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Assessment of Avoidable Yield Losses due to spotted stem borer, *Chilo partellus* (Swinhoe) in Maize (*Zea mays* L.)

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ABSTRACT

Field experiment was carried out at Agricultural Research Station, Darsi to evaluate the avoidable yield loss caused by spotted stem borer in maize during *rabi* season of 2015-16. The treatment with release of 8 first instar larvae per plant recorded significantly higher mean stem borer larval population per plant (9.08) and dead heart incidence (39.74%). The per cent grain yield loss increased with increase in larval density. The maximum loss in grain yield (45.68%) and 100-grain weight (19.25%) was occurred in the treatment with 8 larvae per plant. The correlation coefficients between *C. partellus* larval incidence and grain yield (r = - 0.946) and 100-grain weight (r = - 0.863) were negative and highly significant. In the present investigation, the economic injury level was worked out to be 2.74 larvae per plant.

Key words*: Avoidable yield loss, Chilo partellus, Graded level of infestation, Maize.*

In India, maize is the third most important cereal crop after rice and wheat which is used as the staple food and grown in an area of 94.26 million hectares with an annual production of about 24.35 million tonnes thus giving an average productivity of 2583 kg ha^{-1}. In Andhra Pradesh, it is cultivated in an area of 1063 thousand hectares with a production of 4968 thousand tones and 4673 kg ha^{-1} productivity (Yadav, 2015). Maize is gaining greater popularity among the farmers in recent years because of choice of the high yielding hybrids and cultivability throughout the year. One of the major obstacles in the enhancement of maize yields has been the attack of various insect pests, of which spotted stem borer, *Chilo partellus* (Swinhoe) is most destructive one. Feeding and stem tunneling by borer larvae on maize plants results in crop losses as a consequence of destruction of the growing point, early leaf senescence, interference with translocation of metabolites, and nutrients that result in malformation of the grain, stem breakage, plant stunting, lodging, and direct damage to cobs (Kfir *et al*., 2002). Infestation of *C. partellus* can cause crop damage up to 81% (Moyal, 1998) and grain yield losses to the extent of 35.4% (Panwar *et al*., 2001). Stem borer damage ultimately affects food security and the agricultural economy (Mugo, 2001).

Information on crop losses is prerequisite to determine the relative importance of pests and to provide a sound base for an integrated management schedule. It is also a tool in decision making in agricultural planning and forecasting. The consequence on yield is variable (negligible to total crop loss) depending upon location, season, sowing date, borer species composition, level of abundance, varietal susceptibility, and plant pest interaction as mediated by the climatic, edaphic and biotic environment (Kekule *et al*., 1997; Sosan and Daramola, 1999; Ukeh *et al*., 2007; Ajala *et al*., 2010 and Okweche *et al*., 2010). Yield loss in maize due to *C. partellus* was worked out by several methods. These include visual damage scores, comparing yield from fields having different levels of natural infestation and comparing yield of chemically protected and non-protected plots (Taneja and Nwanze, 1989). However, the present study was undertaken with the main objective of generating data on the avoidable yield losses in maize by releasing *C. partellus* larvae in varying number per plant or plot and correlating damage / yield with insect density.

MATERIAL AND METHODS

A field experiment was conducted at the Agricultural Research Station, Darsi during *rabi* season of 2015-16 with 30V92 maize hybrid. The crop was raised with a spacing of 60 x 20 cm by following all recommended package of practices of ANGRAU except the plant protection schedule. The crop was sown on 23-11-2015. Each treatment consisted of 2.4 x 4.0 m (4 rows each of 4.0 meter length) and four replications were maintained. The first instar larvae of *C. partellus* were released at the rate of 0, 1, 2, 4 and 8 per plant at 21 days after crop emergence (3 week old plants). Maize plants which were not released with *C. partellus* larvae covered by thin nylon net (4.0 m length x 6.0 m breadth x 3.0 m height) served as control. All the plants in the central two rows were infested with specified number of first instar larvae. A selected number of larvae (noted above) were gently introduced in the leaf whorl to initiate infestation. Uniform aged first instar larvae reared in the laboratory were used for this purpose. Throughout the crop growth phase stem borer larvae were allowed to feed on the plants. At the time of harvest, observations were made in each treatment with respect to stem borer population per plant, dead heart incidence, weight of the grains and 100-grain weight.

Loss in Grain Yield

The grain weight of all the plants in the central two infested rows as well as from un-infested rows of control plot in each replication was measured in grams using sensitive balance after harvesting, threshing, cleaning and drying. The same was averaged and expressed in terms of quintal per hectare. Reduction in grain yield was difference between the grain yield obtained in control (no release of larvae) and yield obtained in each treatment. Per cent avoidable loss in grain yield was calculated using the following formula.

$$\text{Avoidable yield loss (\%)} = \frac{\text{Yield in control} - \text{Yield in treatment plot}}{\text{Yield in control}} \times 100$$

100-Grain Weight

The weight of 100-grains from the grains harvested from ten plants in the infested rows as well as from un-infested rows of control plot in each replication was recorded in grams using sensitive balance and averaged. Per cent avoidable loss in 100-grain weight was calculated as mentioned above.

Stem Borer Larval Population

A random sample of 5 stems was taken in the central two infested rows of each treatment plot and un-infested rows of control plot in each replication thrice at 90,100 days after crop emergence and after harvesting the cobs. The stems were split at each sampling time to recover borer larvae and the averages of all three observations were calculated and mean larval population per plant was worked out. The data were then subjected to square root transformations before statistical analysis.

Dead Heart Damage

At three weeks after infestation (42 DAE), the number of plants killed by stem borer (dead-heart) was counted in all the treatment plots including control and expressed as a proportion of the total number of plants within each replication. The data were subjected to angular transformations before statistical analysis.

Economic Injury Level

Based on the level of infestation, yield per hectare, cost of insecticide, average market price of maize grain per quintal, the Economic Injury Level (EIL) was computed by using the procedure mentioned by Raju (2005). The EIL was computed by the following formula.

$$\text{Economic Injury Level} = \frac{\text{Gain threshold}}{\text{Yield reduction per larvae}}$$

Where,

$$\text{Gain threshold (GT)} = \frac{\text{Cost of pest control}}{\text{Market price of grain (Rs/q)}}$$

RESULTS AND DISCUSSION

C. partellus Larval Incidence as Influenced by Graded Level of Infestation

The results with respect to stem borer larval population are presented in table 1. The treatment with release of 8 first instar larvae per plant recorded significantly higher mean stem borer larval population per plant (9.08) followed by treatments with release of 4, 2 and one first instar larva per plant with 5.68, 3.80 and 2.73, respectively. The control treatment with no infestation was kept free from stem borer larvae.

Per cent Dead Heart Incidence as Influenced by Graded Level of Infestation

There was a linear relationship between damage and borer density: increase in borer density increased damage in terms of dead hearts. The treatment with release of 8 first instar larvae per plant recorded significantly highest incidence of 39.74 per cent dead hearts as compared to any other treatments. Release of 4 and 2 first instar larvae per plant reflected dead heart incidence of 19.37 and 15.56 per cent, respectively and were on par with each other. The lowest incidence of dead hearts was observed in treatment with release of one first instar larva per plant with 9.27 per cent and was significantly superior over rest of the treatments. The control treatment with no infestation was free from dead heart expression (Table 1).

Grain Yield as Influenced by Graded Level of Infestation

C. partellus infestation at 21 DAE (3 week old crop) showed linear increase in borer damage and decrease in grain yield, as insect density increased. The highest grain yield of 83.79 q/ha was recorded in control treatment (no infestation) followed by release of one larva per plant (80.56 q/ha) and both were on par with each other. The next best treatments in this regard were release of 2 and 4 larvae per plant with 71.46 and 57.57q/ha, respectively which are significantly different from one another. Significantly lowest grain yield (45.46 q/ha) was obtained in the treatment with release of 8 larvae per plant. The correlation coefficient between stem borer larval population (r = - 0.946), per cent dead heart incidence (r = - 0.887) and grain yield was negative and highly significant.

The highest reduction in grain yield to the extent of 38.33 q/ha over control (no infestation) was recorded in treatment with release of 8 larvae per plant which was significantly inferior over all other treatments followed by release of 4 larvae per plant by recording reduced grain yield of 26.25 q/ha. The treatment with release of 2 larvae per plant was significantly different from above by recording reduction in grain yield to the tune of 12.33 q/ha. The treatment with release of one larva per plant recorded significantly least reduction in grain yield (3.24 q/ha) which was significantly superior over all other treatments. Avoidable losses increased with the increase in borer density. Highest loss was recorded in the treatments with release of 8 and 4 larvae per plant (45.68 and 31.27%, respectively). Remaining treatments with release of 2 and one larva per plant recorded a gradual decrease in avoidable loss of 14.79 and 3.90 per cent, respectively.

100-Grain Weight as Influenced by Graded Level of Infestation

The treatment with no infestation of *C. partellus* larvae was significantly superior over all other treatments by recording highest 100-grain weight of 30.92 g except the treatment with release of one larva per plant which recorded 100-grain weight of 29.18 g. The latter treatment was on par with release of 2 larvae per plant by recording 27.35 g of 100-grain weight. The 100-grain weight was unaffected by the release of 4 first instar larvae per plant with 26.41 g. Release of 8 first instar larvae per plant recorded least 100-grain weight of 24.88 g and was on par with release of 4 first instar larvae per plant. The correlation coefficient worked out between *C. partellus* larval population (r = - 0.863), per cent dead heart (r = - 0.798) and 100-grain weight was negative and highly significant (Table 1). The highest per cent of avoidable loss was recorded in treatment with release of 8 first instar nymphs per plant (19.25 %) and it gradually decreased with release of 4, 2 and one first instar larva per plant accounting for 14.32, 11.42 and 5.52 per cent, respectively.

Artificial release of insects was directly related to the reduction in grain yield and 100-grain weight. With increase in number of larvae per plant there was a decrease in yield. The untreated check with no infestation recorded highest grain yield and 100-grain weight over the other treatments. As the numbers of released larvae were more (8 per plant), the lowest grain yield and 100-grain weight and their highest per cent avoidable losses were recorded. A number of studies in eastern Africa have demonstrated a strong relationship between maize yield and damage caused by artificial infestation of stem borers. Ajala and Saxena (1994) studied the relationship among damage parameters such as foliar damage, dead hearts (%), stem tunnelling, morphological parameters such as plant height and number of ears per plant, and their influence on

Table 1. Estimation of avoidable losses due to graded level of infestation of stem borer, *C. partellus* in maize during *rabi* 2015-16.

Larval infestation / plant	Grain yield (Q/ha)	Reduction in grain yield over control (Q/ha)	% Avoidable loss	100 grain weight (g)	% Avoidable loss	Larval population / plant†	% Dead heart‡
1	80.56 [a]	3.24 [d]	3.90	29.18 [ab]	5.52	2.73 (1.79) [d]	9.27 (17.50) [c]
2	71.46 [b]	12.33 [c]	14.79	27.35 [bc]	11.42	3.80 (2.07) [c]	15.56 (23.21) [b]
4	57.55 [c]	26.25 [b]	31.27	26.41 [cd]	14.32	5.68 (2.48) [b]	19.37 (26.03) [b]
8	45.46 [d]	38.33 [a]	45.68	24.88 [d]	19.25	9.08 (3.10) [a]	39.74 (39.05) [a]
0 (Control)	83.79 [a]	—		30.92 [a]		0.00 (0.71) [e]	0.00 (0.00) [d]
S. Em. ±	2.21	2.21		0.63		0.04	1.56
CV (%)	4.62	19.50		4.53		3.66	14.72
C D (0.05)	4.81	4.81		1.94		0.11	4.80
Correlation coefficient (r) with *C. partellus* larvae	-0.946**			-0.863**			
Correlation coefficient (r) with Dead hearts (%)	-0.887**			-0.798**			

Values in the column followed by common alphabets are non significant at p=0.05 as per DMRT.
** Significant at 1 and 5% level
†Figures in parentheses are square root transformed values ‡Figures in parentheses are arc sin transformed values

Table 2. Cost of inputs and outputs in maize.

S. No.	Particulars	Quantity	Cost (Rs)	Total cost (Rs/ha)
	Inputs			
1	Carbofuran 3G	1.0 kg	80	10kg x 80 = 800
2	Monocrotophos 36% SL	1.0 lt	550	800 ml x 0.55 = 440
	Others (Labour services)			
1	Labour requirement	Per spray	2 No.	
2	Labour charges	Per labour	250	
3	Labour charges for spraying	Per hectare	500	500
4	Labour requirement for whorl application	Per hectare	10 No.	
5	Labour charges	Per labour	250	
6	Labour charges for whorl application	Per hectare	2500	2500
	Total	Per hectare		4240
	Output			
1	Maize grain	1.0 Q	1300	

grain, after artificial infestation of three-week-old maize plants, with 30 first instars. Reduction in the number of ears harvested due to larval infestation was found to be the primary cause of grain yield loss. Yield losses were estimated to fall between 34 and 43 %. Alghali (1992) showed that yield loss due to stem borer damage is influenced by the cultivar, and by the time and number of larvae involved in infestation. The present findings also corroborate with the reports of Manjunath (2013) who reported the per cent grain yield loss increased with increase in larval density and maximum yield loss was occurred in the treatment with 9 larvae / plant.

Data from artificial infestation indicates that early infestation by stem borer is crucial, results in dead heart formation and causes grain yield reduction. Artificial infestation using laboratory-reared first instar larvae showed that maximum grain yield loss occurred when infestation took place at 21 days after crop emergence. This was in agreement with Seshureddy *et al*. (1989) and Seshureddy and Sum (1991) who observed maximum stalk damage in maize and up to 80% grain yield loss in sorghum by *C. partellus* in Kenya on 20-day-old crops, whereas similar infestations gave statistically non significant losses when plants were infested at 60 days after emergence. Similar observations was also reported by Taneja and Nwanze (1989) that artificial infestation with stem borer larvae at 15 days after crop emergence resulted in the more damage by *C. partellus* in sorghum and maximum grain yield loss. The maximum number of dead hearts was formed when infestation took place during this period. This has also been observed by Mohyuddin and Attique (1978), Singh *et al*. (1968) and Taneja and Leuschner (1985). A negative relationship between damage to maize and maize yield was also shown by Gounou *et al*. (1993).

Economic Injury Level

The data from the experiment on yield loss estimation due to graded level of infestation was used to compute economic injury level. Two sprays were required to keep the crop free from stem borer incidence and the insecticide and its application cost worked out to Rs. 4240 per hectare (Table 2). The cost of maize grain was Rs. 1300 per quintal. Yield reduction per larvae was 1.19 q/ha. The economic injury level worked out to be 2.74 larvae per plant (Grain Threshold = 3.26).

Though economic injury level may be affected by complex interactions, it serves as broad guideline for taking up management practices. Seshu Reddy and Sum (1991) found a linear relationship between infestation and yield loss, and that the extent of loss increased with earlier infestations. This permitted the calculation of an economic injury level (EIL). The Katumani Composite B (KCB) had an EIL of 3.2 and 3.9 larvae/ plant for 20- and 40-day-old plants, respectively. Studies with other varieties showed that the EIL varies with the crop variety (Seshu Reddy and Sum, 1992). In the present investigation, the economic injury level was computed to be 2.74 larvae per plant. The present results are in conformity with the findings of Manjunath (2013) who worked out economic injury level for *C. partellus* in maize with graded levels of infestation and reported to be 2.42 and 2.09 larvae per plant during *kharif* and *rabi*, respectively.

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