UTILIZATION OF PHEROMONE TRAPS FOR THE MANAGEMENT OF BRINJAL SHOOT AND FRUIT BORER, *Leucinodes orbonalis* GUENEE (LEPIDOPTERA: CRAMBIDAE)

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UTILIZATION OF PHEROMONE TRAPS FOR THE MANAGEMENT OF BRINJAL SHOOT AND FRUIT BORER, *Leucinodes orbonalis* GUENEE (LEPIDOPTERA: CRAMBIDAE)

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CERTIFICATE

This is to certify that the thesis entitled "UTILIZATION OF PHEROMONE TRAPS FOR THE MANAGEMENT OF BRINJAL SHOOT AND FRUIT BORER, *Leucinodes orbonalis* GUENEE (LEPIDOPTERA : CRAMBIDAE)"submitted by KASTURI MANASA, for the degree of MASTER OF SCIENCE (HORTICULTURE) in HORTICULTURAL ENTOMOLOGY, to the University of Horticultural Sciences, Bagalkot is a record of research work done by her during the period of her study in this University, under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

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Affectionately Dedicated to

My Beloved father

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1. INTRODUCTION

Brinjal or eggplant (*Solanum melongena* Linnaeus) is an agronomically important, highly cosmopolitan and popular vegetable grown in India. India is the second largest producer of brinjal after China. In 2012-13, the area under brinjal is 722 thousand ha, with a production of 13443 thousand tonnes and productivity of 18.6 tonnes per ha. West Bengal, Orissa, Andhra Pradesh, Gujarat and Bihar are the major producers in India. In Karnataka, brinjal is cultivated over an area of 16.1 thousand ha with a production of 421.4 thousand tonnes (Anon., 2013).

Brinjal is reported to stimulate the intrapeptic metabolism of blood cholesterol. Consumption of, fresh or dry form fruit produces marked drop in blood cholesterol level. The de-cholestrolizing action is attributed to the presence of poly-unsaturated fatty acids (linoleic and linolenic) which are present in flesh and seeds of the fruit in higher amount (65.1%) (Gopal Krishnan, 2007). The presence of magnesium and potassium salts also helps in de-cholestrolizing action. Aqueous extracts of fruit inhibits choline esterase activity of human plasma. Dry fruit is reported to contain goitrogenic principles (Gopal Krishnan, 2007).

Unfortunately, the sustainable production of brinjal is under threat from Brinjal shoot and fruit borer (BSFB), *Leucinodes orbonalis* Guenee (Lepidoptera: Crambidae) which causes up to 70 to 90 per cent yield loss (Ali *et al*., 1980; Kalloo, 1988; Anon., 1995; Dhandapani *et al*., 2003). It is considered as nearly monophagous although potato has been recorded as an alternate host (Nandihalli *et al*., 1996). This pest attacks brinjal throughout the crop cycle starting from seedling to harvesting stage. Wilting of young shoots is the main symptom on the shoots and a significant portion of the yield is lost due to fruit damage, often leading to abandonment of the entire crop by the farmers (Bhanu *et al*., 2007).

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, environmental pollution, disruption of natural enemies and health hazards (Mehrotra, 1990). 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.

To develop ecologically safe and viable IPM programme for *L. orbonalis*, usage of ecofriendly insecticides *viz*., chitin synthesis inhibitors, juvenile hormone mimics, ecdysone antagonists, avermectins, neem, *Bacillus thuringiensis* Berliner *etc*., are of vital importance. This approach will also provide safety to the natural enemies and result in insecticide free quality produce. In addition to eco-friendly insecticides, in the recent years, use of pheromones started gaining importance as an effective tool in pest monitoring and mass trapping. Information provided by the pheromone traps on brood emergence and level of pest population in the field will prove vital strategies against the target pest at vulnerable stage. This tool is of certain help in designing the pest management strategy for the given pest.

Sex pheromones are recognised 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 Centre, Taiwan in association with Natural Resources Institute, UK, (Cork *et al*., 2001).

After identification of sex pheromone components (E-11-16: Ac & E11-16: OH) from Indian population of BSFB 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 standardisation of basic aspects such as pheromone blend ratio, effective dose of pheromone, basic designs of traps and lures and also application of the pheromone for pest monitoring. Whereas, a detailed information on usage of pheromone for the purpose of mass trapping of BSFB and relative benefit of this technology over farmers' practice is lacking.

In this context, the present investigations on "Utilization of Pheromone traps for the management of Brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee (Lepidoptera: Crambidae)" was undertaken with the following objectives;

1. To identify the most effective commercially available trap design in catching male moths of brinjal shoot and fruit borer

2. To find out the field longevity of pheromone lure in relation to weather parameters

3. To find out impact of mass trapping technology on the infestation of brinjal shoot and fruit borer in comparison with farmers' practices

2. REVIEW OF LITERATURE

In recent years, use of sex pheromones started gaining importance as an effective monitoring and mass trapping tool in pest management. Efficiency of sex pheromones depends on trap design and lure characteristics and is also influenced by many abiotic factors. Despite of considerable progress made in identification, isolation and use of sex pheromones in respect of lepidopteran pests of different crops, work relating to brinjal shoot and fruit borer, *L. orbonalis* is meager. Hence, information on pheromones of some important lepidopteran pests and factors influencing pheromone trap catches and trap efficiency in India and elsewhere has been reviewed and presented under different headings.

2.1 Influence of trap design in trapping male moths of brinjal shoot and fruit borer and some selected Lepidopteran pests

Among the different trap designs tested against *Helicoverpa armigera* (Hubner) dry funnel traps were superior to sticky traps (Ramachandra Rao, 1983; Pawar *et al*., 1988) and cone traps were superior to funnel traps (Wilson and Morton, 1989). Sleeve and funnel traps were superior over sticky traps (Nandihalli *et al*., 1991). Ecomax type of funnel trap was effective than ICRISAT funnel, Murkumbi and Pheromone India traps (Patil and Mamadapur, 1996), Ecomax and ICRISAT funnel traps were superior over PCI traps (Kulkarni and Patil, 1996), yellow funnel trap and Green Tech Agro Products (funnel) trap recorded maximum moth catches of *H. armigera* (Loganathan and Uthamaswamy, 1997).

In the trapping studies on *Spodoptera litura* Fabricius at ICRISAT, funnel trap was found superior to sleeve trap (Krishnaiah, 1986; Rao, 1986). Further, Polyethylene sleeve trap was observed superior to Zoecon sticky trap (Gupta and Pawar, 1989). Similarly, funnel trap recorded maximum moth catches over other designs (Ranga Rao *et al*., 1991; Lalithakumari and Reddy, 1992).

In the case of *Pectinophora gossypiella* Saunders on cotton, effective trap designs identified were metal trap (Taneja and Jayaswal, 1983), PAU trap (Dhawan and Sindhu, 1989) and water pan trap (Karuppuchamy and Balasubramanian, 1990).

Among the various designs of traps tested *viz*., winged trap, open delta trap, funnel trap and water trough, the open delta traps caught significantly more adults of BSFB than others in trials conducted at Gujarat and Bangladesh (Alam *et al*., 2003). Whereas, in the field trials conducted in U.P., the funnel trap proved to be superior over delta trap (Cork *et al*., 2003).

Similar studies conducted at Indian Institute of Horticulture Research, Bangalore and Central Horticultural Experiment Station, Bhubaneswar revealed that the delta trap was observed to catch higher number of male moths of *L. orbonalis* compared to other trap designs tested. Delta and wing traps baited with synthetic female sex pheromone of *L. orbonalis* caught and retained ten times more moths than either *Spodoptera* or uni-trap designs. Locally-produced water and funnel traps were as effective as delta traps, although 'windows' cut in the side panels of delta traps significantly increased trap catch from 0.4 to 2.3 moths per trap per night. Trap catch was proportional to the radius of sticky disc traps with a range of 5-20 cm radius, while discs with a 2.5 cm radius caught no moths. Wing traps placed at crop height caught significantly more moths than traps placed 0.5 m above or below the crop canopy (Cork *et al*., 2003).

Krishna Kumar *et al.* (2006) observed that the Pest Control India (PCI®) water trap with Indian Institute of Chemical Technology, Hyderabad pheromone lure was observed to attract higher number of males of *L. orbonalis* than PCI delta trap.

Studies under farmer’s field conditions revealed that water traps trapped significantly more number of adults when used with lucinlure as compared to funnel and delta traps (Bhanu *et al*., 2007).

Field trials conducted at Rajanukunte, Bengaluru North and Narasapura, Kolar (Karnataka, South India) to test the efficacy of different colored funnel traps against five lepidopterous pests of vegetables during *Kharif* and *Rabi*, 2007, revealed that the red traps were the most effective in trapping male moths of *H. armigera*, *Earias insulana* (Boisduval) and *Plutella xylostella* (Linn.). The red and pink traps were found to be on par in trapping the male moths of brinjal shoot and fruit borer. Yellow pheromone traps attracted maximum moths of *S. litura* (Prasannakumar *et al*., 2009).

The sleeve traps installed at crop canopy level with 3 mg lure concentration replaced at every 15 days, were found to be effective in trapping the maximum number of *L. orbonalis* moths compared to delta traps (Kumar *et. al*., 2009).

2.2 Field longevity of pheromone lures in relation to weather parameters

Brinjal shoot and fruit borer trap catches were found to be positively correlated with pheromone release rate, with the highest dose tested, 3000 µg, on white rubber septa catching more male moths than lower doses. Field and wind tunnel release rate studies confirmed that E11-16: OH released from white rubber septa and polyethylene vials at approximately twice the rate of E11-16: Ac and that the release rate of both compounds was doubled in polyethylene vials compared to white rubber septa. This difference in release rate was reflected in field trials conducted in Bangladesh where polyethylene vial dispensers caught more male moths than either black or white rubber septa, each loaded with the same 100: 1 blend of E11-16: Ac and E11-16: OH in a 3000 µg loading (Cork *et. al.,* 2001).

Bhanu *et al*. (2007) reported that the half life of the lure was found to be 19 days, during release rate studies under laboratory conditions, with 11 per cent of the initially loaded pheromone remaining in the dispenser after 63 days.

Ibrahim and Cork (2012) determined the longevity, half life and the release rates of pheromone lure from three commercial companies in India for *S. litura*. Lures from Natural Resource Institute (NRI), Basaras, Agriland as well as PCI lures used in cotton field in India in various dispensers like polyethylene vials, rubber tubes, and rubber septum. The results indicated that at the end of sixth week of exposure period the standard NRI lure impregnated with 0.89 mg as initial dose had 5.63 per cent remaining life, Basarass pheromone lure with 0.1 mg as initial dose had 12.88 per cent, PCI lure had 0.01 mg as initial dose and 7.84 per cent remaining life, Agriland lure was impregnated with 0.05 mg as initial dose and 48.02 per cent remaining life. The conclusion was that companies like Basaras and Agriland do not put enough quantity of the major pheromone component and the release rates fluctuate in the field and this had given the clue for measuring longevity with adverse effect on the performance.

Since studies with respect to influence of weather parameters on field lure longevity of pheromone lure is significantly less, the information pertaining to the influence of weather parameters on male moth catches is presented here under.

2.2.1 Temperature

The number of brinjal shoot and fruit borer moths trapped showed significant and negative correlation with minimum temperature (Krishna Kumar *et al*., 2004). Kumar *et al.* (2009) reported that BSFB moths trapped showed significant and positive correlation with maximum temperature during summer season.

Prasannakumar *et al.* (2011) found that maximum temperature showed statistically significant positive correlation with trap catches of *H. armigera*, *E. insulana*, diamond back moth, *P. xylostella*, *L. orbonalis* and *S. litura.*

Pheromone trap catches of *S. litura* showed significantly negative correlation with minimum and maximum temperature (Nandihalli *et al.,* 1989). In another study with *P.*

xylostella, Thangaraju and Uthamaswamy (1990) and Sangareddy and Patil (1997) found a significantly negative relationship with maximum and minimum temperatures. Pheromone catches of *H. armigera* showed non-significantly negative relationship with temperature (Nesbitt *et al*., 1979; Korat and Lingappa, 1995). Kulkarni *et al*. (2004) observed a significantly negative relationship with pheromone trap catches of *H. armigera* with maximum and minimum temperatures.

Correlation studies with pheromone catches of *S. litura* showed significantly positive relationship with maximum and minimum temperatures (Singh and Sachan, 1993; Mahalingam *et al.,* 2003). Nandihalli *et al.* (1993) reported that attraction of *Bemisia tabaci* Genn. to yellow sticky traps was greatly influenced by maximum and minimum temperatures compared to other weather factors.

2.2.2 Relative humidity

The *L. orbonalis* moth catches were negatively correlated with relative humidity and positively correlated with per cent fruit infestation recorded two weeks prior to standard week (Kumar and Babu, 1997). Similarly, Krishna Kumar *et al*. (2004) also reported that the pheromone catches of *L. orbonalis* found negative relation with relative humidity.

H. armigera showed positive but non-significant relationship with morning and afternoon relative humidity. Okra shoot and fruit borer and brinjal shoot and fruit borer moth catches had a positive non significant relation with morning and afternoon relative humidity. Diamond back moth catches had positive relation with morning and afternoon relative humidity (Prasannakumar *et al*., 2011).

Pheromone catches of *P. gossypiella* showed significantly negative relationship with relative humidity (Thangaraju and Uthamaswamy, 1990; Korat and Lingappa, 1995). Whereas, Sangareddy and Patil (1997) reported a non-significant positive influence with the trap catches.

In a study with pheromone catches of *H. armigera* Korat and Lingappa (1995) found significantly negative relation with relative humidity. Whereas Patnaik (2000) reported that the fruit damage in brinjal was significantly and positively correlated with relative humidity.

Mahalingam *et al.* (2003) reported that pheromone catches of *S. litura* showed significantly positive relationship with humidity during rainy season and significantly negative during winter season.

2.2.3 Rainfall

Kumar *et al.* (2009) found significant negative correlation between rainfall and brinjal shoot and fruit borer trap catches. Nesbitt *et al.* (1979) observed a non significantly negative relation between rainfall and pheromone catches of *H. armigera*.

Pheromone catches of *P. gossypiella* showed significantly negative relationship with rainfall (Gupta *et al*., 1990). Whereas, Korat and Lingappa (1995) found positive relationship with rainfall at Dharwad. Chandra Mohan (1995) reported that the pheromone catches of *P. xylostella* showed negative relation with rainfall.

2.2.4 Wind velocity

Pheromone catches of *H. armigera* showed negative relationship with wind velocity (Nesbitt *et al.,* 1979; Korat and Lingappa, 1995), but Singh and Sachan (1993) reported that the pheromone catches of *S. litura* had positive relation with wind velocity.

Correlation studies with *P. gossypiella* showed positive relationship with wind velocity at Tamil Nadu (Thangaraju and Uthamaswamy, 1990) and negative relationship with wind velocity at Dharwad (Korat and Lingappa, 1995).

2.2.5 Evaporation

In a study with pheromone catches of brinjal shoot and fruit borer, Krishna Kumar *et al.* (2004) found positive correlation between trap catches and evaporation. Evaporation had a highly significant relation with brinjal shoot and fruit borer moth catches as observed by Prasannakumar *et al*. (2011).

2.3 Impact of mass trapping on the incidence of brinjal shoot and fruit borer in comparison with farmers' practices

Two field experiments were conducted with sex pheromone of egg plant fruit and shoot borer at IIVR during 2001 and 2002. In 2001, the experiment was conducted at the IIVR experimental farm and on farmers' fields. In 2002, experiment was conducted only on the IIVR experimental farm. The number of egg plant fruit and shoot borer male adults caught ranged from less than 1 per trap per week during the second week of January, 2002 to over 227 during the last week of November at IIVR. A similar trend in moth catch was observed on farmers' fields in Adalpura. The average weekly moth catch differed slightly between two sites, 60.2 at IIVR to 67.5 at Adalpura. This average level of moth catch throughout the season is considered quite substantial and contributed to reduction in pest population (Alam *et al*., 2003).

Cork *et al.* (2003) conducted replicated integrated pest management (IPM) trials (3 × 0.5 ha per treatment) in farmers fields with young and mature egg plant crops. Farmers applied insecticides at least three times a week in all check and IPM plots. In addition pheromone traps were placed out at a density of 100 per ha and infested shoots removed weekly in the 0.5 ha IPM plots. Pheromone trap catches reduced significantly from 2.0 to 0.4 moths per trap per night respectively in check and IPM plots in a young crop and 1.1 to 0.3 moths per trap per night in check and IPM plots respectively in a mature crop. Fruit damage was significantly reduced from an average of 41.8 per cent and 51.2 per cent in check plots of young and mature crops respectively to 22 and 26.4 per cent, respectively in the associated IPM plots.

Rath and Dash (2005) reported that the average weekly brinjal shoot and fruit borer male moth catch (recorded for 15 weeks) was found to be 1.68 per week during summer season, while it was 0.21 during *kharif* season. As regards to shoot infestation, it was significantly less i.e. 1.83 and 1.79 per cent during summer and *kharif* seasons, respectively for IPM plots as against 12.67 and 9.52 per cent in non-IPM plots during both the season. Similarly per cent fruit damage (number and weight basis) also varied significantly. The per cent fruit infestation (number basis) was 13.07 and 6.56 for summer and *kharif* seasons under IPM plots and the corresponding figures in non-IPM plots were 43.34 and 27.30 per cent, respectively. Similar trends were observed on weight basis. The yield was significantly higher (21.45 t/ha) in IPM plots than non-IPM plots (12.20 t/ha).

In brinjal crop mass trapping was supplemented with neem spray and clipping which was second in order to fetch higher protected yield (55.2 q/ha), additional income (` 8090/ha) and the cost: benefit ratio was lower (1:1.4) than other less effective treatments. Nylon net barrier plus clipping recorded less improvement in brinjal shoot and fruit damage over control but yielded highest pesticide free marketable yield (Singh *et al.,* 2008).

The study revealed that mass trapping of *L. orbonalis* moths with the help of plastic funnel traps @ 1 per 100 m^2 baited with leucinlure sex pheromone, clipping of infested shoots at weekly interval starting at 20 days after transplanting (DAT), spraying with NSKE (4%) four times at an interval of 15 days starting at flowering and destruction of infested fruits after harvest had reduced the shoot infestation to the extent of 80.44 per cent over untreated plot and 61.64 per cent over plot without mass trapping. The increase in yield was 44.75 per cent over untreated control and 11.76 per cent over plot without mass trapping (Pawar *et al*., 2009).

The module with three components *i.e.* pheromone trap, timely mechanical control and application of azadex (neem based insecticides) was found most effective in reduction of shoot damage (76.59%) followed by the farmers' practice (*i.e.* twenty times application of insecticides) (76.36%). Whereas highest protection in fruit damage (48.26%) and yield increment (53.19%) were obtained from the practices of setting trap plus timely mechanical control and trap plus application of azadex, respectively. The module having all three components was found to be next best, which provided 45.91 per cent less fruit damage coupled with 52.29 per cent more production. Moreover, setting of only pheromone trap @ 75 numbers per hectare gave quite substantial protection in shoot damage (58.35%), fruit damage (33.73%) and yield (28.67%) while simultaneous use of trap plus azadex afforded 71.72 and 39.06 per cent protection against brinjal shoot and fruit borer damage, respectively (Chattarjee, 2009).

Mazumder and Khalequzzaman (2010) reported that the number of BSFB for three trap catches was 1.7 to 4.5 with a mean number of 3.26 ± 0.32 male moths catch per trap in field 1. In Field 2 the number was 7.0 to 10.5 with a mean of 8.49 ± 0.36. In Field 3 the number was 4.2 to 6.4 with a mean number of 5.20 ± 0.24 moths. In farmer's field (Field 4) the minimum number of BSFB for three trap catches was13.0 and the maximum was 16.4 with a mean number of 14.95 ± 0.34 male moths/trap. The average moth catch per trap was 1.76 ± 0.56 and 4.54 ± 0.94 in the 0.5 and 1 mg lure weight, respectively. The shoot damaged was 19.34 ± 2.31 per cent at 0.5 m lure height, whereas at 1m height no damaged shoot was recorded. Damaged fruit was 29.74 ±1.87 per cent and 14.47 ± 2.29 per cent with the fruit yield (in q/ha) of 176.58 ± 6.38 per cent and 232.56 ± 6.63 per cent at the 0.5 and 1m lure height plots, respectively. When no trap was operated in the eggplant fields the shoot damage, fruit damage and fruit yields were 3.48 per cent, 31.15 per cent and 13.70 kg/100 m^2, respectively in the non-IPM blocks. On the other hand they were 1.56 per cent, 10.66 per cent and 27.54 kg per 100 m^2, respectively in the IPM blocks.

An experiment was conducted by Kabir *et al*. (2010) at two locations (L1=Islampur and L2=Gafargaon) to evaluate the effectiveness of IPM practices for management of brinjal fruit and shoot borer in terms of number of affected shoots in different days after transplanting (DAT), total yield and benefit cost ratio (BCR). Results showed that the maximum total yield of brinjal (34.09 t ha^{-1}) and Benefit cost ratio (BCR) (4.00) were found in Gafargaon and the minimum (31.16 t ha^{-1}) and BCR (3.66) in Islampur. In case of treatment effect the highest total yield of brinjal (50.62 t ha^{-1}) and BCR (5.81) were found from treatment T1= pheromone trap plus sanitation plus bio-control agent release. And the lowest yield (20. 72 t ha^{-1}) and BCR (2.50) were from treatment T5=control (farmers' practices). In case of interaction effect (location × treatment), the highest total yield (52.10 t ha^{-1}) and BCR (5.98) were found in Gafargaon × treatment T1 and the lowest yield (20.27 t ha^{-1}) and BCR (2.45) found in Islampur × treatment T5.

3. MATERIAL AND METHODS

To accomplish the objectives of the present study, various experiments aimed at "Utilization of pheromone traps for the management of brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee (Lepidoptera: Crambidae)", were conducted in farmers' field around Baglkot, Karnataka, India. The materials used in conducting the experiments and the various methods employed during the course of investigations were furnished below.

3.1 Identification of the most effective commercially available trap design in catching male moths of brinjal shoot and fruit borer

Two field experiments were carried out to identify most effective commercially available trap design in catching male moths of brinjal shoot and fruit borer. The first experiment was conducted at Haveli, nearby College of Horticulture, Bagalkot, during the months of July to August, 2013. In this experiment, four trap designs *viz.,* Water trap, Funnel trap, Fligh–T trap and Cross winged traps were evaluated for their efficiency in attracting male moths of brinjal shoot and fruit borer (Plate 1).

The second experiment was conducted at Kadampur, old Bagalkot. During the month of September to October, 2013 (Plate 2), in this experiment, three trap designs *viz.,* Wota-T trap, Funnel trap, Delta sticky traps were evaluated for their efficiency in attracting male moths of brinjal shoot and fruit borer .

3.1.1 Details of trap design

3.1.1.1 Wota-T trap

Water trap consisted of an adaptor, basin to hold water and a lure holder with canopy. The adapter provided with the basin was used to fit the trap on to a stick which was driven into the ground. The basin was filled with water and tea spoon of detergent powder was mixed to the water. The lure was also fixed to the lure holder. Adult male moths attracted by the lure, fly around it, fall and drown in the water. Water was topped up as and when it was required. Catches can be easily identified and counted as moths remained intact (Plate 1a).

3.1.1.2 Delta sticky trap

The delta trap consists of a triangular or delta shaped cardboard tube. The lure was hung in the top angled portion and the bottom was covered with a glue sheet. Male moths of brinjal shoot and fruit borer got attracted to the lure and trapped in the glue while flying around the lure (Plate 1b).

3.1.1.3 Funnel trap

The funnel trap consisted of a plastic ring with a diameter of 11 cm which was reverted to a plastic plate at a clearance of 2.5 cm and a Polytethylene sleeve (60 cm length) was attached below. The polythene sleeve had an open end at its bottom but the bottom end was tightly secured with twine or rubber band so as to collect the moths trapped when required. At the centre of plate, a small plastic stick was hung to suspend the lure at the centre of the trap (Plate 1c).

3.1.1.4 Cross winged trap

In this, pheromone lure was placed on sticky surface of the trap. It allows for easy counting of captured insects, and replacement of trapping surface. This trap can also be discarded at the end of season (Plate 1d).

3.1.1.5 Fligh -T trap

Fligh-T trap consists two parts, one is basin, where water is holding. Another one is cap it is usefull for holding the lure. Adult male moths attracted by the lure, fly around it, fall and drown in the water. Water was topped up as and when it is required. Catches can be easily identified and counted as moths remain intact (Plate 1e).

3.1.2 Traps installation procedure

Wota-T trap, Funnel trap, Fligh-T trap and Cross winged traps were installed in brinjal shoot and fruit borer affected brinjal field (Variety MAHYCO 10) by adopting Randomized Complete Block Design (RCBD) with five replications. The traps were placed with a 7.5 m inter trap distance by leaving 5 m from the border. Traps were installed at a half to one feet above the crop canopy level at fruiting stage using bamboo sticks. Further, trap height was adjusted as crop growth progressed. Traps were rotated after each observation on clock wise direction to eliminate position effect. Plastic vials loaded with 4 mg pheromone used as single type of dispenser in all the traps throughout the study period.

In second experiment, water trap, Funnel trap and Delta sticky traps were evaluated by replicating seven times. Similar procedure was followed for trap installation as adopted in first experiment.

3.1.3 Field observations

The efficiency of different traps were assessed based on the total number of moths trapped Observations on moth catches of *L. orbonalis* were recorded at daily intervals from 20th July to 20th August, 2013. The weekly average were worked out to evaluate their efficacy during the period of experimentation and the same was subjected to statistical analysis. Similar procedure was followed for recording observations in second experiment also from 30th September to 30th October, 2013.

3.2 Studies to find out the field longevity of pheromone lures in relation with weather parameters

3.2.1 Traps installation procedure

The experiment was conducted at Simikeri, Bagalkot District during 6th February to 6th April to assess the field longevity of pheromone lures. Water trap with plastic vial as a single dispenser was used during the experimentation. Totally, 30 lures loaded with 4 mg of pheromone in each lure were used in 30 traps and installed in brinjal crop (variety MAHYCO 10) at half feet above the crop canopy.

3.2.2 Pheromone lure

The pheromone lures (plastic vials) used during present investigations were obtained from Bio-control Research laboratories, Bangalore, containing 4 mg of sex pheromone of brinjal shoot and fruit borer having components of (E)-11-hexadecenyl acetate and (E)-11-hexadecen-10-0l in 100:1 blend, respectively (Plate 3).

3.2.3 Field observations

At weekly interval, five lures from the installed traps were taken out and sent to Bio-Control Research Laboratories, Bangalore, for analysis of left over pheromone in the lure. Similar procedure was followed up to two months. Simultaneously, observations were also made at weekly interval on male moth catches in the pheromone traps. Weather parameters such as maximum and minimum day temperature, relative humidity and rainfall were also obtained from Agro meteorological Department, Regional Horticultural Research and

Extension Centre, UHS, Bagalkot. Weather parameters and trap catches were correlated to know the possible relationship between them.

3.3 Studies to assess impact of mass trapping on the infestation of brinjal shoot and fruit borer in comparison with farmers' practices

To find out impact of mass trapping on the infestation of brinjal shoot and fruit borer in comparison with farmers' practices, a field experiment was undertaken during summer season (20^{th} February to 20^{th} May, 2014) at Simikeri, Bagalkot District. For this purpose, two months old transplanted brinjal crop of one acre was selected and divided into two equal blocks for mass trapping and farmers'practices.

3.3.1 Mass trapping

3.3.1.1 Traps installation procedure

In mass trapping field, totally ten water traps containing lures loaded with 4 mg pheromone were installed at half feet above the crop canopy level (Plate 5).

3.3.2 Farmers' practices

3.3.2.1 Application of treatments

The treatments Emamectin benzoate (0.6 ml/lit), Chlrantraniliprole (0.2 ml/lit) and Methomyl (0.5 g/lit) were administered at six weeks after transplantation. Where brinjal shoot and fruit borer crossed its economical threshold level.

3.3.2.2 Preparation of spray fluid

The measured quantity of the respective insecticide was initially mixed in a one litre of water and later the volume was made up to 16 litre of spray fluid. The spray fluid was thoroughly stirred before spraying.

3.3.2.3 Insecticidal application

Sprayings were made during morning hours using a knapsack compression sprayer. The sprayer and the container used for preparing the spray fluid were thoroughly cleaned with water after each spray of treatment. The spraying was done to the point of run off for ensuring good coverage of the plant surface. The totally, 10 sprays were made at seven days intervals during study period.

3.3.2.4 Field observation

The observations were made on the total number of moths trapped in pheromone traps in mass trapping. Infestation level of shoot and fruit borer in both mass trapping and farmer practices at weekly intervals were also recorded. Per cent shoot and fruit damage was recorded from randomly selected 100 plants in each experiment (Mass trapping & farmer practices).

$$\text{Shoot damage (\%)} = \frac{\text{Number of shoots infested}}{\text{Total number of shoots observed}} \times 100$$

$$\text{Fruit damage (\%)} = \frac{\text{Number of affected fruits}}{\text{Total number of fruits observed}} \times 100$$

Observations were also be made on recording yield data both in farmer practices and mass trapping technology.

3.4 Statistical Analysis

Data obtained from various experiments were analysed using suitable statistical tools and methods after suitable transformation of the data. Data obtained from different trap design studies were analysed by adopting one way ANOVA. Data pertaining to the male moth catches in pheromone traps in relation with left over pheromone in the lures and weather parameters were analysed using simple correlation method. Efficacy of mass trapping method in comparison with farmers' practices was analysed using students' 't' test.

3.5 Economics

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.

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

4. EXPERIMENTAL RESULTS

The results of the studies on identification of effective commercially available trap design for catching male moths of brinjal shoot and fruit borer, lure longevity under field conditions and impact of mass trapping technology on the infestation of brinjal shoot and fruit borer are presented here under.

4.1 Identification of the most effective commercially available trap design in catching male moths of brinjal shoot and fruit borer

Two field experiments were conducted at Haveli and old Bagalkot during, 20th July to 20th August, 2013 and 30th September to 30th October, 2013, respectively to find out most suitable trap design for moth catches of *Lecinodes orbonalis*.

The data obtained on moth catches in five types of traps *viz.*, Water trap, Funnel trap, Fligh-T trap, Delta sticky trap and Cross winged trap which were evaluated for male moth catches for brinjal shoot and fruit borer, are presented in Table 1 and 2.

The *L. orbonalis* moth catch data collected during the month of 20th July to 20th August revealed significantly higher mean male moth catches of 17.10 over four weeks in Water trap and moth catches were statistically significant from other trap designs. Whereas, the trap catches were low in Funnel trap and Fligh-T trap with 0.05 and 0.20 mean numbers of moths over four weeks, respectively. There was no catches in the case of Cross winged trap during four weeks of study period (Table 1 and Plate 4).

In the second experiment, among the three different trap design evaluated, the highest mean number of male moth catches of 11.0 were observed with Water trap over a four weeks of study period. Similar trend was noticed with respect to male moth catches in other two trap designs namely Funnel and Delta sticky trap as noticed in the first experiment (Table 2).

In the first experiment, during the four weeks of study period, the highest numbers of adults were caught during third week of traps installation in Water trap (22.60 moths/trap/week). Whereas, least number of adults were caught during first week of trap installation in Water trap (12.40 moth/trap/week) (Table 1).

Differences were also noticed between moth catches recorded over the four week study period of 30th September to 30th October in each trap design. Thus the highest mean moth catches recorded in water trap was 14.71 adults per trap per week during the fourth week followed by 13.28 adults per trap per week during second week (Table 2).

4.2 Studies to find out the field longevity of pheromone lures in relation with weather parameters

The field experiment was conducted in a farmers’ field at Simikeri, Bagalkot district during 6th February to 6th April, 2014, to assess the left over pheromone in the lure and its impact on male moth catches of brinjal shoot and fruit borer.

As the lure exposure period increased under field condition, the mean quantity of pheromone and number of the male moth catches decreased. The results revealed that the mean quantity of pheromone left over in the lures was 3.04 mg and 1.55 mg at 15 and 60 days of exposure period, respectively. The moth catches were 3.80 and 1.40 per trap per day at 15 and 60 days of exposure periods, respectively (Table 3).

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, and left over pheromone with major weather 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 (r=0.416) and left over pheromone (Table 4).

The recorded data indicated that there was non significant negative correlation between maximum temperature (r=-0.107) and minimum temperature (r=-0.414) with *L. orbonalis* male moth catches. Similarly, the morning and evening relative humidity had negative correlation with number of male moth catches of *L. orbonalis* which was statistically non-significant. The rainfall had positive correlation with male moth catches, while wind speed had negative correlation. Both were statistically non-significant (Table 4).

4.3 Studies to assess impact of mass trapping on the infestation of brinjal shoot and fruit borer in comparison with farmers' practices

A field experiment was carried out at Simikeri, Bagalkot district during 20th February to 2nd May, 2014, to assess the impact of mass trapping 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. The data on trap catches of male moths of *L. orbonalis* are presented in Table 5, 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 during different weeks.

The results presented in Table 6 revealed that highest fruit damage (6.6 %) was reported in ninth week, whereas, lowest (0.2%) fruit damage was in mass trapping during seventh week. Whereas, in farmers practices highest 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 6 and Figure 6. In mass trapping block, highest shoot damage (6 %) was recorded during first week of trap installation which is on par with second week *i.e.* 5.7 %, whereas, lowest per cent shoot damage observed during10th week of traps installation *i.e.* 0.4 per cent. In case of farmers' practices, highest 7.6 per cent shoot damage was recorded during second week of traps installation, whereas, lowest was recorded during eighth week of traps installation (0%) (Plate 8).

The results presented in Table 7 showed that in mass trapping practices yield was 90.12 q/ha and in farmers' practices 74 q/ha . Cost of cultivation in mass trapping practices was ` 53,037.00 and in farmer practices ` 52,787.00. Highest cost benefit ratio (0.86) was recorded in the mass trapping practices as compared to farmers' practices.

5. DISCUSSION

The results obtained with regard to finding out an effective and most suitable trap design, longevity of the lure under field conditions and impact of mass trapping on the management of brinjal shoot and fruit borer are discussed in the light of earlier work here under.

5.1 Identification of the most effective commercially available trap design in catching male moths of brinjal shoot and fruit borer

Use of pheromones for attraction of target insect pest is influenced by various factors which can either increase or decrease the trap efficiency considerably. Among such factors, trap design, type of dispenser, trap installation height, density of traps, purity of pheromone chemicals and weather parameters like temperature, relative humidity, wind speed *etc*. are playing major role in pheromone trap efficiency. In the present investigation, five trap designs *viz*., Water trap, Funnel trap, Fligh-T trap, Cross winged trap and Delta sticky traps were used to find out the most efficient trap design which could attract male moths of brinjal shoot and fruit borer.

Among trap designs tested for their efficacy in terms of male moth catches, Water trap was found to be more promising as evidenced by the maximum number of moth catches as compared to Funnel trap, Fligh-T trap, Cross winged trap and Delta sticky trap. In first experiment, the mean male moth catches per trap per week in Water trap, Funnel trap, Fligh-T trap, Cross winged trap catches were 17.10, 0.05, 0.20 and 0.00, respectively (Fig. 1 and 2). Similar trend with respect to male moth catches was observed in second experiment. The mean male moth catches in Water trap was highest followed by Funnel trap and Delta sticky trap (11.00, 0.53 and 0.21, respectively) (Fig. 3 and 4).

The results obtained in the present investigation are in accordance with findings of Krishna kumar *et al.* (2006), who also observed water trap was effective than PCI delta trap and similar results were also reported by Bhanu *et al*. (2007) and Nandagopal *et al.* (2010).

The high efficiency of water trap in catching male moths of *L. orbonalis* may be due to availability of more surface area or volume for retaining caught moths. In Water trap, availability of surface area is relatively more than that of other trap designs. Reduced efficacy of Delta, Cross winged traps may be attributed to existence of more open sides which results in the increased chances for escape of the caught moths and with a clear possibility of more deposition of dust on them. The deposited dust obviously reduces the stickiness of the trapping surface and ultimately reduces the trapping efficacy. In addition to the target pest large number of beneficial insects, like predators, parasitoids also caught in both Delta sticky and Cross winged trap. Guptha and Pawar (1989) and Rai *et al.* (2000) reported that polyethylene sleeve traps were superior to sticky traps. In the case of Figh-T traps, release rate of the pheromone may be interpreted as the lures are fixed inside the cavity or dome of the trap, thus lesser number of male moths are attributed caught in the trap. Similarly lesser number of moths caught in Funnel trap could be because of the less area available for dissemination of pheromone from lures as compared to Water trap. In addition to the above mentioned factors, one of the important factors which determine suitability of trap design is flight behaviour of the target insect.

Significant difference existed between the numbers of moths caught over different weeks. This difference could be because of prevailing environmental situation, crop stage during study period and life cycle of the pest.

It was also observed that higher level of field infestation noticed during third week and second week of study period in first and second trial, respectively. This synchronized with fruiting stage of the crop. The results of these studies are in agreement with Bhanu *et al.,* 2007, who reported that the highest mean moths catches recorded in PCI's Water trap was 20.67 adults per trap during the fourth week followed by 16.16 and 11.83 second and third week, respectively.

5.2 Studies to find out the field longevity of pheromone lures in relation with weather parameters

Pheromone release rate is one of the important factors which influences the male moth catches. In the view of this, field study was conducted to know the release rate pattern of pheromone lure over a period of two months.

It was observed that the efficiency of tested lures was optimum in catching male moths of brinjal shoot and fruit borer up to two months under field conditions.

Lure longevity study revealed that after 2 months of exposure of lure in the field, the left over pheromone quantity observed was 1.55 mg (Fig. 5). These results are in conformity with Bhanu *et al.* (2007) who reported that lures were 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 were not efficient in catching male moths. However, further studies are needed to confirm these results.

Maximum and minimum temperature showed non-significant negative relationship with male moth catches. Similar findings were also observed in the case of *H. armigera* (Nesbitt *et al*., 1979; Korat and Lingappa, 1995; Kulkarni *et al*., 2004). However, Krishna Kumar *et al.* (2009) reported that the significant negative correlation between minimum temperature and brinjal shoot and fruit borer moth catches.

Morning and afternoon relative humidity had negative relationships with brinjal shoot and fruit borer moth catches, which is broadly in line with findings of Kumar and Babu (1996), Kumar *et al*. (2004) and 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).

5.3 Studies to assess impact of mass trapping on the infestation of brinjal shoot and fruit borer in comparison with farmers' practices

The total male moth caught during 10 weeks study period was 861. The highest mean number of male moth catches (29.6 per 10 traps) was recorded during 10th week after trap installation (Table 5 and Fig. 7).

In both mass trapping and farmers' practices the blocks per cent fruit damage increased gradually as the crop stage advanced under natural conditions. These results are in line with the findings of Geetha Lakshmi (2009), where the fruit damage varied from 16.67 to 86.25 from first to sixth harvesting stage.

The mean per cent shoot infestation was 2.38 and 4.15 and fruit infestation was 4.15 and 9.20, respectively in mass trapping and in the case of farmers' practices (Fig. 8 and 9). Results of the present investigation indicated that the performance mass trapping was on par with farmer practices, even though more number of chemical pesticides were used in the farmer practices.

Highest cost benefit ratio (0.86) was recorded in the mass trapping when compared to farmer's practice (0.41). These results are in agreement with finding of Cork (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 (Rashid *et al.,* 2003).

In addition, the yield of healthy fruits from pheromone plot was higher than farmers' practices. Since more number of sprays were applied in farmer practices field the pollinators and natural enemies were affected badly noticed during the field observations.

Future line of work

1. Systematic studies are required to understand the population dynamics of brinjal shoot and fruit borer.

2. Revalidation of pheromone trapping method as a component of IPM is required to manage brinjal shoot and fruit borer.

3. Systematic field studies are required to understand pheromone release patter from lures in relation with weather parameters.

6. SUMMARY AND CONCLUSIONS

Brinjal, *Solanum melongena* (Linnaeus) is one of the most economically important vegetables for small-scale farmers and popular among low-income consumers. During the past two decades, this crop has been increasingly ravaged by Brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee. Presently farmers are depending only on using of number of pesticides to manage the pest. However, control with this practice proved to be unstatisfactory in most of the situations. This indicated the necessity of integrated pest management for brinjal shoot and fruit borer.

In the light of this, present investigation was undertaken to standardize pheromone based method for management of brinjal shoot and fruit borer.

The results indicated that, the attraction was influenced by variety of factors which can either increase or reduce the trap efficiency considerably. Among such factors, type of trap used had considerable impact on the trap catches. Water trap was proved to be the most efficient with highest trap catches (17.10 moths/trap) over other trap designs *viz.,* Funnel trap, Fligh-T trap, Cross winged trap and Delta sticky trap. This clearly gave an indication that water trap is most effective in trapping the male moths of *L. orbonalis.*

Lure longevity study revealed that, longevity of the lure under field condition was up to two months. Weather factors had no significant correlation with pheromone release rate and male moth catches of brinjal shoot and fruit borer.

The per cent shoot and fruit damage was similar in the case of mass trapping and farmer practices and it was statistically non significant. However, with respect to benefit cost ratio, the mass trapping had higher benefit cost ratio as compared to farmers' practices.

From the above results, the following conclusions are precisely drawn:

- Water trap emerged as most suitable trap design in catching male moths of *Leucinodes orbonalis.*
- Lure longevity or shelf life of tested lure lost up to two months under field conditions.
- Mass trapping can be adopted by the farmers to manage a noxious pest, brinjal shoot and fruit borer, as this technology is ecofriendly, easy to adopt and economically viable.

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UTILIZATION OF PHEROMONE TRAPS FOR THE MANAGEMENT OF BRINJAL SHOOT AND FRUIT BORER, *Leucinodes orbonalis* GUENEE (LEPIDOPTERA: CRAMBIDAE)

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ABSTRACT

Studies “on Utilization of pheromone traps for the management of brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee (Lepidoptera: Crambidae)” were carried out during 2013-2014 at College of Horticulture, Bagalkot, University of Horticulture Sciences, Bagalkot. Among the different trap designs tested for their efficacy, Water trap found to be more superior in terms of male moth catches of *L. orbonalis* as compared to Funnel trap, Fligh-T trap, Cross winged trap and Delta sticky trap. During first trial, the mean number of male moth catches in Water trap, Funnel trap, Fligh-T trap, Cross winged trap catches were 17.10, 0.05, 0.20 and 0.00 moths per trap per week, respectively. Similar trend with respect to male moth catches was observed in second field trials also. Lure longevity study revealed that, after 2 months of exposure period under field conditions, the left over pheromone was 1.55 mg per lure. Hence, results clearly indicated that, the shelf life of brinjal shoot and fruit borer pheromone lure under field conditions last for two months. Weather factors *viz*., temperature, relative humidity, wind speed and rainfall had no significantly correlation with pheromone release rate and male moth catches of brinjal shoot and fruit borer. Management of brinjal shoot and fruit borer study revealed, that the significantly higher yield (90.12 q/ha) and benefit-cost ratio (0.86) recorded in mass trapping as compared to farmers’ practice (74 q/ha and 0.41, respectively). However, the per cent shoot and fruit damage was found statistically on par in both the practices, installation of water trap at the rate of 50 per hectare was found to be effective in managing brinjal shoot and fruit borer as compared to farmers’ practices in spite of number of insecticides applications were made.

ಬದನೆಯ ಕಾಂಡ ಮತ್ತು ಕಾಯಿ ಕೊರಕದ ನಿರ್ವಹಣೆಯಲ್ಲಿ ಲಿಂಗಾಕರ್ಷಕ ಮೋಹಕ ಬಲೆಗಳ ಬಳಕೆ

ಕಸ್ತೂರಿ ಮಾನಸ	**2014**	**ಡಾ. ಗಂಗಾಧರ ನರಬೆಂಚಿ**
	ಸಾರಾಂಶ	**ಪ್ರಮುಖ ಸಲಹೆಗಾರರು**

ಬದನೆಯ ಕಾಂಡ ಮತ್ತು ಕಾಯಿ ಕೊರಕದ ನಿರ್ವಹಣೆಯಲ್ಲಿ ಲಿಂಗಾಕರ್ಷಕ ಮೋಹಕ ಬಲೆಗಳ ಬಳಕೆಯ ಬಗ್ಗೆ ತೋಟಗಾರಿಕಾ ಮಹಾವಿದ್ಯಾಲಯ, ಬಾಗಲಕೋಟದಲ್ಲಿ 2013–14 ರ ಸಾಲಿನಲ್ಲಿ ಅಧ್ಯಯನ ಕೈಗೊಳ್ಳಲಾಯಿತು. ಕಾಂಡ ಮತ್ತು ಕಾಯಿ ಕೊರಕದ ಗಂಡು ಪತಂಗಳನ್ನು ಆಕರ್ಷಿಸಿ ಬಲೆಗೆ ಬೀಳಿಸಿಕೊಳ್ಳುವ ಸಾಮರ್ಥ್ಯವನ್ನು ವಿವಿಧ ವಿನ್ಯಾಸದ ಲಿಂಗಾಕರ್ಷಕ ಮೋಹಕ ಬಲೆಗಳಾದ ನೀರಿನ ಬಲೆ (ವಾಟರ್ ಟ್ರ್ಯಾಪ್), ಆಲಿಕೆ ಬಲೆ (ಫನೇಲ್ ಟ್ರ್ಯಾಪ್) ಡೆಲ್ಟಾ ಅಂಟು ಬಲೆ (ಡೆಲ್ಟಾ ಸ್ಟಿಕಿ ಟ್ರ್ಯಾಪ್), ಫ್ಲೈ–ಟಿ ಬಲೆ (ಫ್ಲೈ–ಟಿ ಟ್ರ್ಯಾಪ್) ಮತ್ತು ಕ್ರಾಸ್ಡ್ ವಿಂಗಡ್ ಬಲೆಗಳನ್ನು ಪರೀಕ್ಷಿಸಿ ಹೋಲಿಕೆ ಮಾಡಿದಾಗ, ಸರಾಸರಿ 17.10, 0.05, 0.20 ಮತ್ತು 0.00 ಗಂಡು ಪತಂಗಗಳು ಪ್ರತಿ ಬಲೆಗೆ ಪ್ರತಿ ವಾರಕ್ಕೆ ಬಿದ್ದಿದ್ದು ಕಂಡುಬಂದಿತು. ಪರೀಕ್ಷಿಸಿದ ಎಲ್ಲಾ ವಿನ್ಯಾಸದ ಬಲೆಗಳ ಪೈಕಿ ನೀರಿನ ಬಲೆಗಳಲ್ಲಿ ಅತೀ ಹೆಚ್ಚಿನ ಸಂಖ್ಯೆಯಲ್ಲಿ ಕಾಂಡ ಮತ್ತು ಕಾಯಿ ಕೊರಕದ ಗಂಡು ಪತಂಗಗಳು ಬಿದ್ದಿದ್ದು ಕಂಡುಬಂದಿತು. ಈ ಬಲೆಗಳಲ್ಲಿ ಬಳಸುವ ಮೋಹಕಗಳ (ಲ್ಯೂರ್) ಬಾಳಿಕೆಯನ್ನು ಪರೀಕ್ಷಿಸಲು ರೈತರು ಬೆಳೆದ ಬದನೆ ಕ್ಷೇತ್ರದಲ್ಲಿ ಪ್ರಯೋಗವನ್ನು ಕೈಗೊಳ್ಳಲಾಯಿತು. ಈ ಪ್ರಯೋಗದ ಫಲಿತಾಂಶದ ಪ್ರಕಾರ ಮೋಹಕಗಳನ್ನು ಪ್ರತಿ ಎರಡು ತಿಂಗಳಿಗೊಮ್ಮೆ ಬದಲಾಯಿಸಬೇಕು ಎಂದು ಕಂಡುಬಂದಿದೆ ಹಾಗೂ ಮೋಹಕಗಳು ಲಿಂಗಾಕರ್ಷಕವನ್ನು ಹೊರಸೂಸುವ ಕ್ರಿಯೆಯ ಮೇಲೆ ಹವಾಮಾನವು ಯಾವುದೇ ರೀತಿ ಪರಿಣಾಮವನ್ನು ಬೀರುವುದಿಲ್ಲ ಎಂದು ತಿಳಿದು ಬಂದಿದೆ. ಬದನೆಯ ಕಾಂಡ ಮತ್ತು ಕಾಯಿ ಕೊರಕದ ನಿರ್ವಹಣೆಗಾಗಿ ಅನುಸರಿಸಿದ ಎರಡು ಕ್ರಮಗಳಾದ ನೀರಿನ ಬಲೆಗಳನ್ನು ಉಪಯೋಗಿಸಿ ಗಂಡು ಪತಂಗಗಳನ್ನು ಗುಂಪಾಗಿ ಹಿಡಿಯುವದು ಮತ್ತು ರೈತರು ಅನುಸರಿಸುವ ಪದ್ಧತಿಗಳನ್ನು ರೈತರ ಕ್ಷೇತ್ರಗಳಲ್ಲಿ ಪರೀಕ್ಷಿಸಲಾಯಿತು. ಈ ಪ್ರಯೋಗದ ಫಲಿತಾಂಶದ ಪ್ರಕಾರ ರೈತರ ಕ್ರಮಗಳಿಗೆ ಹೋಲಿಕೆ ಮಾಡಿದಾಗ ಪ್ರತಿ ಹೇಕ್ಟರ್‌ಗೆ 50 ನೀರಿನ ಬಲೆಗಳನ್ನು ಬಳಸುವದರಿಂದ ಕಾಂಡ ಮತ್ತು ಕಾಯಿ ಕೊರಕವನ್ನು ಪರಿಣಾಮಕಾರಿಯಾಗಿ ಹತೋಟಿ ಮಾಡುವದರ ಜೊತೆಗೆ ಹೆಚ್ಚಿನ ಇಳುವರಿಯನ್ನು ಪಡೆಯಬಹುದು ಎಂದು ಕಂಡುಬಂದಿದೆ. ನೀರಿನ ಬಲೆಗಳನ್ನು ಉಪಯೋಗಿಸಿದ ತಾಕುಗಳಲ್ಲಿ ಪ್ರತಿ ಹೇಕ್ಟರ್‌ಗೆ 90.12 ಕ್ವಿಂಟಾಲ ಇಳುವರಿ ಪಡೆದರೆ ರೈತರ ಕ್ರಮಗಳನ್ನು ಅನುಸರಿಸಿದ ತಾಕುಗಳಲ್ಲಿ ಕೇವಲ 74 ಕ್ವಿಂಟಾಲ ಇಳುವರಿ ಪಡೆಯಲಾಯಿತು. ಮೇಲಾಗಿ ರೈತರು ಲಿಂಗಾಕರ್ಷಕ ಮೋಹಕ ಬಲೆಗಳ ಬಳಕೆಯ ಕ್ರಮವನ್ನು ಅನುಸರಿಸುವದರಿಂದ ಸುಮಾರು ಎರಡು ಪಟ್ಟು ಅಧಿಕ ವರಮಾನವನ್ನು ಗಳಿಸಬಹುದಾಗಿದೆ ಎಂದು ಕಂಡುಬಂದಿದೆ.

TABLES

Table 1: Influence of trap design on performance of sex pheromone of *Leucinodes orbonalis* in catching male moths at different weeks (20th July to 20th August, 2013)

Trap design	***Mean Number of male moth catches per trap per week**					
	Week 1	**Week 2**	**Week 3**	**Week 4**	**Total**	**Mean**
Water trap	12.40 (3.50)	16.20 (4.01)	22.60 (4.67)	17.20 (4.14)	68.40 (16.32)	17.10 (4.08)[a]
Funnel trap	0.00 (0.70)	0.00 (0.70)	0.20 (0.81)	0.00 (0.70)	0.20 (2.91)	0.05 (0.72)[b]
Fligh –T trap	0.20 (0.81)	0.00 (0.70)	0.40 (0.91)	0.20 (0.81)	0.80 (3.23)	0.20 (1.77)[b]
Cross winged trap	0.00 (0.70)	0.00 (0.70)	0.00 (0.70)	0.00 (0.70)	0.00 (2.8)	0.00 (0.70) [b]
Mean	3.15 (1.42)	4.05 (1.52)	5.8 (1.77)	4.35 (1.58)		
CD (P=0.05)	NS					0.3
Trap design x Weeks	NS					

*Mean of five replications
Figures in the parenthesis are $\sqrt{x+0.5}$ transferred values.
In a column means followed by same alphabet do not differ significantly by DMRT (P=0.05)

Table 2: Influence of trap design on performance of sex pheromone of *Leucinodes orbonalis* in catching male moths at different weeks (30th September to 30th October, 2013)

Trap design	*Mean number of male moth catches per trap per week					
	Week 1	Week 2	Week 3	Week 4	Total	Mean
Water trap	6.00 (2.11)	13.28 (3.21)	10.14 (2.90)	14.71 (3.45)	44.13 (11.67)	11.0 (2.91)[a]
Funnel trap	0.28 (0.85)	0.28 (0.85)	0.57 (0.95)	1.00 (1.11)	2.13 (3.76)	0.53 (0.94)[b]
Delta sticky trap	0.14 (0.78)	0.28 (0.85)	0.42 (0.90)	0.00 (0.70)	0.84 (3.23)	0.21 (0.80)[b]
Mean	2.14 (1.24)	4.61 (1.63)	3.57 (1.51)	5.23 (1.75)		
CD (P=0.05)	NS					0.5
Trap design x Weeks	NS					

*Mean of five replications

Figures in the parenthesis are $\sqrt{x+0.5}$ transferred values.

In a column means followed by same alphabet do not differ significantly by DMRT (P=0.05)

Table 3: Influence of exposure period on release rate of pheromone from the lure under field conditions

Batch number	Lure exposure period (Days)	*Mean quantity of left over pheromone in the lure (mg)	Mean male moth catches/trap/day Mean ± SD
1	15	3.04	3.80±0.53
2	30	2.30	3.04±0.32
3	38	2.56	0.85±0.20
4	45	2.39	1.20±0.26
5	52	1.88	2.40±0.20
6	60	1.55	1.40±0.52

*Mean of five lures

Table 4: Simple correlation among left over pheromone, weather parameters and mean male moth catches of *Leucinodes orbonalis*

Weather parameters	Correlation coefficient 'r'
Average mean male moth catches	0.416
Maximum temperature (ºC)	-0.107
Minimum temperature (ºC)	-0.414
RH I (%)	-0.537
RH II (%)	-0.698
Rain fall (mm)	0.262
Wind speed (km/h)	-0.124

RH I= Morning Relative Humidity
RH II=Evening Relative Humidity

Table 5: Trap catches of male moths of *Leucinodes orbonalis* using sex pheromone lure in mass trapping.

Weeks of after flowering	**Total number of moths caught in 10 traps /week**	**Mean number of moths/trap/week**	**Range**
1	74.00	7.40 (2.72)[bc]	1-25
2	62.00	6.20 (2.49)[c]	0-19
3	17.00	1.70 (1.30)[d]	0-7
4	50.00	5.00 (2.20)[cd]	2-8
5	63.00	6.30 (2.51)[c]	4-10
6	61.00	6.10 (2.47)[c]	3-13
7	72.00	7.20 (2.68) [bc]	4-17
8	58.00	5.80 (2.41)[c]	2-9
9	108.00	10.80 (3.29)[b]	4-15
10	296.00	29.60 (5.44)[a]	17-42
Total	861.00	27.51	
Mean	86.10	2.75	
S.Em±		0.21	
(CD=0.05)		0.81	

Figures in the parenthesis are square root ($\sqrt{x+0.5}$) are transferred values
In a column means followed by same alphabets do not differ significantly by DMRT (P=0.05)

Table 6: Brinjal shoot and fruit damage due to *Leucinodes orbonalis* in mass trapping and farmers' practices

Weeks	* Mean shoot and fruit damage (%)			
	*Mean Shoot damage (%)		*Mean fruit damage (%)	
	Mass trapping	Farmer practice	Mass trapping	Farmer practice
1	6.00 (14.10)	5.10 (13.00)	Nil	Nil
2	5.70 (13.80)	7.6 0 (15.90)	Nil	Nil
3	4.00 (11.50)	1.60 (7.20)	1.90 (7.90)	2.10 (8.30)
4	4.10 (11.60)	1.00 (5.70)	4.10 (11.60)	4.90 (12.70)
5	0.50 (4.00)	1.10 (6.00)	5.20 (13.17)	0.90 (5.40)
6	0.70 (4.70)	0.50 (4.00)	5.70 (13.80)	6.90 (15.20)
7	0.60 (4.40)	1.10 (6.00)	0.20 (2.50)	1.29 (6.50)
8	0.70 (4.70)	0.00 (0.00)	5.50 (13.50)	25.8 (30.50)
9	1.10 (6.00)	0.80 (5.10)	6.60 (14.80)	27.3 (31.40)
10	0.40 (3.60)	0.20 (2.30)	4.00 (11.50)	5.11 (13.40)
Mean	2.38	1.89	4.15	9.20
t_{α} (P=0.05)	NS		NS	

*Mean of 100 plants

Figures in the parenthesis are Arc sine transformed values

Table 7: Economics of mass trapping and farmers' practices in management of *Leucinodes orbonalis*

Treatments	Yield q/ha	Cost of plant protection (`/ha)	Cost of cultivation (`/ha)	Gross income (`/ha)	Net income (`/ha)	B:C
Farmers' practices	74.00	10,170	52787	88800	25843	0.41
Mass trapping	90.12	5250	53037	108144	49857	0.86

GRAPHS

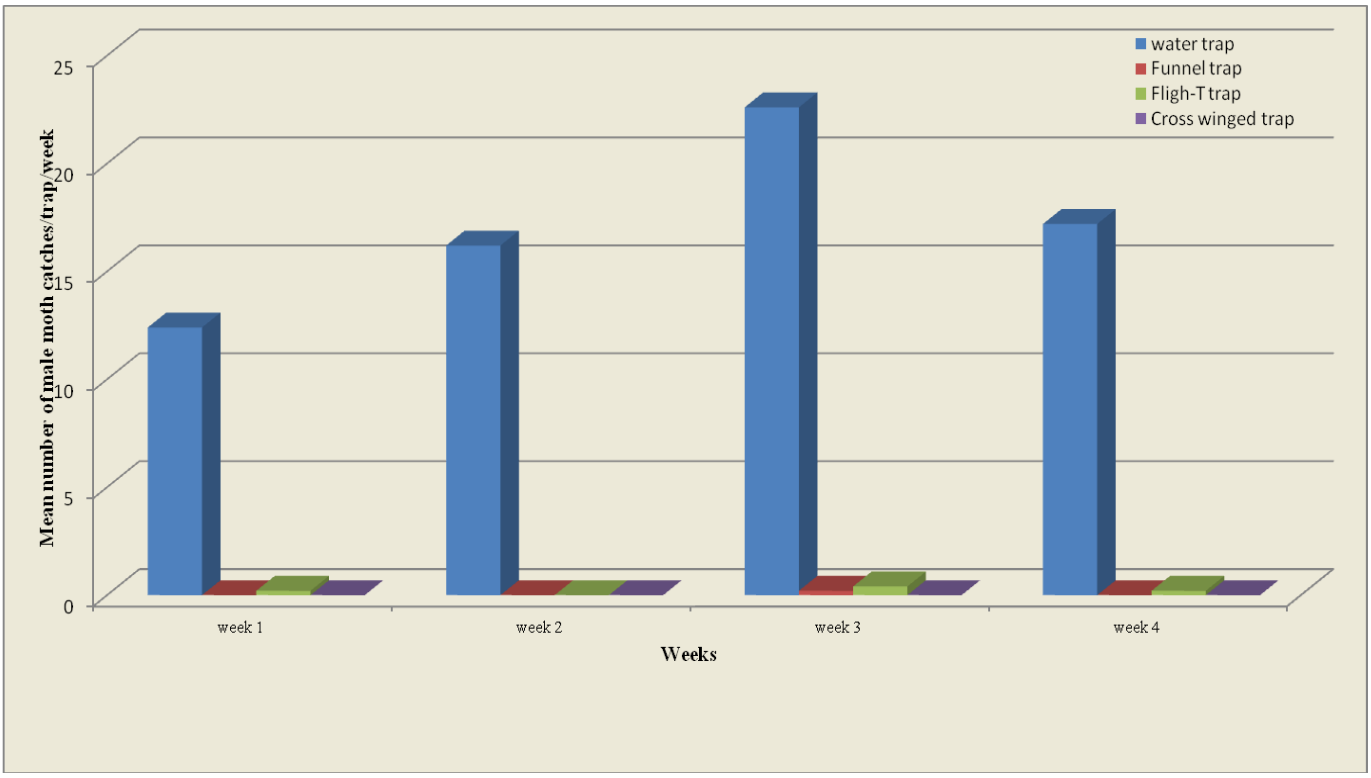


Fig. 1: Influence of different trap designs on male moth catches of *Leucinodes orbonalis* from 20th July to 20th August, 2013

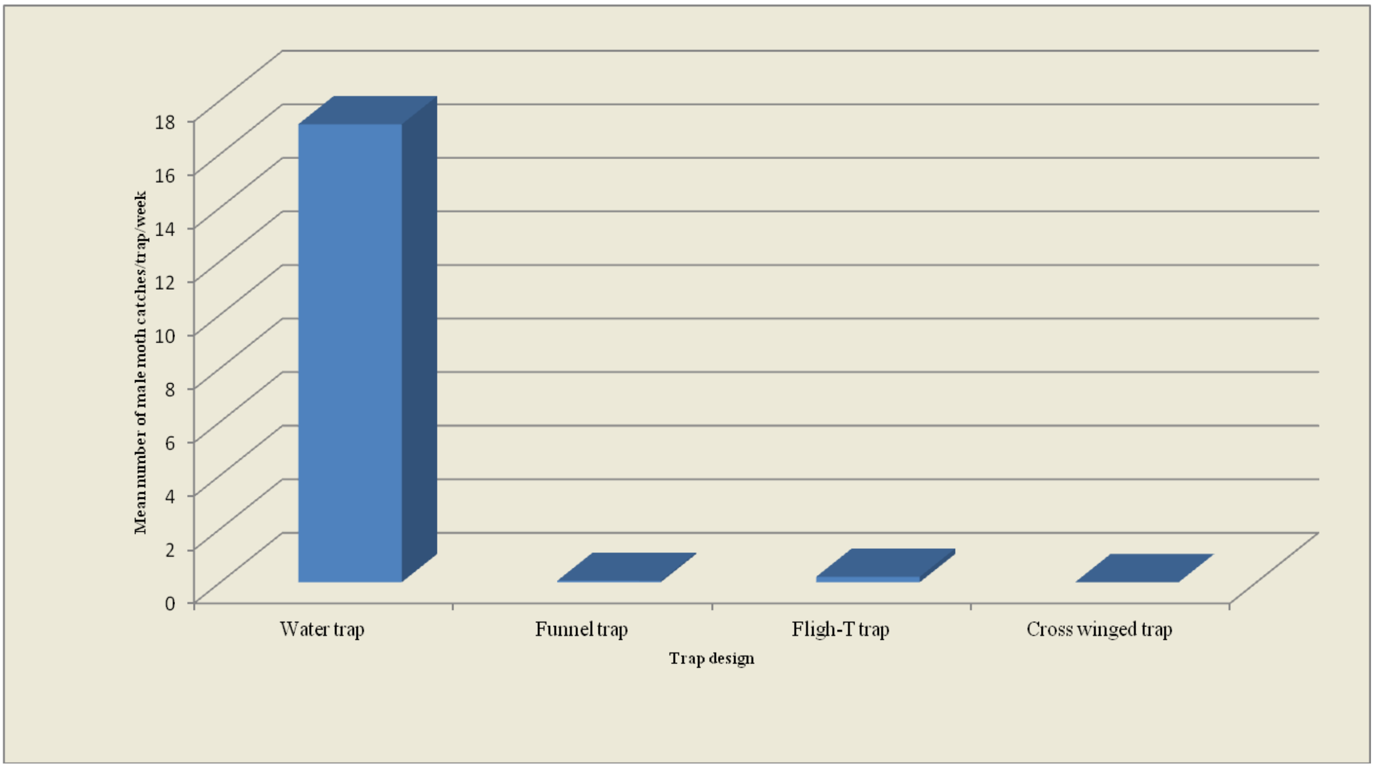


Fig. 2: Performance of different trap designs on male moth catches of *Leucinodes orbonalis* from 20th July to 20th August, 2013

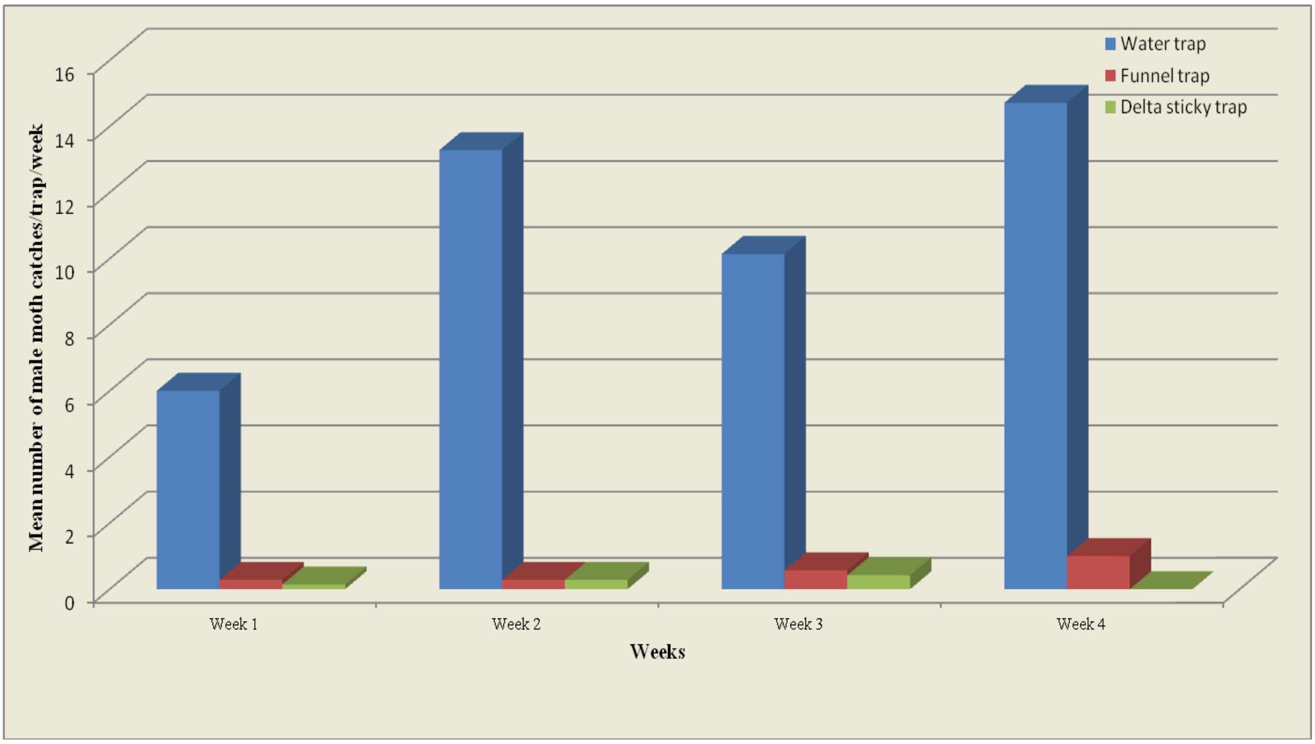


Fig. 3: Influence of different trap designs on male moth catches of *Leucinodes orbonalis* from 30th September to 30th October, 2013

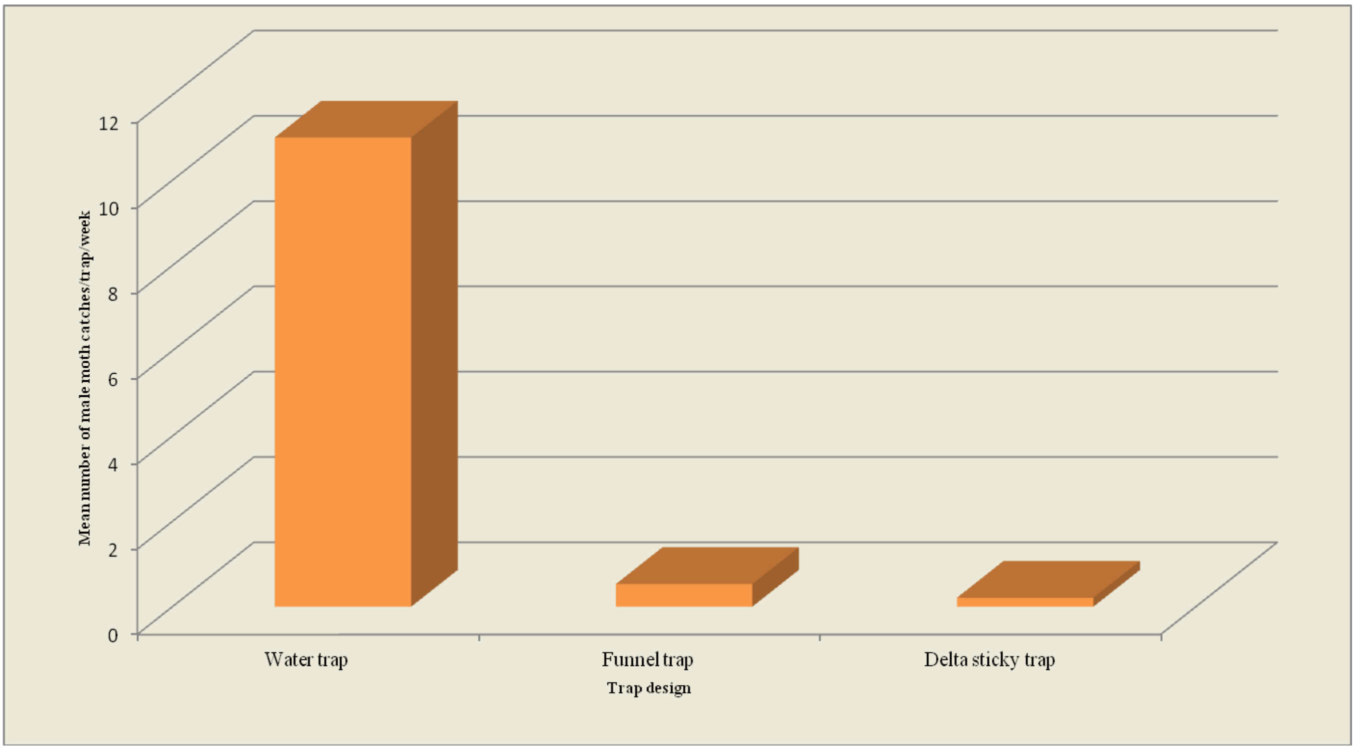


Fig. 4: Performance of different trap designs on male moth catches of *Leucinodes orbonalis* from 30th September to 30th October, 2013

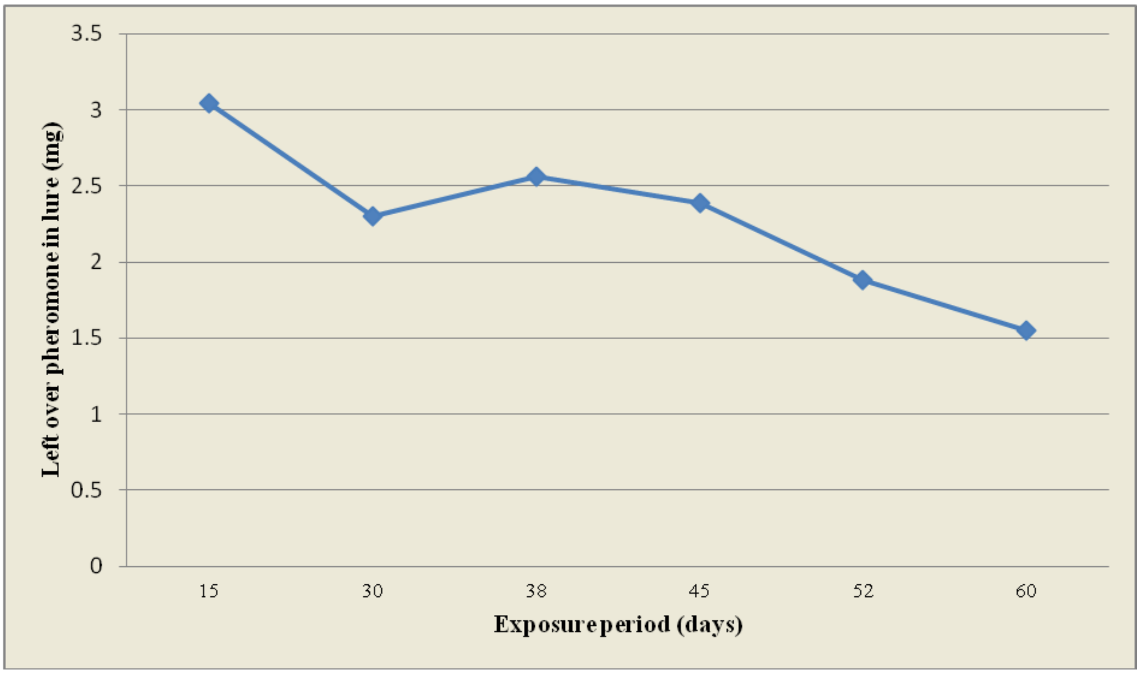


Fig. 5: Release pattern of sex pheromone of *Leucinodes orbonalis* from the lures over the period of exposure under field conditions at Bagalkot.

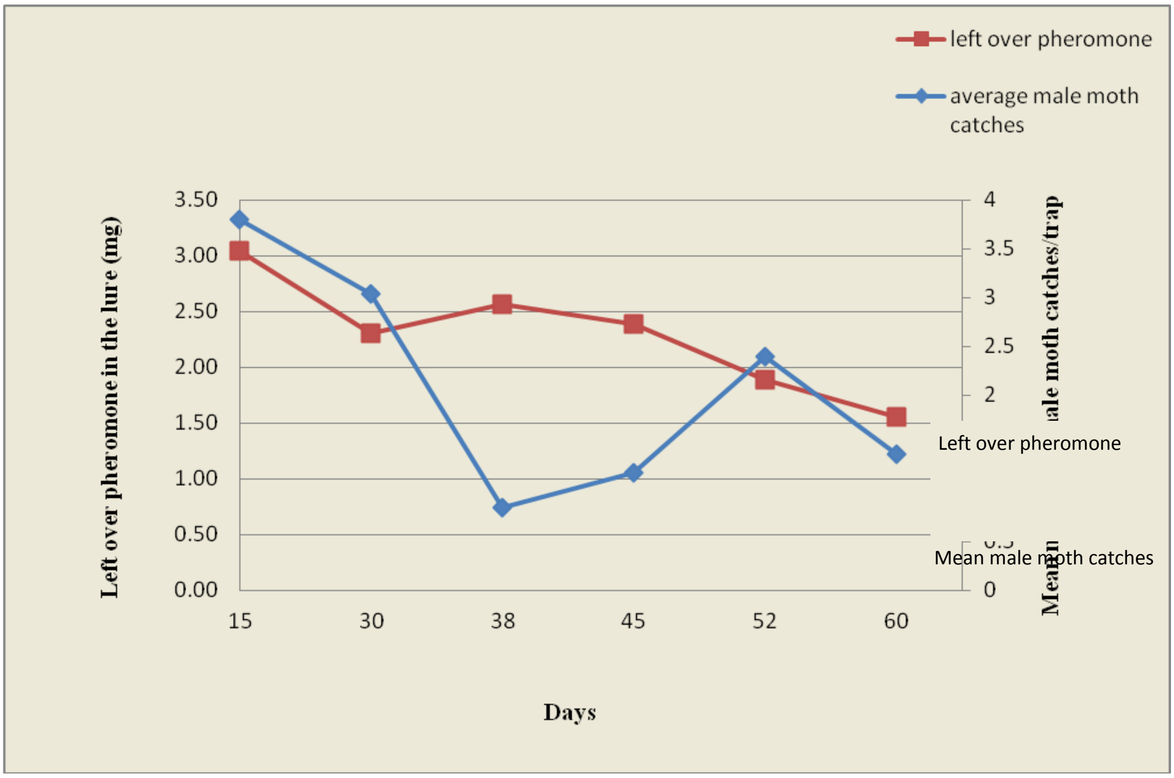


Fig. 6: Comparison of mean number of male moth catches to left over pheromone in the lure

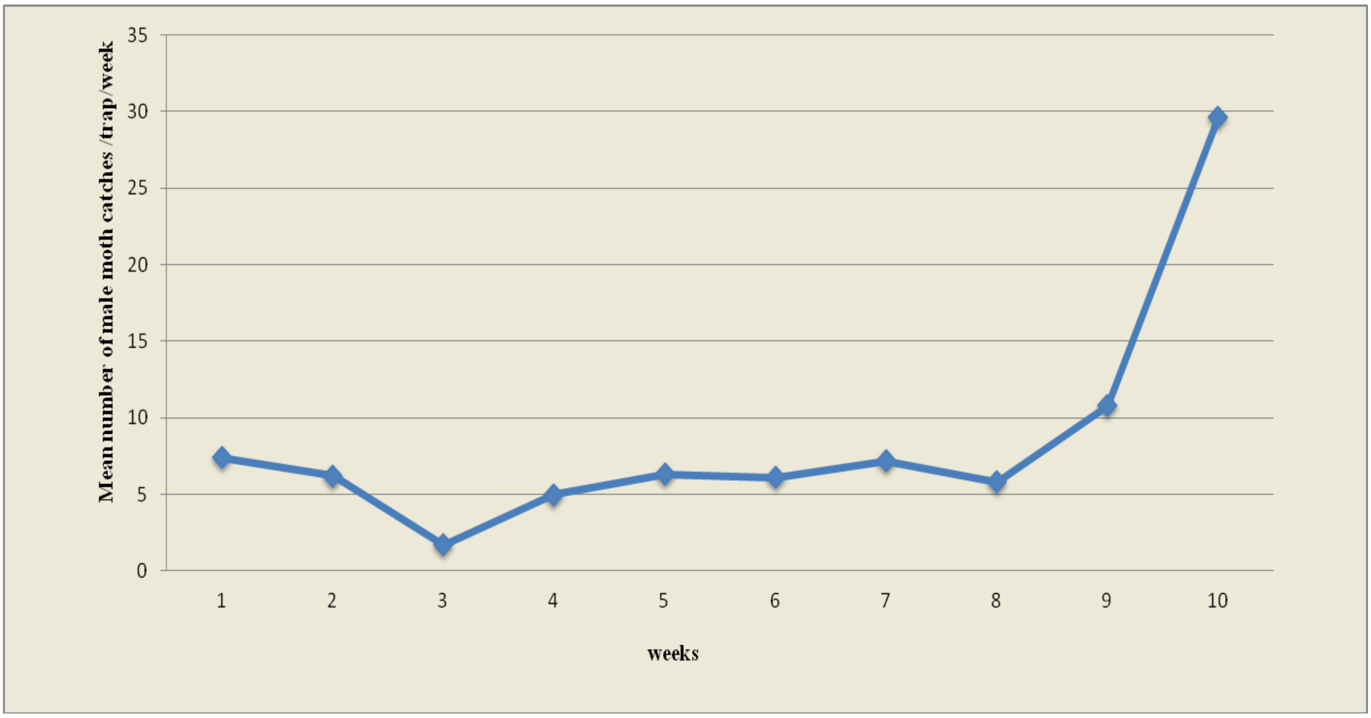


Fig. 7: Mean number of male moth catches over a period of ten weeks in mass trapping

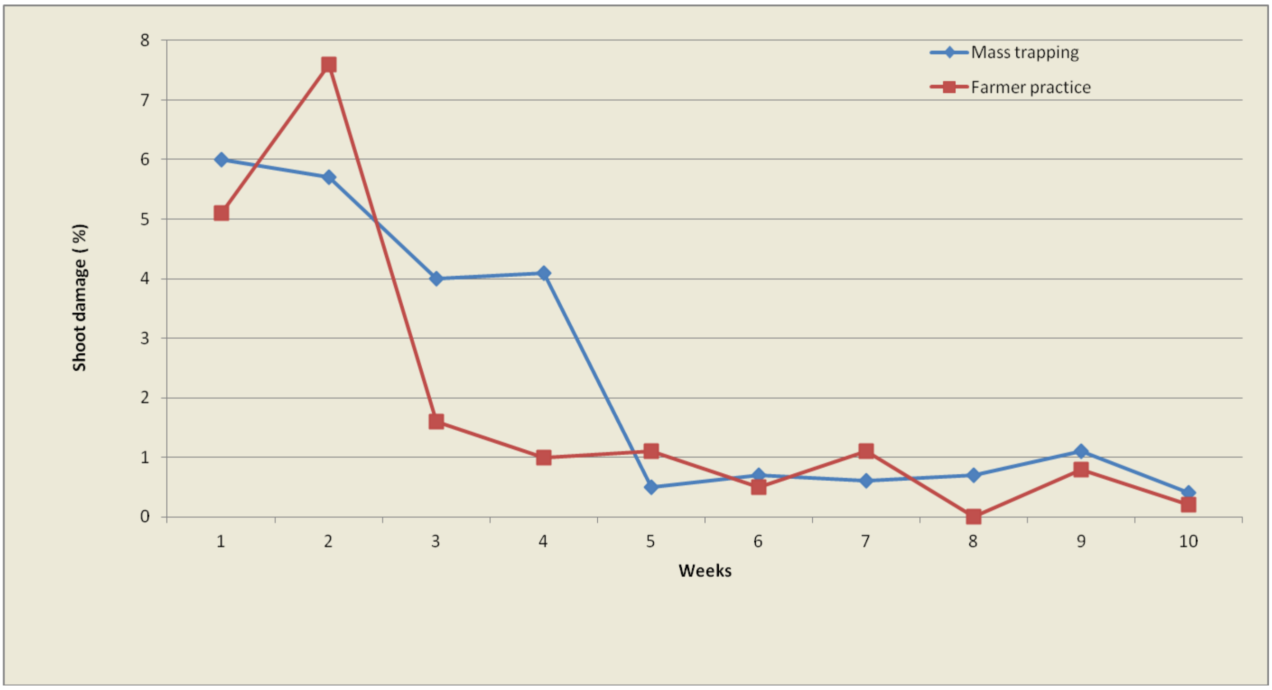


Fig. 8: Comparison of shoot damage due to *Leucinodes orbonalis* under mass trapping with farmer practices

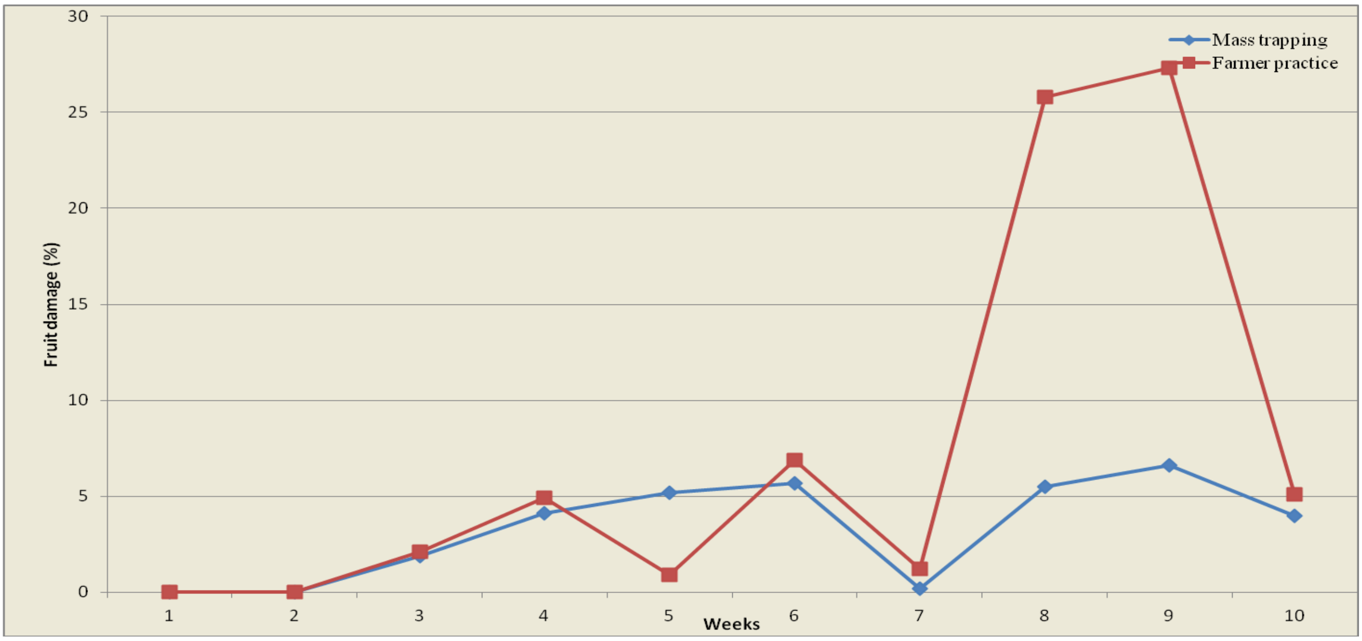


Fig. 9: Comparison of fruit damage due to *Leucinodes orbonalis* under mass trapping with farmer practices

IMAGES

a. Water trap

Plate 1a Different trap designs used in the experiment

b. Delta sticky trap

Plate 1b Different trap designs used in the experiment

c. Funnel trap

Plate 1c Different trap designs used in the experiment

d. Cross winged trap

Plate 1d Different trap designs used in the experiment

e. Fligh T trap

Plate 1e Different trap designs used in the experiment

a. Location: Haveli, Bagalkot

Plate 2a General view of the experimental plots

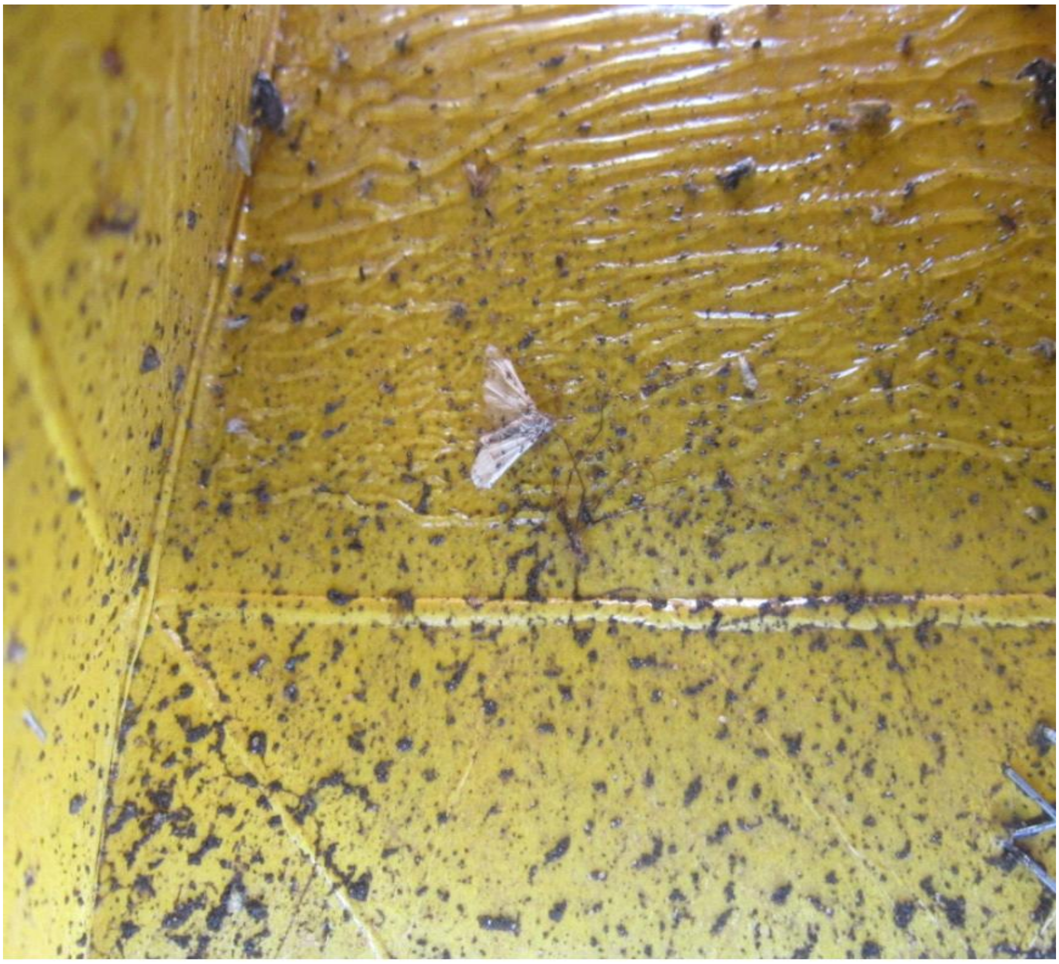
b. Location: Kadampur, Old Bagalkot

Plate 2b General view of the experimental plots

Plate 3 Pheromone lures of Leucinodes orbonalis used in the experiment

Funnel trap

Plate 4a Leucinodes orbonalis male moths trapped in different traps



Delta sticky trap

Plate 4b Leucinodes orbonalis male moths trapped in different traps

Water trap

Plate 4c Leucinodes orbonalis male moths trapped in different traps

Plate 5 Field view of mass trapping experiment at Simikeri, Bagalkot

Plate 6a Brinjal fruit damage due to Leucinodes orbonalis

Plate 6b Brinjal fruit damage due to Leucinodes orbonalis

Plate 7 Brinjal shoot damage due to Leucinodes orbonalis

Plate 8 Leucinodes orbonalis male moths trapped in water trap in mass trapping

Appendix I: Weekly Temperature, Relative Humidity, Rainfall and Wind speed prevailed during study period from February to April, 2014 at Bagalkot

Weeks	Temperature (°C)		Rain fall (mm)	Relative Humidity (%)		Wind speed (km/h)
	Maximum	Minimum		Morning	Evening	
06/02/2014 to 20/02/2014	31.50	17.50	0.00	46.60	18.90	8.60
20/02/2014 to 07/03/2014	32.40	19.40	0.20	51.90	22.60	7.70
07/03/2014 to 14/03/2014	32.50	18.50	0.50	38.0	17.40	10.70
14/03/2014 to 21/03/2014	31.40	17.20	0.00	54.20	17.80	10.10
21/03/2014 to 28/03/2014	30.40	17.10	0.00	55.10	24.10	9.710