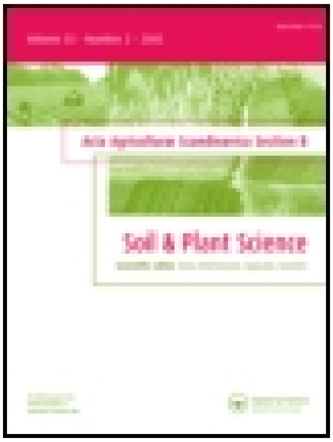



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# Determination of sex pheromone traps distances in control of spiny bollworm, Earias insulana Boisduval. (Lep.: Noctuidae) by mass trapping method in cotton fields

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ORIGINAL ARTICLE

# Determination of sex pheromone traps distances in control of spiny bollworm, *Earias insulana* Boisduval. (Lep.: Noctuidae) by mass trapping method in cotton fields

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Spiny bollworm, *Earias insulana* Boisduval. (Lep.: Noctuidae), causes huge losses to cotton crops each year. As a relatively hardy species of insect, *E. insulana* tolerates a wide range of environmental conditions and so is prevalent in many regions of the world. Effect of sex pheromone traps to control spiny bollworm by mass trapping method was studied. Investigation of monthly changes in captures in relation to temperature carried out during 2012 in the Darab region of the Fars Province of Iran. The experiment was carried out in randomised complete blocks design with four treatments and four replications. The treatments used application of the sex pheromone trap at the rates of 16, 20, 24 and 30 traps/ha. The captured male moths were collected and counted every three days. Analysis of the variance of results showed significant differences between time and trap number in the trapping values of *E. insulana*. Moth populations were observed in the second week of September. The highest and lowest captured insects per hectare were 30 and 16 traps/ha, respectively. The peak captured *E. insulana* adult males in the sampling period was on 18 November. These results enable forecasting of seasonal *E. insulana* population peaks, providing additional information vital for the development of a successful, integrated pest-management programme for spiny bollworm.

**Keywords:** *Earias insulana*; cotton; sex pheromone trap; mass trapping; Darab; Iran

## Introduction

Cotton, the world's major fibre crop, is perhaps unique in the broad nature of the insect attack to which it is subjected, and the control of cotton insect pests remains an unabated challenge (Johnstone 2006). Iran has 214,000 hectares of cotton cultivation (Bayat Asadi & Arab Salmani 2005), and presently cotton is grown in 18 provinces (Yazdani Khorasgani & Hoseinibay 2007). The Darab region is the largest producer area of cotton in southern Iran. The cotton produced in this region is of high quality in terms of colour, elegance, strength and other characteristics (Raiegan 2012).

The spiny bollworm, *Earias insulana* Boisduval. (Lep.: Noctuidae) is a serious cotton pest in Africa, the Mediterranean region and eastward to Malaya (Kehat & Gordon 1977). To control this pest, farmers rely heavily on insecticides, whose application is often based on inaccurate pest scouting. Since the larvae of *E. insulana* penetrate the bolls soon after hatching, and are then difficult to control, early detection of the pest is key to its effective management. Pheromone traps can be used as an effective tool for finding early adult populations (Cohnstaedt et al. 2012; Devetak et al. 2014) or as a warning device to detect the attack potential time (Cruz et al. 2012). Pheromone traps are useful especially as a means of warning of attack potential of the larvae of the pest (Kehat et al. 1981; Cork 2004). The best time of trap setting, the changing time of pheromone capsules, the suitable distance of traps and the height of traps can affect trap efficiency (Ghobari et al. 2009). Use of traps baited with virgin females for monitoring the pest population was described by Kehat and Bar (1975).

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The use of pheromone traps for mass trapping is an insect control method that has been thoroughly researched (El-Sayed et al. 2006; Athanassiou et al. 2007). Mass trapping has also been investigated as a stand-alone approach or, in combination with insecticides, as a control option for pink bollworm in Pakistan, India, Brazil and Egypt (El-Sayed et al. 2006).

In Egypt, season-long control of pink bollworm (*Pectinophora gossypiella* (Saunders)) has been accomplished with three to four applications of the pheromone Gossyplure (Hosny 1988). This has resulted in the abolition of all chemical-insecticide treatments in some pheromone-treated cotton fields and in a reduction of up to three pesticide applications in area. The area of cotton treated commercially with *Pectinophora* pheromone is continually rising in Egypt; in 1986 about 20,000 hectares were treated with three formulations (Hosny 1988). Krishnaiah (1986) reported on the use of pheromone traps for both monitoring and mass trapping of males of *Spodoptera litura* Fab. on cotton. Based on the relationship between captures and larval incidence/damage, mass trapping of males over a 240-ha area at a rate of 5 trap/ha was found to be promising in the suppression of the pest and reducing insecticide usage. Mass trapping of the Egyptian cotton leafworm (*Spodoptera littoralis* Boisd.) with its sex pheromone for four consecutive years (1976–1979) resulted in a 20–45% reduction in treatments, together with reduction in the number of egg clusters and egg viability in treated fields as compared to control, on vast areas of thousands of hectares (Teich et al. 1985). Mass trapping of the pest in cotton fields in Israel is now part of the integrated control. In Pakistan, season-long control of the cotton pests including *P. gossypiella*, *E. insulana* and *Earias vittella* was achieved by disruption of mating with a saving of up to five applications of insecticide per season (Cork & Hall 1998).

(*E,E*)-10, 12-Hexadecadienal (HDD) was identified as a sex pheromone component of *E. insulana* (Hall et al. 1980). This was confirmed by field studies in which a funnel trap baited with 1–3 mg HDD dispensed in a polyethylene vial was found to be suitable for capturing *E. insulana* males (Kehat et al. 1981). Because the number of sex pheromone traps is the main factor for success, the objective of this study was to evaluate the effect of different trap densities on the number of male *E. insulana* captured.

## Materials and methods

### Pheromone trap catches

Pheromone traps were installed from 1 September in an experimental field at Darab Agricultural Research Station, Fars Province, Iran (1110 m a.s.l., latitude 28°29′N, longitude 54°55′S). Sex pheromone used in the experiment was provided by the TRIPHERON Company, Germany, with a concentration of one milligram of pheromone per capsule. Traps comprised plastic containers (funnel trap with 12 cm diameter, 20 cm height), funnels (3.5 cm diameter) and pheromone dispensers (inside centre of plastic roof). Potassium cyanide was used inside the container to kill the trapped males. Pheromone dispensers were replaced every four to five weeks. The experiment consisted of four treatments in a randomised block design with four replications. The dimensions of each block were 100 × 50 square metres in rectangular form; there was a distance of 20 m between each of the treatments and a minimum of 10 m between traps. To minimise the effects of possible interference fringes and proximity, distance between each of the treatments was 20 m, and the central lines of each treatment were used for the sampling. The treatments involved application of the sex pheromone traps at the different densities 16, 20, 24 and 30 traps/ha. Traps were re-baited at one-month intervals. Traps were located on the highest part of the plant at a height of 1 m, approximately, and at a detected distance in the field. The captured male moths were collected and counted every three days.

The percentage of infestation was determined weekly, counting 100 infected bolls and buds in total. So far, no other pest species except *E. insulana* has been reported in the cotton fields of the region, and no damage observed from other species of *Earias*. However, if damage by any other species of Noctuidae moths, like *Helicoverpa armigera*, was detected, after examination, the contaminated plants were separated. The damage and infestation levels of bolls and buds on each of the components were analysed, and percentage of infected bolls and buds was calculated using the fallowing formula:

$$\frac{N-i}{N} \times 100 = I$$

$I$ = Infestation level
$N$ = Total number of counted bolls and buds
$i$ = Number of infected bolls and buds

### Statistical analysis

The data were analysed using the analysis of variance (ANOVA) technique ($P < 0.05$) after checking for normality. Means were compared by Duncan's multiple range test (Steel & Torrie 1984) admitting significant differences at $P < 0.05$. SAS software was used for all analyses (SAS Institute 1997).

The means were converted into graphics for easy comparison between dates, population of moths and temperature.

## Results

### *Moth population*

Previous studies showed that the developmental growth period of pest took a month in the summer, an average of 60–50 days in spring and autumn and lasts four months in winter. On average, there are 6–8 generations per year (Hajatmand 2013). Population fluctuations of the spiny bollworm, *E. insulana*, throughout the year are shown in Figure 1. As can be seen, adult moths emerge from pupa in late March and early April. In this period of time, due to lack of host plants such as cotton, the pest lives on weeds such as common mallow (*Malva sylvestris* L.) and marshmallow (*Althaea officinalis* L.) and cotton fields are then attacked in May and June. Because in this period of the growing season cotton plants are without flowers and bolls, they are attacked in the terminal buds of cotton. With the sharp rise in temperature in the second half of July and August, insect activity stops, and with the decreasing of the temperature, it begins in September again and gradually the population increases. At this time of year, because of the flowers and the freshness of young bolls of cotton plants, damage is considerable; in fact, reproduction of the spiny bollworm is activated in this period and continues until the end of harvest time. In November, pest population in cotton fields is maximised; with decreasing temperature and the cold weather of December, the population is reduced again. Other causes of depopulation are reduced vitality, harvesting and reduction in numbers of attacked host plants. In the months of January and February, pupae remain in plant debris; from late March, adult moths will appear.

ANOVA for the mean number of moth's captured/trap/night showed highly significant ($P < 0.01$) correlation between sampling dates and trap density (Figure 2). The results also showed that the highest moth population occurred in the third week of November. The number of traps per hectare over time did not interact with the number of insects caught per hectare.

A steady increase in population from September through November was detected by pheromone traps located in the field (Figure 2). Only a few males were trapped by late August; their number increased rapidly in early September, was high for a relatively short period and slightly decreased in early October. This adult peak was followed by larval infestation. In this case, pheromone traps not only detected an early moth population but also indicated potential infestation by larvae. The highest adult peak was recorded during the middle of November, although many males were captured subsequently, during late November. Rate of captures on 18 November was 17.12 times greater than at the beginning of the season, reached maximum and then reduced in the end of the season. The maximum number of captures was in October when the average monthly temperature was 25°C; with decreasing temperature, the rate also decreased.

Captures of male moths in different months of sampling and density of traps per hectare are shown in Figure 3. In all traps, the trend pattern of population increase and captured moths was similar; thus, the lowest rate of male captures was in September and the maximum was in November; it was reduced again in December. *E. insulana* captures increased as the trap density increased (Figure 3). Densities of 24 and 30 traps/ha captured a significantly higher number ($P < 0.05$) of males than the 16 and 20 traps/ha density. However, between the higher density traps (24 and 30 traps/ha), the mean

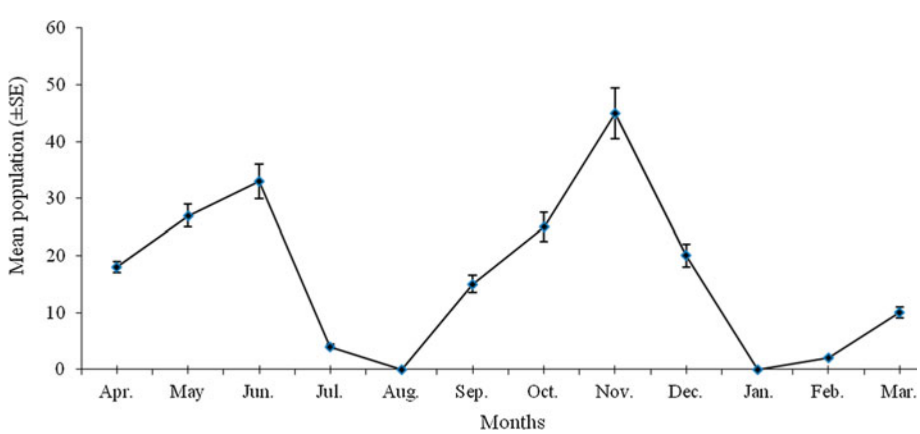


Figure 1. Seasonal changes in adult population (mean ± SE) of the spiny bollworm, *E. insulana,* in different sampling times in 2012.

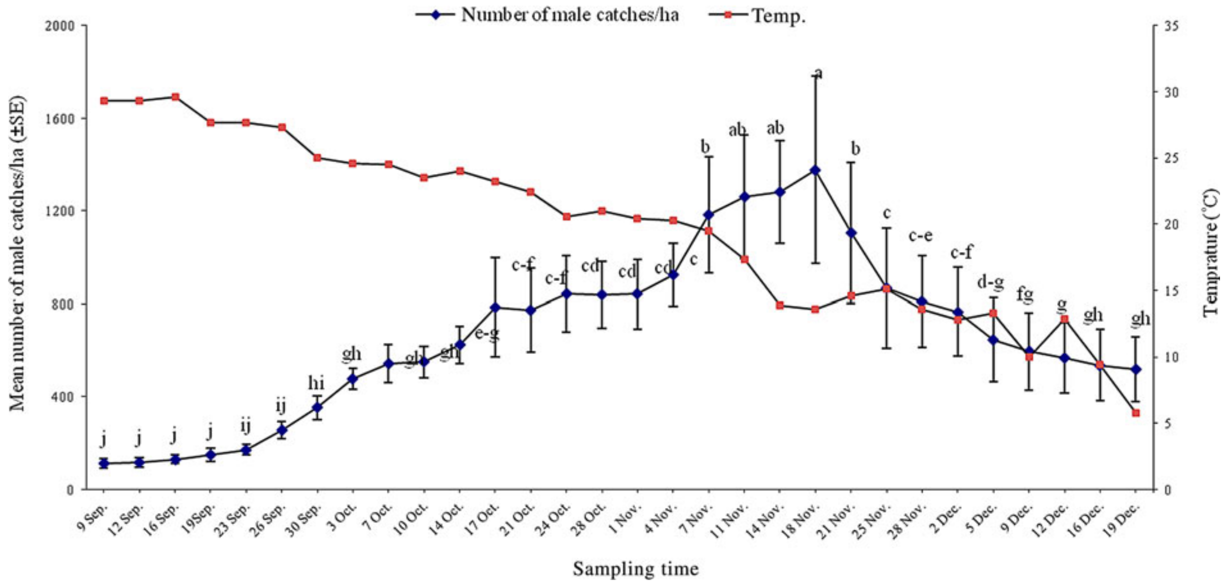


Figure 2. Monthly catches of spiny bollworm, *E. insulana* (mean ± SE), in relation to average daily temperature in different sampling times in 2012. Small letters on the each data point showed significant difference between sampling dates.

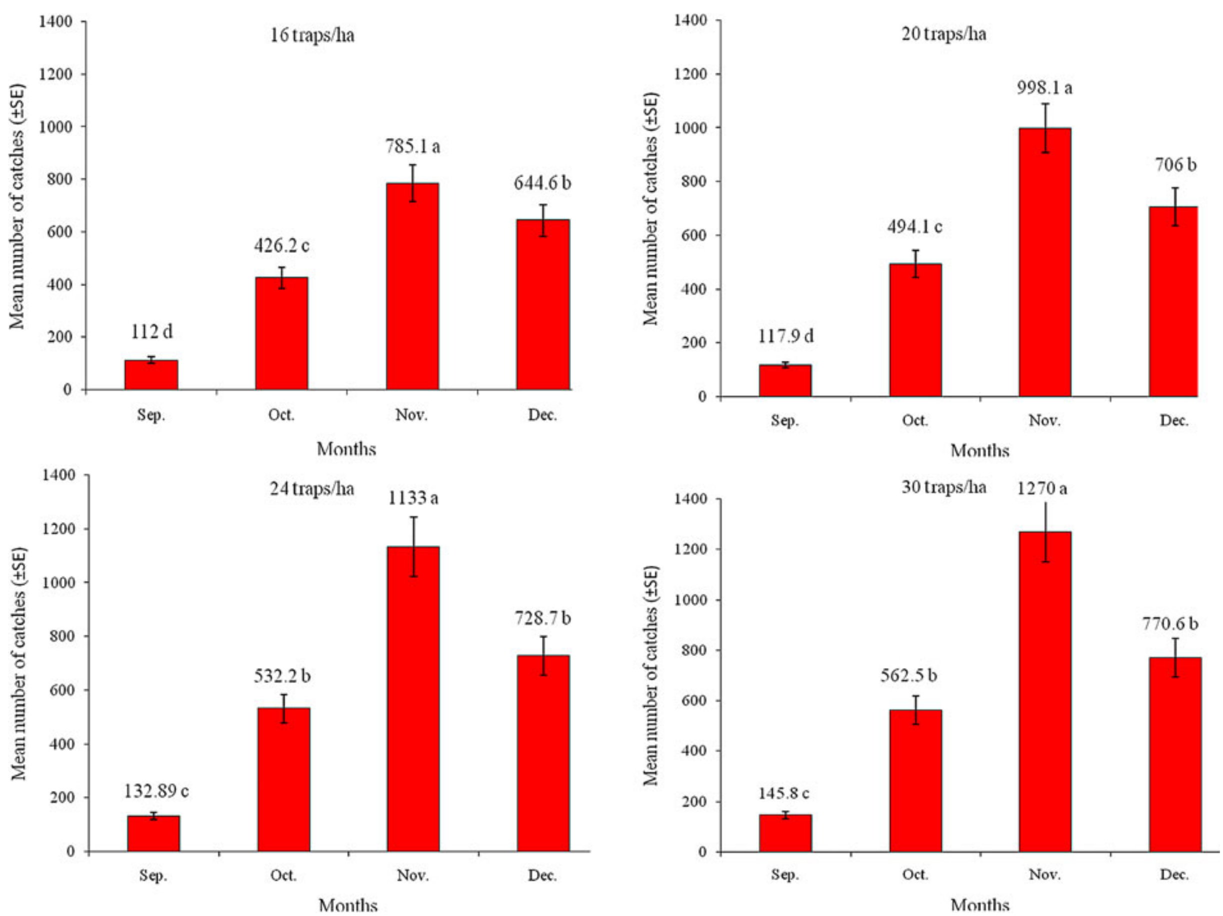


Figure 3. Influence of season on the occurrence of spiny bollworm, *E. insulana,* male adults in different trap density treatments (traps/ha) in sampling months in 2012. Small letters on the bars showed significant difference between different months in each treatment.

of males captured in November was significantly different, especially in certain months ($P < 0.05$). The mean of males captured per hectare indicates that approximately 1270 and 1133 males were captured with densities of 30 and 24 traps/ha, respectively.

Monthly captures in different treatments of pheromone traps are shown separately in Figure 4. As can be seen in this figure, the amount of capture in September and in 16 traps/ha was 112, and in the treatments of 20, 24 and 30 traps/ha there were 117.9, 132.89 and 145.8 males, respectively. In October and in the treatments of 16, 20, 24 and 30 traps/ha, there were 426.2, 494.1, 532.2 and 562.5 males, respectively. Male capture by pheromone traps in November increased significantly, but the trend pattern of male density in each of the treatments was similar. In the treatments of 16, 20, 24 and 30 traps/ha, there were 785.1, 998.1, 1133 and 1270 males, respectively. Male captures in December were reduced significantly – there were 644.6, 706.8, 728.7 and 770.6 males, respectively. In total, highest capture was observed in November and in the treatments of 24 and 30 traps/ha. Male captures in these two treatments were not significantly different.

Changes in percentage of infestation showed that infestation was up on 18 November; after that, because of cold weather and reduction in green cotton field, it declined (Figure 5). At this time, percentage of infestation increased 7.4 times compared to the beginning of the season and was placed in the highest statistical group. Infestation percentage at the end of the season was 3.6 times that at the beginning. The lowest infestation was observed at the beginning and end of the season, with no statistically significant differences.

Total infestation level in the growing season showed the highest percentage of infestation was related to control treatment (Figure 6). Use of pheromone traps was highly reduced in the high levels of infestation. The lowest infestation levels were occurred in the treatments of 30 and 24 traps/ha and statistically were placed together in a group. By reducing the number of traps, infestation rate was increased, so that the rate of infestation in the

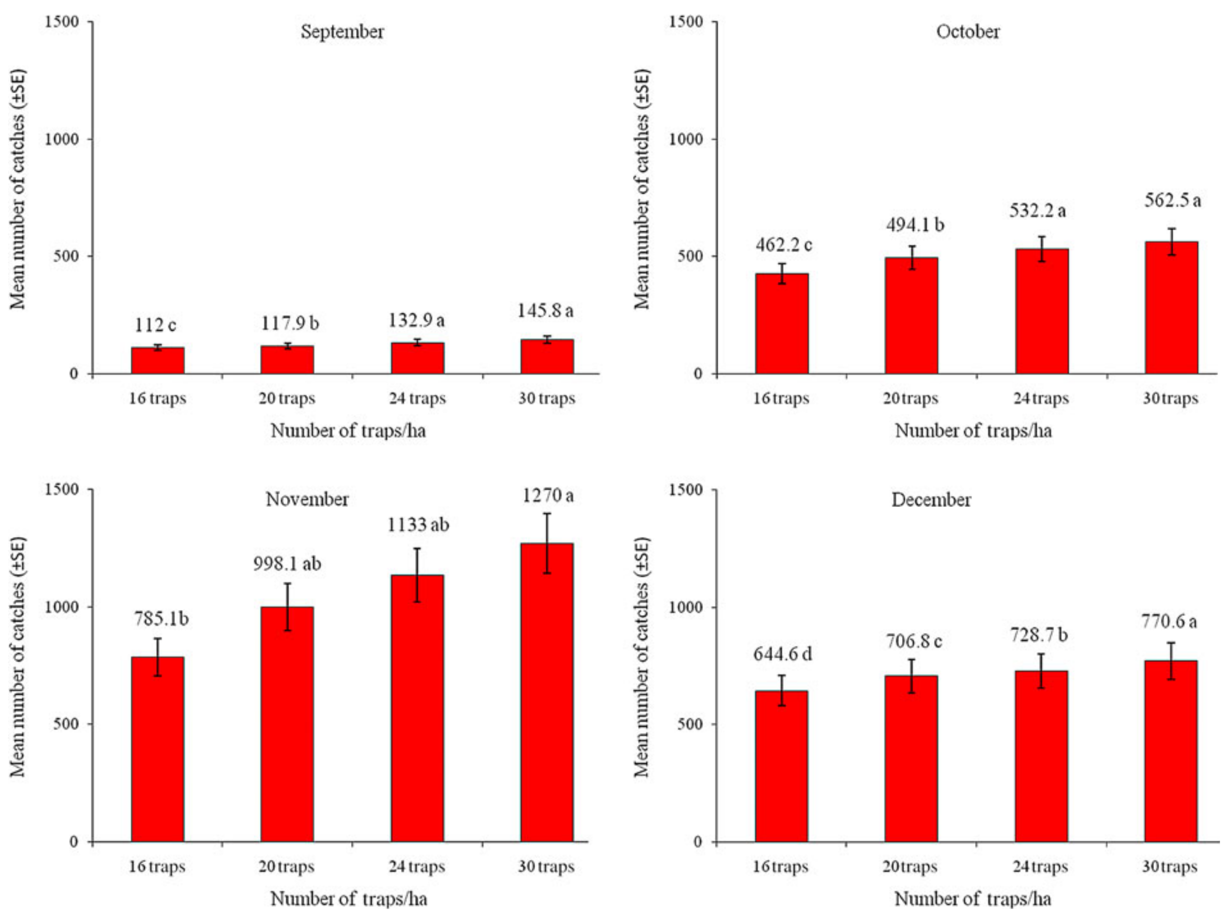


Figure 4. Influence of different trap density (traps/h) on the occurrence of spiny bollworm, *E. insulana*, male adults in different months of sampling in 2012. Four trap densities (trap/ha) were used for each month. Small letters on the bars showed significant difference between different trap densities in each month.

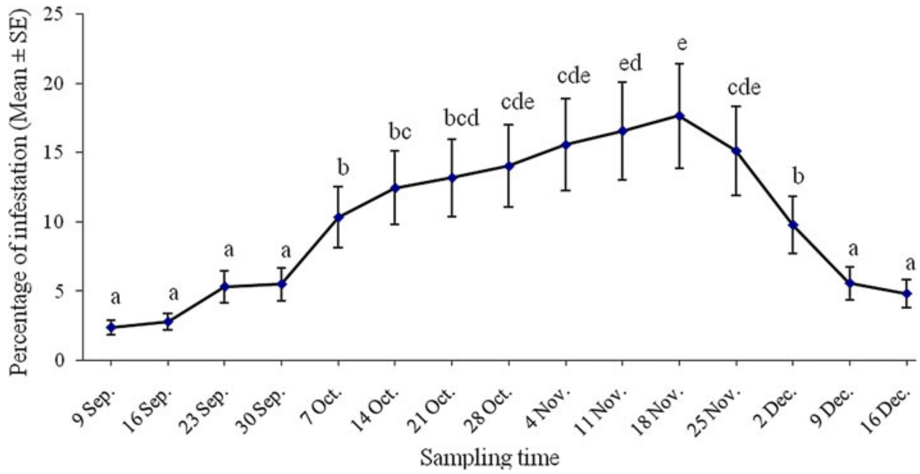


Figure 5. Percentage of infestation (mean ± SE) of cotton to the spiny bollworm, *E. insulana*, in different sampling times in 2012. Small letters on the each data point showed significant difference between sampling dates.



treatment of 16 traps compared to 30 traps, 33.8%, was increased. Trapping efficiency was greatest in the period of November, when infestation level was high and adult moth numbers were high (Figure 4). The trapping efficiency was lowest in September when the crop was in flower flush and moth numbers were low (Figure 4). The sharp drop in trapping efficiency at the end of the season corresponded with falling temperatures. The mass trapping technique applied to the cotton crop maintained the infestation rate of bolls at an acceptable level of around 1–3% (Figure 6).

## Discussion

The captures of male moths by use of pheromone traps during the experimental period began in September, increased in October and reached the maximum in November; captures decreased from December onwards. The causes of this reduction were the drop in temperature and absence of green host plants. Studies in cotton fields in Egypt during 1988 to determine the efficacy of HDD sex pheromone for detecting spiny bollworm showed that three factors, wind speed, temperature and humidity, were effective in pest control, so that when the wind speed was 6.95 metres per second, the temperature 18.6°C and relative humidity was 65–70%, maximum moth captures occurred (Salem et al. 1990). The results showed that despite reaching the end of the growing season and harvesting time the number of captures never reached zero. Because at harvest time there are still flowers and immature bolls that are not harvestable, a field remains a suitable location for the activity of the last generation of the pest. In fact, the existence of weeds and wild hosts like wild *Hibiscus* is another factor that can attract pests to traps (Javanmoghadam et al. 2002).

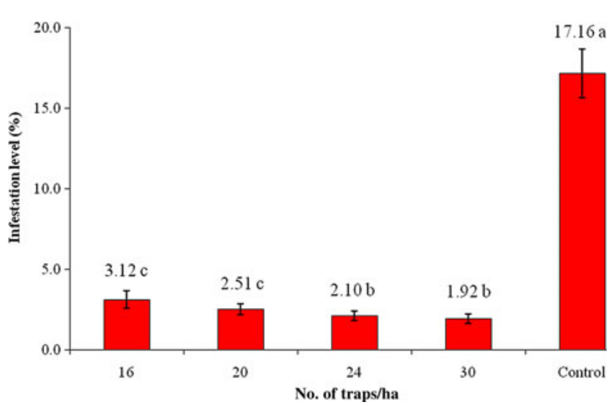


Figure 6. Influence of different trap density (traps/h) treatments compared to control on percentage of infestation to the spiny bollworm, *E. insulana,* in 2012. Small letters on the each data point showed significant difference between different treatments.

The correlation between the number of captures per hectare and the number of traps was positive and significant; by increasing the number of traps, the total amount of captures could be increased – although the rate of capturing per trap was reduced. Although various factors such as population density, temperature, humidity, wind and pheromone formulations and purity affect trap impact, traps' density and distance from each other are key factors in the efficiency of this control method (Batcu & Nastase 1996). It seems that whenever the number of traps per hectare is increased, or in other words, the distance between traps is decreased, the amount of overlapping smell that comes from the pheromones is increased, which causes more attraction for male moths, which are then captured. This causes reduction in fertility, and therefore the rate of flower and boll infestation by spiny bollworm is reduced. In contrast, in treatments where the number of traps is reduced, the amount of captured male moths is reduced, and as a result the rate of infestation increases. Changes in temperature and green surface crop are effective factors in increasing the amount of insect captures per hectare (Amin & Monsef 1994). Generally, it is concluded that, although the treatments 24 and 30 traps/ha were the best treatments for capturing of the pest and reducing the rate of infestation, in terms of insect captures and rate of infestation, and considering the economic aspects and related costs, 24 pheromone traps per hectare seem the best practical option for control of the pest.

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## Disclosure statement

No potential conflict of interest was reported by the authors.



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