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Field Sustainability and Mass Trapping Efficiency on the Infestation of Brinjal Shoot and Fruit Borer *Lecinodes orbonalis* (Guenee)

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Abstract Experiments were conducted to study the field sustainability and mass trapping technology on the infestation of brinjal shoot and fruit borer in comparison with farmers' practices in the fields around the town of Bagalkot, Karnataka, India. The results indicated that the male moth catches of *L. orbonalis* in the pheromone trap was influenced by pheromone quantity which can remain viable under field conditions for over two months. The data recorded gave an indication that there was non significant negative correlation between maximum temperature (-0.107) and minimum temperature (-0.414) against *L. orbonalis* male moth catches. The total number of moths caught during 10 weeks of study period from ten traps was 861 and the highest mean number of male moths trapped per week was 29.6 during 10^{th} week and the lowest was 1.7 during third week. Highest percentage of fruit damage (6.6%) was reported in ninth week, whereas, lowest percentage was 0.2 in mass trapping during seventh week. Whereas, in farmers practices highest per cent fruit damage (27.3%) was observed in the ninth week and lowest (0.9%) was found in the fifth week. Highest cost benefit ratio (8.0) was recorded in the mass trapping technology when compared to farmers' practices.

Keywords Benefit cost ratio, Field sustainability, *L. orbonalis*, Mass trapping, Pheromone lure.

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Introduction

Brinjal or eggplant (*Solanum melongena* Linnaeus) is an agronomically important, highly cosmopolitan and popular vegetable grown in India. Brinjal is also an economically important vegetable of Bangladesh, China, Pakistan, Philippines, Sri Lanka and Thailand. India is the second largest producer of vegetables after China produced in an area of 680 thousand ha and a production of 11,896 thousand tonnes/ha with a productivity of 17.5 tonnes/ha. Orissa, Bihar, Karnataka, West Bengal, Andhra Pradesh, Maharashtra and Uttar Pradesh are the major states in India. In Karnataka, brinjal is cultivated over an area of

14.2 thousand ha with a production of 3,542 thousand tonnes (Vanitha et al. 2013).

The farmers resort to indiscriminate use of insecticides to keep the pest under check. Since brinjal crop is harvested at regular and short intervals as a vegetable for consumption, the use of toxic pesticides is not advisable and if at all situation demands, relatively safe and effective chemicals need to be used for controlling the pest. Due to the frequent pickings, the use of chemicals for management of this pest started proving to be detrimental to the health of consumers vowing to the toxic residues of the chemicals in the produce. Frequent and indiscriminate use of insecticides has also posed other problems like resistance development and resurgence of pests (Mehrotra 1990). The indiscriminate use of pesticides understandably led to the situation like development of resistance, environmental pollution, disruption of natural enemies and health hazards. Even though one cannot do away with chemical pesticides completely, a paradigm shift in the approach is warranted in tackling the pest species. Integration of ecologically viable and cost effective methods with other available methods of pest management is the need of the hour.

Sex pheromones are recognized as one of the important components in the management of many lepidopteran tissue borers, including sugarcane borers (Jayanth and Bhanu 2004). The sex pheromone of BSFB was identified in late 1980's (Zhu et al. 1987, Attygalle et al. 1988) and the blend was optimized for field use in 2001 by Asian Vegetable Research and Development Center, Taiwan in association with Natural Resources Institute, UK (Cork et al. 2001). After identification of sex pheromone components (E-11-16: Ac and E-11-16: OH) from Indian population of brinjal shoot and fruit borer by Cork et al. (2001), number of studies were carried out in different parts of the country to manage BSFB using sex pheromone. But, most of these studies were concentrated on standardization of basic aspects such as pheromone blend ratio, effective dose of pheromone, basic designs of traps and lures and also application of this pheromone for pest monitoring. Whereas, a detailed information on usage of pheromone for the purpose of mass trapping BSFB and relative benefit of this technology over farmers' practice is lacking. In this context, the present investigations were taken to study the field longevity and impact of mass trapping technology on the infestation of brinjal shoot and fruit borer in comparison with farmers' practices.

Table 1. Release rate of *L. orbonalis* pheromone from the lures under field conditions at Bagalkot.

Lot	Standard days	Average left over pheromone	Mean male moth catches/trap/ standard days
1	15 days	3.04	3.8
2	30 days	2.3	3.04
3	38 days	2.56	0.85
4	45 days	2.39	1.2
5	52 days	1.886	2.4
6	60 days	1.55	1.4

Materials and Methods

Installation procedure

This experiment conducted at Simikeri, Bagalkot district during February 6 to April 6 period to assess the field longevity of pheromone lures. Water trap with plastic vials as a single dispenser was used during the experimentation on the basis of the results obtained during the previous season of experimentation. In total, 30 lures loaded with 4 mg of pheromone used in 30 traps. Traps were installed after one month of transplantation crop (Variety MAHYCO 10) and half feet above the crop canopy.

Pheromone lure

The pheromone lures used during present investigations were purchased from Pest Control of India (PCI), Bangalore. The sex pheromone of brinjal shoot and fruit borer consisted of (E)-11-hexadecenyl acetate and (E)-11-hexadecen-10-01 in 100 : 1 blend, respectively. This commercialized blend was used in the present investigations.

Field observations

At weekly interval, five lures from the installed traps were taken out and sent to Bio-Control Research Labo-

Table 2. Simple correlation among left over pheromone, mean male moth catches of *L. orbonalis* and weather parameters. ^{NS} Non significant at 5% level.

Weather parameters	Correlation coefficient r
Average mean male moth catches	0.416 ^{NS}
Maximum temperature	-0.107 ^{NS}
Minimum temperature	-0.414 ^{NS}
RH I	-0.537 ^{NS}
RH II	-0.698 ^{NS}
Rain fall	0.262 ^{NS}
Wind speed	-0.124 ^{NS}

ratories (PCI), Bangalore. Similar procedure was followed up to two months. Simultaneously, observations made at weekly interval on male moth catches. Weather parameters such as maximum and minimum day temperature, maximum and minimum night temperature, relative humidity and rainfall were also obtained from Agro Meteorological Department, Regional Horticultural Research and Extension Center. The correlation studies were made between the weather parameters and trap catches. At the same time recorded the per cent of shoot and fruit infestation.

To find out impact of mass trapping technology on the infestation of brinjal shoot and fruit borer in comparison with farmers' practices, a field experiment was undertaken during summer season (20th February to 20th May, 2014) at Simikeri, Bagalkot district. For this purpose, two months old transplanted brinjal crop (MAHYCO 10) of one acre was selected divided into two equal blocks mass trapping and farmer practices. In mass trapping field totally, 10 water traps with lures were installed at half feet above the crop canopy level. The observations were made on the total number of moths trapped in mass trapping and infestation level of shoot and fruit borer in both mass trapping and farmer practices at weekly intervals. Per cent shoot and fruit damage was recorded from randomly selected 100 plants in each block (Mass trapping and farmer practices) by using formula :

$$\text{Per cent shoot damage} = \frac{\text{Number of shoots infested}}{\text{Total number of shoots observed}} \times 100$$

$$\text{Per cent fruit damage} = \frac{\text{Number of affected fruits}}{\text{Total number of fruits observed}} \times 100$$

Data obtained from various experiments were analyzed using suitable statistical tools and methods after suitable transformation of the data.

The price of the inputs that were prevailing at the time of their use was considered for working out the cost of cultivation. A net return per hectare was calculated by deducting cost of cultivation per hectare from gross income. Benefit: Cost ratio was worked out as follows :

$$\text{Benefit: Cost ratio} = \frac{\text{Gross returns (Rs/ha)}}{\text{Cost of cultivation (Rs/ha)}} \times 100$$

Results and Discussion

Field longevity of pheromone lures under field conditions

The field experiment was conducted in a farmers' field at Simikeri, Bagalkot district during February 6 to April 4 to evaluate the effectiveness of left over pheromone in attracting the moths catches of brinjal shoot and fruit borer, *Leucinodes orbonalis* infesting brinjal.

In the present study, 30 water traps were installed with lures in brinjal field to evaluate effect of left over pheromone in trapping the moths by taking weekly observations on moth catches of *L. orbonalis*. Simultaneously weather parameters were also recorded at weekly intervals during the entire period of experimentation.

The results indicated that the male moth catches of *L. orbonalis* in the pheromone trap was influenced by pheromone quantity which can remain viable under field conditions for over two months. The trap catch data presented in Table 1 indicated that leu-

Table 3. Brinjal fruit damage due to *Leucinodes orbonalis* in mass trapping and farmers' practices.

Weeks	% fruit damage in mass trapping	% fruit damage in farmer practices
1	–	–
2		
3	1.9 (7.9)	2.1 (8.3)
4	4.1 (11.6)	4.9 (12.7)
5	5.2 (13.17)	0.9 (5.4)
6	5.7 (13.8)	6.9 (15.2)
7	0.2 (2.5)	1.29 (6.5)
8	5.5 (13.5)	25.8 (30.5)
9	6.6 (14.8)	27.3 (31.4)
10	4 (11.5)	5.11 (13.4)
Mean	4.15	9.2
SD	2.13	10.8
T (0.05)	2.36	
T (0.01)	3.49	

cinlure can be actively and attract *L. orbonalis* moths for about 60 days.

At the same time correlation between left over pheromone trap catches and weather parameters was worked out during study period to find out the interaction between the number of male moth catches, by left over pheromone with major a biotic factors like maximum and minimum temperature, morning and evening relative humidity, rainfall and wind speed. The results indicated that there was non-significant positive relationship between trap catches (0.416) and left over pheromone (Table 2).

The data recorded gave an indication that there was non significant negative correlation between maximum temperature (-0.107) and minimum temperature (-0.414) *L. orbonalis* male moth catches. The morning and evening relative humidity had negative correlation with number of male moth catches of *L. orbonalis* and but statistically non-significant. The rainfall had positively correlation with male moth catches, while wind speed had negative correlation but both were statistically non-significant.

Field longevity of pheromone lures under field conditions

In any pheromone trap, the concentration of the lure and the frequency at which the lure is changed influenced the efficiency but also the economic feasibility of such traps at field level. These two factors happen to be critical to derive fullest advantage from this pheromone technology and hence in the present study an effort was made to optimize them.

The results revealed that after 2 months of exposure of lure in the field, the left over quantity observed was 1.55 mg. These results are in conformity with Bhanu et al. (2007) who reported that lures must be viable under field conditions for over 2 months which was confirmed by release rate studies carried out under laboratory conditions. Even though commercial companies claim lures work for two months but last 15 days lures are not efficient catching moth catches.

Maximum and minimum temperature showed non-significant negative relationship with male moth catches. Similar findings were also observed in case of *H. armigera* (Nesbitt et al. 1979, Korat and Lingappa 1995, Kulkarni et al. 2004). However, Kumar et al. (2009) reported significant and negative correlation with minimum temperature for BSFB moths.

Morning and afternoon relative humidity had negative relationships with BSFB moth catches, which broadly in line with findings of Patnaik (2000). Rainfall had non-significant positive relationship with male moth catches of brinjal shoot and fruit borer. These results differed from those of Kumar et al. (2009), who recorded significant negative correlation between rainfall and BSFB trap catches. Wind speed showed negative relationship with BSFB, which was also recorded in the case of *H. armigera* (Nesbitt et al. 1979; Korat and Lingappa 1995).

A field experiment was carried out at Simikeri, Bagalkot district during 20th February to 2 May, 2014, to assess the impact of mass trapping technology on the infestation of brinjal shoot and fruit borer in comparison with farmers' practices. Total number of moths caught during 10 weeks of study period from ten traps was 861 and the highest mean number of male moths trapped per week was 29.6 during 10th week and the lowest was 1.7 during third week. Significant difference was observed in the number of moths trapped

Table 4. Brinjal shoot damage due to *Leucinodes orbonalis* in mass trapping and farmers' practices.

Weeks	% shoot damage in mass trapping	% shoot damage in farmer practices
1	6 (14.1)	5.1 (13)
2	5.7 (13.8)	7.6 (15.9)
3	4 (11.5)	1.6 (7.2)
4	4.1 (11.6)	1 (5.7)
5	0.5 (4)	1.1 (6)
6	0.7 (4.7)	0.5 (4)
7	0.6 (4.4)	1.1 (6)
8	0.7 (4.7)	0 (0)
9	1.1 (6)	0.8 (5.1)
10	0.4 (3.6)	0.2 (2.3)
Mean	2.38	1.89
SD	2.17	2.33

during different weeks.

The results presented in Table 3 revealed that highest percentage of fruit damage (6.6%) was reported in ninth week, whereas, lowest percentage was 0.2 in mass trapping during seventh week.Whereas, in farmers practices highest per cent fruit damage (27.3%) was observed in the ninth week and lowest (0.9%) was found in the fifth week. The data pertaining to per cent shoot damage in mass trapping block and farmer practices are presented in Table 4. In mass trapping block, highest shoot damage (6%) was recorded during first week of trap installation which is at par with second week i.e. 5.7%, whereas, lowest per cent shoot damage observed during 10th week of traps installation i.e. 0.4%. In case of farmers' practices, highest 7.6% shoot damage was recorded during second week of traps installation, whereas, lowest was recorded during eighth week of traps installation (0%).

The results also showed that in mass trapping technology yield was 2160 kg in farmer practices 3,605 kg. Cost of cultivation in mass trapping technology was 25,115 and in farmer practices 23,015. Highest cost benefit ratio (8.0) was recorded in the mass trapping technology when compared to farmers' practices. The total male moth caught during 10 weeks study period was 861. The highest mean number of male moth catches (29.6) was recorded during 10th week after trap installation. In both the blocks per cent fruit damage increased gradually as the crop stage advanced under natural conditions. These results are in line with the earlier findings where the fruit damage varied from 16.67 to 86.25 from first to sixth harvesting stage.

The mean per cent shoot and fruit infestation was 2.38 and 4.15, respectively in mass trapping block and in the case of farmers' practices per cent shoot and fruit infestation was 4.15 and 9.2, respectively. Results indicated that the performance mass trapping was on par with farmer practices, even though number of chemical pesticides used in the farmer practices. Highest cost benefit ratio (8.0) was recorded in the mass trapping technology when compared to farmers' practice. These results are in agreement with fin ding of Cork et al. (2005), who reported that a cost-benefit of 0.03:0.8 was associated with the adoption of mass trapping despite the high density of traps currently required. In addition, the yield of healthy fruits from pheromone plot was higher that farmers' practices. Since more number of sprays were applied to farmer practice field the pollinators and natural enemies were affected badly as it was reflected which reduced damaging of pests affects noticed during the field observations.

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