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AVOIDABLE YIELD LOSSES AND NATURE OF DAMAGE IN SORGHUM BY EARHEAD BUGS

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SUMMARY

To understand the merit of timely control measure tactic and feeding behaviour of earhead bugs, present investigations carried out at the Research Farm, Forage Section, Department of Genetics & Plant Breeding, CCS HAU, Hisar during *Kharif*, 2020-21 and 2021-22. Four sorghum varieties; selected on the basis of maturity, panicle type and susceptibility namely SSG 59-3 (loose), HJ 513 (semi compact), HC 136 and HC 308 (compact) for the experimentation and seeded in the month of July with 45 cm x 45 cm spacing. Yield losses to the tune of 36.3, 27.4, 30.9 and 7.1 per cent in *Kharif*, 2020 and 26.6, 26.5, 29.1 and 10.1 per cent in *Kharif*, 2021 avoided in varieties, HC 308, HJ 513, HC 136 and SSG 59-3, respectively can be avoided by adapting timely and proper control measures. Irrespective of varieties, 25.4 and 23.1 per cent of losses were averted during *Kharif,* 2020 and *Kharif,* 2021. Earhead bugs were first observed 64 to 68 days after sowing of sorghumvarieties. At this stage, panicles just started emerging from boot leaves. During anthesis period, only adults were observed in panicles and nymphs, if present, were scanty that confirms for anthesis period to be considered as preferred time for oviposition by earhead bugs. Number of earhead bugs *i.e.,* adults and nymph were maximum at milky stage of panicle indicating a preference for milk stage of panicle. During initial stage of panicle, the apex part of panicle was most preferred for oviposition by numbers of adult females of earhead bugs and then they moved towards lower end of panicle as flowering portion progressed to bottom is very much crucial for population build-up of earhead bugs.

Keywords: Earhead bugs, feeding behaviour, nature of damage, sorghum, yield losses

Genus *Sorghum* belongs to the family Poaceae or Gramineae that includes both cultivated and wild species meant for grain, fooder, feed, syrup, commercial and other may more purposes. Over the last two decades' interest in sorghum for human consumption and animal feed has increased tremendously. Sorghum grains have multipurpose aspects as it is eaten as *Chapatti* (Bread), biscuit, sweet corn, pop sorghum, *sankatti* or *mudda* or *kali*, used for brewing to make beer, stockfeed, pigs, poultry, used as fuel, extracting dye, making basket and fish trap and construction of hut roof (Rao *et al.,* 2010).

Productivity of sorghum in India is 849.05 kg/ha, is well below the world's average (1444.6 kg/ha). In India, a total of 3.47 million tons of sorghum grains were produced over the acreage of 4.07 million hectares during 2020 (FAO, 2022). The variability of grain type and plant type is remarkable. It is this ability to give a useful yield of grain under difficult agronomic conditions which makes sorghum such a valuable cereal (Satyagopal *et. al.,* 2014). Absence of improved genotype and plant protection measures resulted in 39 and 31 per cent reduction in fodder yield of sorghum, respectively (Satpal *et al.,* 2021). A major reason pitifully low sorghum yields, especially in African and Asian countries, are insect attack; although reliable yield loss data are hard to come by. Increased interest in sorghum grains for human consumption and animal feed ended with the entomology input (ICRISAT, 1984). Losses to earhead caused by midge and earhead bug alone varies from 15.0 to 30.0 per cent to 75.0 per cent in local sorghum, while in commercial cultivars damage ranges from 5.8 to 68 per cent in fodder yield (Jakhar *et al.,* 2021) to 43.0 to 93.0 per cent in grain for earhead bug (Kumar *et al.,* 2022). However, it is established that advancing date of planting not only returns good yield and (also eliminates

shoot fly attack) most sorghum pests can be avoided (Ahlawat and Kumar, 2021).

There are over 150 insect species known to damage sorghum plant from germination to crop harvest (Verma and Singh, 2000). Various earhead bugs reported damaging this crop from India and abroad are, *Calocoris angustatus, Dolycoris indicus, Creontiades pallidus, Eurystylus immaculatus, Campylomma* spp. and *Taylorilygus vosseri* (Kumar *et al,* 2022). Of which *C. angustatus* is most important species in India and *E. immaculatus* in West-Africa. Damage results from bugs sucking juices from the immature developing grains, resulting in shrivelling of grain thereby affecting both yield and quality. Often the damaged seeds are infected with fungus that causes the seed to turn black and results in further deterioration in quality of seed. Damaged seeds rarely develop fully and all considerably smaller, softer and lighter in weight than the undamaged seed and subject to loss during harvesting (Kumar, 2005).

Keeping in view of the above facts, the present investigation was attempted to estimate the avoidable yield losses and nature damage caused by earhead bugs in dual purpose sorghum to ascertain the feeding behavior to initiate the specific control measures accordingly.

MATERIALS AND METHODS

To record the nature of damage, the sorghum varieties selected on the basis of maturity, panicle type and susceptibility were: SSG 59-3, HJ 513, HC 136 and HC 308 and were sown on July 11, 2020 and July 21, 2021. Each variety was monitored regularly to observe the first presence/ appearance of earhead bug on sorghum panicle to record the actual time of feeding, actual stage of panicle emergence and when head bugs start feeding on panicle after their appearance was studied in *Kharif* season at research farm of Forage Section, Department of Genetics & Plant Breeding, CCS Haryana Agricultural University, Hisar, in Haryana State conditions, geographically located in Indo-Gangetic plains of North-West India at 215.2 meter (705 ft MSL) coordinates at 29°10′0′′N, 75°43′0′′E on map, receives average precipitation 490.6 mm annually with average summer and winter temperature 32.5°C and 17.6°C, respectively.

In order to estimate the yield losses, the crop of each variety was divided into two sets of conditions, *i.e.,* protected and unprotected. A pre-spraying population of insect pests was observed under both set of condition. The crop was protected from earhead feeders in protected plots by application of quinalphos 1.5 % DP at the rate of 26.6 kg per hectare as and when ETL of panicle feeder insect pests is observed. A second spray at fifteen days' interval was done to prevent further crop damage. In unprotected plots, the crop was not given any protection and natural infestations of earhead bugs were allowed to occur in all selected cultivars. Observation on avoidable yield losses were recorded at the time of harvesting, twenty random earheads of sorghum plants were selected and threshed separately from both type of plots *i.e.*, protected as well as unprotected plots. Avoidable losses in grain yield were then worked out in per cent by comparing grain yield contributing parameters in each variety by formula as under;

$$\text{Per cent avoidable yield loss} = \frac{X-Y}{X} \times 100$$

Where,

X = Yield in protected plot

Y = Yield in unprotected plot

Statistical analysis

The data obtained pertaining to avoidable yield losses in different sorghum varieties were subjected to statistical analysis by using standard analysis of variance (ANOVA) as per procedures of Sheoran *et al.*, 1998.

RESULTS AND DISCUSSION

Irrespective of varieties, mean grain weight/ earhead was always more (57.8 g/earhead) under sprayed conditions (Table 1) as compared to unsprayed (41.3 g/earhead) ones during the 2020 cropping season. Irrespective of the protection provided, the mean grain weight/earhead was significantly more (59.2 g) in variety HC 308 and was least (29.5 g) in variety SSG 59-3. In remaining two varieties *i.e.,* HJ 513 and HC 136, it was 53.1 and 56.2 g, respectively. Mean grain weight (g) per earhead under protected condition was significantly more (77.3 g) in variety HC 308 and was followed in variety HC 136 (66.4 g) and was least (30.7 g) in variety SSG 59-3. Similar trend was observed under unprotected conditions. The mean per cent avoidable loss was significantly more (36.3%) in variety HC 308 and was least (7.1 %) in variety SSG 59-3. In other two varieties, the mean per cent avoidable losses were 27.4 and 30.9 per cent in variety HJ 513 and HC 136, respectively.

TABLE 1
Grain weight of sorghum genotypes under protected and unprotected conditions in relation to earhead bug incidence *Kharif*, 2020

Varieties(A)	Mean grain weight (g)/ panicle under		Mean (A)	Avoidable loss (%)	Mean number of earhead bugs/20 panicles under		Mean	Reduction in bug population (%)
	Sprayed condition	Unsprayed condition			Sprayed* condition	Unsprayed** condition		
HC 308	77.3	46.1	59.2	36.3	7.5	387.1	197.3	98.0
HJ 513	61.5	44.7	53.1	27.4	4.1	223.4	113.8	98.2
HC 136	66.4	45.9	56.2	30.9	8.6	456.3	232.5	98.1
SSG 59-3	30.7	28.4	29.5	7.1	2.1	31.3	16.7	93.3
Mean (B)	57.8	41.25	49.5	25.4	5.6	274.53	140.1	96.9

*Mean no. of earhead bugs/ 20 panicles observed after 3rd day of 2nd protection, first application of quinalphos 1.5 % DP given on 64-68 days after sowing, **Mean no. of earhead bugs/20 panicles observed before insecticide application.

Tables of SE (m) and CD

Factors	SE (m)	CD (P=0.05)
Varieties (A)	0.174	0.513
Treatments (B)	0.123	0.367
Interaction (AxB)	0.246	0.725

Without reference to the variety, the mean numbers of bugs/20 panicles were significantly more (274.5 bugs) under unsprayed condition as compared to those observed under sprayed condition (5.6 bugs). The mean numbers of earhead bugs/20 panicles were 456.3, 387.1, 223.4 and 31.3 in variety HC 136, Hc 308, HJ 513 and SSG 59-3 under unsprayed condition and under sprayed condition the mean number of bugs were 8.6, 7.5, 4.1 and 2.1, respectively.

To confirm the earlier results achieved during 2020, the experiment was repeated during *Kharif,* 2021 and the results (Table 2) recorded clearly indicated that no matter what of varieties, the mean grain weight (g) per earhead was significantly more (62.5g) under sprayed condition as compared to that observed (46.7g) under unsprayed conditions. Irrespective of protection provided, mean grain weight was significantly more (67.4g) in variety HC 136 and was least (31.3g) in variety SSG 59-3. In other two sorghum varieties, *i.e.,* HJ 513 and HC 308 the mean grain weight/earhead was 60.9 and 58.8g, respectively. Mean grain weight (g)/earhead were invariably more under sprayed condition than observed under unsprayed condition in all the tested varieties. Under protected conditions, it was significantly more (78.91g) in variety HC 136, followed by variety HJ 513 (70.1g), and was minimum (32.9g) in SSG 59-3. Same trend was observed under unprotected conditions in different varieties. Mean per cent avoidable loss was significantly more (29.1 %) in variety HC 136 and was least (10.1 %) in variety SSG 59-3. In other two varieties, the mean per cent avoidable losses were 26.5 and 26.6 per cent in variety HJ 513 and HC 308, respectively. Irrespective of the varieties, the mean numbers of earhead bugs per 20 earheads were always lesser (3.9 bugs) under sprayed condition as compared to those observed in unsprayed condition (223.5).

The mean numbers of bugs/20 earheads under sprayed condition were 6.2, 4.5, 3.3 and 1.8 in variety HC 136, HC 308, HJ 513 and SSG 59-3, respectively and corresponding number under unsprayed conditions in these varieties was 402.4, 271.4, 191.7 and 28.6, respectively. It is evident from the data that mean grain weight/earhead was always more under sprayed conditions as compared to unsprayed conditions. Although, varieties with compact or semi-compact type of earheads supported more population of bugs versus varieties with loose type of earhead had lower populations of bugs. Notwithstanding, mean grain weight was more in variety with compact or semi-compact type of earheads/panicles and was lesser in variety with loose type of earheads/panicle. It becomes essential to check the population build-up of these bugs, hence insecticidal interventions become necessary as soon as the pest approaches economic threshold levels. It was well documented that midge and earhead bugs could cause damage amounting to more than 75 per cent for causing grain damage in sorghum earheads (Kumar *et al.,* 2022) and have advocated the application of insecticides for the management of bugs infesting sorghum earheads (Galvan *et al.*, 1995). However, Rao and Azam (1987)

TABLE 2
Grain weight of sorghum genotypes under protected and unprotected conditions in relation to earhead bug incidence *Kharif*, 2021

Varieties(A)	Mean grain weight (g)/ panicle under		Mean (A)	Avoidable loss (%)	Mean number of earhead bugs/20 panicles under		Mean	Reduction in bug population (%)
	Sprayed condition	Unsprayed condition			Sprayed* condition	Unsprayed** condition		
HC 308	67.8	49.8	58.8	26.6	4.5	271.4	137.95	98.3
HJ 513	70.1	51.6	60.9	26.5	3.3	191.7	97.50	98.3
HC 136	78.9	55.9	67.4	29.1	6.2	402.4	204.30	98.5
SSG 59-3	32.9	29.7	31.3	10.1	1.8	28.6	15.20	93.7
Mean (B)	62.5	46.7	54.6	23.1	3.9	223.5	113.7	97.2

*Mean no. of earhead bugs/ 20 panicles recorded after 3rd day of 2nd protection, first application of quinalphos 1.5 % DP given on 64-68 days after sowing, **Mean no. of earhead bugs/20 panicles observed before insecticide application.

Tables of SE (m) and CD

Factors	SE (m)	CD (P=0.05)
Varieties (A)	0.156	0.455
Treatments (B)	0.112	0.324
Interaction (AxB)	0.219	0.642

had shown the effectiveness of simple tapping of earheads in water kerosene mixture (10:1) to control bugs population upto 58 per cent. Whereas Ramamurthy and Rajaram (2001) and Sharma *et al.* (1999) utilized extract of plant origin to control, *C. angustatus* effectively to avoid losses in grain sorghum.

Nature of Damage

Mote and Jadhav (1990), Hall and Teetes (1982) had have observed losses in grain weight were due to shrivelled, lighter and smaller grains due to earhead/panicle feeder feeders. Both, nymphs and adults of earhead bugs infest the panicle as soon as they emerge from the boot leaf stage and suck sap from the developing grains (Sharma *et al.*, 1992; Teetes *et al.*, 1983).

For this experiment, four sorghum varieties i.e. HC 136, HJ 513, SSG 59-3 and HC 308 were sown in the month of July, 2020. During 2020, the earhead bugs were first observed 64 to 66 days after sowing of varieties. At this stage, panicles just started emerging from boot leaves. However, in case of variety SSG 59-3, the bugs were first observed when anthesis started in panicles. While during 2021, head bugs were observed 66 to 68 days after sowing in varieties HC 136, HJ 513 and HC 308 as the panicles started emerging from boot leaves in field. This year, the bugs were simultaneously observed in variety SSG 59-3 at the same time *i.e.,* 66 to 68 days after sowing.

During anthesis period, only adults were observed in panicles and nymphs, if present, were scanty and they can be counted easily that confirms for anthesis period to be considered as preferred time for oviposition by earhead bugs. The same observations were recorded by Sharma and Lopez (1989) and Hall and Teetes (1982).

Number of earhead bugs *i.e.,* adults and nymph were maximum at milky stage of panicle indicating a preference for milk stage of panicle. During initial stage of panicle, the apex part of panicle was most preferred for oviposition by adult females of earhead bugs and then they moved towards lower end of panicle as flowering portion progressed to bottom. Present findings are also in conformity with these as recorded by Kumar (2005), Sharma and Lopez (1989). Authors were of the opinion that head bug density at half anthesis, complete anthesis, milk and dough stage is very much crucial for population build-up of earhead bugs in sorghum crop (Sharma *et al.*, 1992).

CONCLUSION

Number of earhead bugs on the dual purpose sorghum is decided by time of maturity, panicle type *viz.,* loose, semi compact or compact type and susceptibility. Moreover, mean (24.3%) yield losses to the tune of 31.5, 27.0, 30.0 and 8.6 per cent can be avoided in varieties, HC 308, HJ 513, HC 136 and SSG 59-3, respectively by adapting timely and proper control measures of sorghum earhead bugs at Economic Threshold (ET). Earhead bugs were first

observed 64 to 68 days after sowing of sorghum cultivars when panicles just started emerging from boot leaves and during anthesis period only adults were observed in panicles considered as preferred time for oviposition by earhead bugs. Apex part of panicle was most preferred for oviposition by adult females of earhead bugs and then moved towards lower end of panicle as flowering portion progressed to bottom is very much crucial for population build-up of earhead bugs in different sorghum varieties.

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