean
S_1	1922	1202	964	1363	16.24 (23.76)	9.69 (18.14)	17.17 (24.48)	14.37 (22.27)	30.79	24.58	16.67	24.01	28.93 (32.54)	20.43 (26.88)	39.66 (39.04)	29.68 (33.01)
S_2	1867	1071	846	1262	22.06 (28.01)	13.41 (21.48)	23.32 (28.87)	19.60 (26.27)	29.79	23.33	16.25	23.13	31.43 (34.10)	25.65 (30.43)	41.34 (40.01)	32.81 (34.94)
S_3	1764	1033	800	1199	23.00 (28.66)	17.17 (24.93)	24.32 (29.55)	21.70 (27.76)	28.21	22.42	15.54	22.06	35.00 (36.27)	28.26 (32.11)	44.13 (41.63)	35.80 (36.75)
S_4	1601	1032	740	1124	27.60 (31.70)	21.16 (27.39)	29.18 (32.70)	25.98 (30.65)	27.46	21.54	15.00	21.33	36.79 (37.34)	29.13 (32.67)	45.81 (42.60)	37.24 (37.61)
S_5	2075	1392	1367	1612	5.55 (13.62)	3.39 (10.61)	5.87 (14.02)	4.93 (12.83)	36.67	30.00	19.79	28.82	15.36 (23.07)	13.91 (21.90)	28.49 (32.26)	19.25 (26.03)
S_6	1677	1179	1033	1297	37.48 (37.75)	12.44 (20.65)	45.64 (42.50)	31.85 (34.36)	27.08	16.88	18.50	20.82	37.50 (37.76)	29.57 (32.94)	33.52 (35.38)	33.53 (35.38)
S_7	2245	1493	1598	1779	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	43.33	33.96	21.63	32.97	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Mean	1879	1200	1050	1376	21.99 (27.96)	12.98 (21.12)	24.25 (29.50)	19.74 (26.38)	31.90	24.67	17.63	24.73	26.43 (30.94)	20.99 (27.27)	33.28 (35.23)	26.90 (31.24)
For Comparison			C.D.@ 5%	S.Em.±	C.D. @5%		S.Em.±		C.D. @5%		S.Em.±		C.D. @5%		S.Em.±	
Varieties (V)			265.08	44.19	1.29		0.22		9.67		1.62		4.67		0.78	
Shoot bug population (S)			244.33	81.46	5.76		1.93		3.07		1.03		4.91		1.64	
'S' at same 'V'			265.52	88.51	6.82		2.28		3.49		1.16		5.01		1.68	
Interaction 'S' x 'V'			277.17	92.33	9.55		3.19		3.52		1.18		5.15		1.72	

Varieties: V_1 – M 35-1, V_2– Y-75, V_3 - Hathi kunta
Release rate of shoot bug population: S_1 - 5 shoot bugs/plant, S_2 –10 shoot bugs/plant, S_3 - 15 shoot bugs/plant, S_4 - 20 shoot bugs/plant
S_5 - Complete control plot (calendar-based sprays), S_6 -Untreated control (Natural control), S_7 -Cage control without release of shoot bug
Figures in the parenthesis are arc sine transformed values

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