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Crop loss estimation due to capsule borer *Helicoverpa armigera* (Hubner) in safflower

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Abstract
Safflower yield loss assessment due to the capsule borer *Helicoverpa armigera* (Hubner) on plants in field conditions. The *H. armigera* density had a significant effect on number of seeds per capsule, 100 seed weight, yield per plant and recorded minimum in 10 larvae per plant (8.40, 2.50g and 2.53g respectively) and maximum in control plot (36.66, 6.82g and 13.46g respectively) followed by completely protected (spray) treatment and natural population (No cage) treatment and these three were on par with each other. The economic injury level of *H. armigera* was worked out to be 0.53 larvae per plant for A-1 variety of safflower. This means chemical control measures are to be imposed before *H. armigera* population reaching 5.3 larvae per 10 plants so as to realize a profitable safflower crop production.

Keywords: loss estimation, capsule borer, *Helicoverpa armigera*, safflower

Introduction
Safflower (*Carthamus tinctorius* Linn.) is an important *Rabi* oilseed crop in semi arid areas of India. Among the several factors responsible for low production of safflower, insect pests have been considered as one of the important biotic factors. The gram pod borer, *H. armigera* is a polyphagous pest and has been reported on safflower crop by Fletcher (1921) [2] and Chavan (1960) [1]. In case of severe infestation (5.24 larvae/plant) in the month of March was recorded and severe defoliation resulted in stunted plant growth and 17.27 per cent of plants bore no capsules. If infestation at harvesting stage, 93.8 to 100 per cent of capsules will be bored, and of these, 57.69 to 80.11 per cent capsule will not have any grains (Singh and Singh, 1992) [7]. The damage caused by capsule borer (*H. armigera*) surpasses the loss caused by all insect pests together by their direct damage to the economically important parts (capsule and leaf) of plant. It has been claimed that the loss due to this pest range from 62.6 to 100 per cent (Sekhar and Rai, 1989) [6]. The present study was conducted to estimate the crop loss caused by the capsule borer *H. armigera* in safflower in Vijayapur district of Northern Karnataka.

Material and Methods
Crop loss estimation due to *H. armigera* in safflower
To assess the extent of loss caused by capsule borer, *H. armigera*, in safflower, cage experiment was conducted by adopting Complete Randomized Block Design with nine treatments and three replications. The details of treatments are as follows.

T1	1 larva per plant
T2	2 larvae per plant
T3	4 larvae per plant
T4	6 larvae per plant
T5	8 larvae per plant
T6	10 larvae per plant
T7	No larva (control)
T8	Natural population (No cage)
T9	Completely protected(spray)

The safflower was sown in field condition and care was taken to avoid infestation by sucking insects and foliar diseases by two sprays of plant protection chemicals at 20 days intervals. The plants were examined for the eggs, larvae and adults of *H. armigera* and were removed from the plants. Then known numbers of uniform sized third instar larva/e was released according to treatment and external entry of other capsule borer was avoided by cloth made cage installation.

After pupation, cloth net were removed and recorded data on the nature of damage, larval behavior, damaged and good capsules, and seeds per capsule was recorded and data was analyzed by using following formulas to estimate the loss caused by capsule borer.

Yield loss in respective treatment = (Yield in completely protected treatment) - (Yield in respective treatment)

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

Calculation of economic injury level (EIL) for capsule borer

Based on the level of infestation, yield per plant, cost of insecticide used and market price of Safflower (Rs/q), the EIL was computed by utilizing the modification of the procedure as followed by Stone and Pedigo (1972) [10] and adopted by Ogulana and Pedigo (1974) [5] and Giraddi (1982) [3].

The correlation coefficient "r" between the two parameters namely population levels (x) and reduction in safflower yield per plant (y) and the regression coefficient was calculated by utilizing the following formula.

$$R = \frac{N \sum xy - \sum x \sum y}{\sqrt{[N \sum x^2 - (\sum x)^2][N \sum y^2 - (\sum y)^2]}}$$

Where,

N - Number of observations,

X – Population levels of capsule borer per capsule

Y – Reduction in the seed yield per plant

Regression equation, $y = a + bx$

$$b = \frac{(\sum xy) - (\sum x . \sum y)/N}{\sum x^2 - (\sum x)^2/N}$$

$$a = \frac{\sum y}{N} - b\frac{\sum x}{N}$$

The economic injury level was computed with the help of formula given below:

$$\text{Economic Injury Level (EIL)} = \frac{\text{Gain Threshold (GT)}}{\text{Yield reduction per capsule borer}}$$

$$\text{Gain threshold (GT)} = \frac{\text{Cost of plant protection measures (Rs/ha)}}{\text{Market price of the produce (Rs/q)}}$$

In calculating the cost of pest control, the cost of chemical and quantity of Indoxacarb 14.5 SC (the recommended rate is 0.3ml/l) was worked out by considering the cost of chemical.

When the crop matured, the crop was harvested and the seed yield was recorded on net plot basis. Test weight (thousand seed weight) in different treatments was also recorded. The data were subjected to the statistical analysis.

Results and Discussion

Plant height and number of branches per plant: The *H. armigera* larval density had no significant effect on height of plant and number of branches per plant. The height of plant and numbers of branches per plant in all the treatments were on par with each other (Table 1).

Per cent damage capsules per plant: Based on the regression equation, it could be inferred that the maximum of 62.85 per cent crop loss was recorded when the 10 larvae per plant was released, minimum capsule damage seen in insecticidal spray treatment (2.60) and any damage was not seen in treatment were no larvae was released (Table 1). Further, it was estimated that one, two, four, six, eight, natural population and completely protected plots were larvae responsible for 12.36, 20.47, 30.70, 42.23, 51.11, 9.76 and 2.60 percent damage respectively.

Number of seeds per capsule, 100 seed weight and seed yield per plant: Among various treatments, there was a significant difference with respect to number of seeds per capsule, 100 seed weight and seed yield per plant. The maximum number of seeds per capsule, 100 seed weight and seed yield per plant was recorded from control plot (36.66, 6.82 g and 13.46g respectively) followed by completely protected (spray) treatment and natural population (No cage) treatment and these three were on par with each other. Whereas, minimum of number of seeds per capsule, 100 seed weight and seed yield per plant was recorded from the 10 larvae per plant (8.40, 2.50 and 2.53 respectively). There was no significant difference among the treatments 1 larva per plant, 2 larvae per plant and 4 larvae per plant.

There is no literature on estimation of crop loss in safflower due to capsule borers to compare and discuss the present findings. However, the loss caused by *H. armigera* in chickpea ranged from 16.7 to 20.0 per cent (Sithanantham *et al*., 1984) [9], 66 to 87.5 per cent (Singla *et al*., 1989) [8], 16.7 to 18 per cent (Srivastava and Srivastava, 1990)

Table 1: Effect of larval population of capsule borer, *H. armigera* on yield parameters in cage experiment

Tr. No.	Treatment	Plant height (cm)	No. of branches/ plant	Per cent damaged capsules/plant*	No. of seeds/capsule	100 seed weight (g)	Yield / plant (g)	Yield (q/ha)
T_1	1 larva/plant	65.76^{a}	7.89^{c}	12.36 (20.58)^{c}	31.36^{c}	6.35^{bc}	11.30^{c}	9.16^{bc}
T_2	2 larvae/plant	65.71^{a}	7.92^{c}	20.47 (26.90)^{d}	28.65^{d}	6.05^{c}	10.08^{d}	8.65^{c}
T_3	4 larvae/plant	63.88^{c}	8.06^{c}	30.70 (33.65)^{e}	25.47^{e}	5.10^{d}	7.58^{e}	7.56^{cd}
T_4	6 larvae/plant	63.72^{c}	8.25^{abc}	42.23 (40.53)^{f}	16.03^{f}	4.76^{e}	5.46^{f}	5.83^{d}
T_5	8 larvae/plant	64.18^{bc}	8.22^{bc}	51.11 (45.64)^{g}	10.40^{g}	3.43^{f}	3.60^{g}	3.53^{e}
T_6	10 larvae/plant	64.56^{bc}	7.26^{d}	62.85 (52.45)^{h}	8.40^{h}	2.50^{g}	2.53^{h}	2.53^{f}
T_7	No larva (control)	66.06^{a}	8.65^{a}	0.00 (0.00)^{a}	36.66^{a}	6.82^{a}	13.46^{a}	11.16^{a}
T8	Natural population (No cage)	65.74^{a}	8.57^{ab}	9.76 (18.20)^{c}	33.90^{b}	6.56^{ab}	11.36^{bc}	9.52^{b}

T9	Completely protected (spray)	65.13[ab]	7.16[d]	2.60 (9.28)[b]	34.76[b]	6.79[a]	12.60[b]	10.77[ab]
	S.Em±	0.330	0.141	1.290	0.308	0.106	0.193	0.141
	CD @5%	0.99	0.42	3.88	0.92	3.42	3.85	2.54
	CV(%)	6.17	5.90	8.15	6.42	8.32	9.27	8.65

Calculation of economic injury level for *H. armigera*

The economic injury level was computed by the following formula.

$$\text{Economic Injury Level} = \frac{\text{Gain threshold}}{\text{Regression coefficient}}$$

The regression coefficient between number of *H. armigera* larvae (x) and the seed yield (y) was computed for 'n' number of observations (Table 2).

$$\text{i) Regression coefficient (b)} = \frac{\sum xy - \sum x * \sum y/N}{\sum x^2 - (\sum x)^2/N}$$

$$\text{Therefore b} = \frac{152.73x\ 31.85*68.71/9}{221.48-(31.85)^2/9}$$

$$= \frac{152.73-2188.41/9}{221.48-1014.42/9}$$

$$= -0.83$$

Intercept on Y = a = $\sum y/n$ - b$\sum x/n$ = 68.71/9 – (-0.83) x 31.85/9

= 12

y = a + bx

= 12 – 0.83x

For calculating the cost of pest control, quantity of insecticide and labour cost were considered. Totally 500 litres of spray solution was used for one hectare area of safflower crop.

The market price of the produce was fixed at Rs. 3200/q.

Spraying cost was Rs. 500/ha

Insecticide (Indoxacarb) cost was Rs. 900/ha

Total cost was 900+500 = 1400

$$\text{Then, gain threshold (GT)} = \frac{\text{Cost of plant protection measures (Rs./ha)}}{\text{Market price of the produce (Rs./Q)}}$$

$$\text{Therefore gain threshold (GT)} = \frac{1400}{3200} = 0.44$$

$$\text{Economic Injury Level} = \frac{\text{Gain threshold}}{\text{Regression co-efficient}}$$

$$\text{Economic Injury Level} = \frac{0.44}{0.83} = 0.53 \text{ larva/plant}$$

Table 2: Relationship of larval population of capsule borer, *H. armigera* versus seed yield in cage experiment

Tr. No.	Treatments	Number of *H. armigera* larvae released/plant (X)	Seed yield (q/ha) (Y)	XY	X^2
T_1	1 larva/plant	1	9.16	9.16	1
T_2	2 larvae/plant	2	8.65	17.3	4
T_3	4 larvae/plant	4	7.56	29.44	16
T_4	6 larvae/plant	6	5.83	34.98	36
T_5	8 larvae/plant	8	3.53	28.24	64
T_6	10 larvae/plant	10	2.53	25.30	100
T_7	No larva (control)	0	11.16	0.00	0
T8	Natural population (No cage)	0.68	9.52	6.48	0.46
T9	Completely protected(spray)	0.17	10.77	1.83	0.02
		$\sum X = 31.85$	$\sum Y = 68.71$	$\sum XY = 152.73$	$\sum X^2 = 221.48$

Differential number of capsule borer (*H. armigera*) larvae starting from 1 to 10 per plant was artificially released on to caged plants for calculating economic injury level of *H. armigera* The economic injury level of *H. armigera* was worked out to be 0.53 larvae per plant for A-1 variety of safflower.

There is no literature available on the estimation of Economic Injury Level against capsule borer *H. armigera* in safflower. However, EIL for *H. armigera* has been worked out in several crops like pigeonpea (0.60 larva/plant) (Venkataiah *et al*., 1994) [11], 0.80 larva/plant (Narendra Reddy *et al*., 2001) [4].

In the present investigation estimation of crop loss on safflower due to capsule borer *H. armigera* was studied in the field. Based on the regression equation, and cost of plant protection and market price of produce, that economic injury level of *H. armigera* was worked out to be 0.53 larvae per plant means chemical control measures are to be imposed before *H. armigera* population reaching 5.3 larvae per 10 plants so as to realize a profitable safflower crop production.

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