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Research Article

Effectiveness of IPM strategies against eggplant shoot and fruit borer *Leucinodes orbonalis* (Lepidoptera: Crambidae)

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Abstract: *Leucinodes orbonalis* (Guenee) inflicts considerable damage on eggplant. In the present study farmers' practice (Regime 1: Repeated use of different insecticides *viz.*, Cypermethrin, Monocrotophos, Chlorpyriphos and Triazophos once or twice at weekly intervals) was compared with two IPM regimes, during 2010-12. The IPM regimes were: 1) Regime 2: weekly shoot clipping of infested twigs at the time of infestation along with installation of pheromone traps at 100/ha (lure was changed at 25 days intervals); and 2) Regime 3: weekly shoot clipping of infested twigs at the time of infestation along with installation of pheromone traps at 100/ha (lure was changed at 25 days interval) and need based application of NSKE at 4% and cartap hydrochloride at 1 g/l. The least fruit damage (20.46%) was observed in regime 3. With this IPM regime, the fruit damage was prevented by 35.01 to 36.18% and 22.87 to 23.33% additional yield was recorded over the regime relied upon only chemical pesticides. An additional income of USD $ 1064.22/ha was also obtained in open pollinated and USD $ 1799.35/ha in hybrid cultivars with a 10 to 11 times reduction of chemical sprayings in the regime 3. The selected regime not only reduced the total cost of crop production but also increased the net return per unit area. The IPM programme (regime 3) that consisted of cultural, mechanical and chemical components was proved to be an ideal management strategy against eggplant shoot and fruit borer along with a benefit: cost ratio of 3.65 to 4.27.

Keywords: Cartap hydrochloride, eggplant shoot and fruit borer, IPM, NSKE, pheromone trap

Introduction

Eggplant *Solanum melongena* L. is one of the most important solanaceous vegetable crops in the Indian sub-continent (Srinivasan and Huang 2008). It is also known as brinjal and as poor man's crop. It contributes about 8.12% of the total vegetable production and about 8.0% of the total area under vegetables in India (Indian Horticulture Database 2011). A sizeable damage, about 40% of the total production, during the entire growth period of the crop is caused by some insect pests. The eggplant shoot and fruit borer (ESFB), *Leucinodes orbonalis* (Guenee) (Lepidoptera: Crambidae) is recorded as the principal pest on *Solanum melongena* L. (Solanaceae). It also attacks other species of *Solanum* such as *S. indicum, S. tubersoum* and *S. xanthocarpum* much less seriously. *L. orbonalis* has a worldwide distribution in many countries viz., China, Japan, Burma, Sri Lanka, India, Nepal, Pakistan and much of Southeast Asia including Indonesia and Philippines (Hayden *et al.*, 2013). The origin of this pest is South Asia.

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It is the most devastating pest in India as it inflicts considerable damage in almost all eggplant growing areas (Sardana *et al*., 2004). It is a cosmopolitan pest in the Indian subcontinent and causes 20.70 to 88.70% fruit infestation in various parts of India (Raju *et al.,* 2007; Haseeb *et al.*, 2009). The Larvae cause serious damage to shoots during the early growth period and to fruits, which not only hampers the scale of marketable fruits but also reduce the income during prolonged harvesting period (Alam *et al.*, 2003). The Larvae bore into young shoots and feed on internal tissues. Zig-zag galleries due to feeding are often clogged with frass and cause wilting of the shoot which reduces plant growth and the number and size of the fruits (Atwal and Dhaliwal 2007).

Farmers usually spray insecticides *viz*., Cypermethrin, Monocrotophos, Chlorpyriphos and Triazophos once or twice at weekly intervals to control the ESFB. In India According to Alam *et al*. (2006), more than 95% of the farmers applied more than 40 sprays per season (in Gujrat) and 86% sprayed their crops twice or three times a week (in Uttar Pradesh) against eggplant shoot and fruit borer. Sole reliance on chemicals for the control of *L. orbonalis* made eggplant cultivation uneconomical and also caused residual toxicity (Chandra *et al.*, 2014). Even novel insecticides fail to produce blemish free fruits due to the development of resistance in recent years (Kabir *et al.*, 1996). Srinivasan (2008) advocated that IPM strategy for the control of *L. orbonalis* consisted of resistant cultivars, sex pheromone, cultural, mechanical and biological control methods. Although use of the resistant cultivars is one of the major elements in any IPM program there has been no commercial cultivar developed with resistance to ESFB in this region (Srinivasan, 2008). Screening programs have been conducted to develop resistant cultivars in India with few dozens of eggplant accessions but these programs ended with few or none as resistant to ESFB (Darekar *et al.*, 1991; Singh and Kalda, 1997; Behera *et al.*, 1999; Doshi *et al.*, 2002). The lack of any natural source of resistance to ESFB in all cultivated species and conventionally cross compatible species of eggplant has been a major obstacle in developing conventional ESFB resistant cultivars (IIVR, 2013). Likewise; the predators, parasitoids and entomopathogens have been recorded against ESFB in South and Southeast Asia but their role is not significant in keeping the ESFB population at levels below causing economic damage (Srivastava and Butani, 1998). Despite serious damaging nature of *L. orbonalis*, its control tactic by and large is limited to frequent sprays of chemical insecticides in this region. Such practices of insecticides usage is detrimental to the environment, also increases the chances of insecticide residues in the fruit. Considering the principles of Integrated Pest Management (IPM), the present study was undertaken with the objective to investigate the effectiveness of IPM programs (weekly shoot clipping of infested twigs at the time of infestation along with installation of pheromone traps at 100/ha and in addition to it need- based application of NSKE at 4% and cartap hydrochloride at 1 g/l) against *L. orbonalis* under field.

Materials and Methods

Details of IPM regimes assessed against ESFB

The different insecticides are the only control measures adopted by farmers (Regime 1). To find out a safe, effective, economical and sustainable strategy for the management of *L. orbonalis*, two IPM regimes were formulated on the basis of researches conducted by Chakraborti (2001), Sardana *et al.* (2004), Satpathy *et al.* (2005); Chaterjee (2009).

Regime–1 (R1):	Repeated use of different insecticides *viz*., Cypermethrin, Monocrotophos, Chlorpyriphos and Triazophos once or twice in weekly intervals (Farmers' usual practice over the area of study).
Regime–2 (R2):	Weekly shoot clipping of infested twigs at the time of infestation along with installation of pheromone traps at 100/ha (lure was changed at 25 days intervals).
Regime–3 (R3):	Weekly shoot clipping of infested twigs at the time of infestation along with installation of pheromone traps at 100/ha (lure was changed at 25 days interval) and need based application of NSKE at 4% and cartap hydrochloride at 1 g/l in alternate manner.

Pheromone trap

Pheromone traps were installed 20 days after transplanting (in September-vegetative stage of the crop) at 100 traps per hectare at a distance of 10 × 10 m. Commercial lures of *L. orbonalis* were obtained from Pest Control India Ltd. (PCI) ®. Traps were erected inside the field in such a way that lure was placed at 30 cm above the crop canopy.

Neem seed kernel extract (NSKE)

NSKE was prepared at 4% and tested against *L. orbonalis*. To prepare 4% NSKE, dried neem seed kernels were grinded. Eight hundred gram of grinded material was put into a double layered muslin cloth that was then secured with a tying material. The material inside the muslin cloth was placed into 10 litres of water for 24 hours. The material inside the muslin cloth was kept loosely enough that water could penetrate inside easily. After 24 hours, the material was taken out and squeezed thoroughly in to the same container and water was added to bring the total volume up to 20 litres for a 4% solution. In a similar manner, the desired quantity of NSKE was prepared to cover the selected area to be sprayed.

Cartap hydrochloride

The active ingredient cartap hydrochloride is under the insecticide group 'Carbamate' with the commercial name Padan® 50 WP (Coromandel Agrico Pvt. Ltd., New Delhi) at 1.0g l^{-1} was tested.

Location of the study

The study was conducted in 0.125 ha area located in Bhadohi ($82^0$56' east longitude and $25^0$40' north latitude). The climate was hot and humid in summer and cold and dry in winter with an in between rainy season. The temperature in the area ranged between 5 ºC to 46 ºC and an annual rainfall of 1563 mm was reported (Singh *et al.*, 2008).

Field trials

Seedlings of eggplant were planted on raised beds in the first week of July. Improved open pollinated variety BR-14 and hybrid Kashi Sandesh (both developed by the Indian Institute of Vegetable Research, Varanasi) were grown in the field to test the fitness of the IPM regime. Effectiveness of BR-14 and Kashi Sandesh were tested during 2010-11 and 2011-12, respectively, due to their popularity among the farmers (Rai *et al.*, 2005). The seed bed was lightly irrigated regularly for ensuring proper growth and the development of the seedlings. Thirty to thirty five day old seedlings were transplanted in the second week of August with a distance between row to row and plant to plant of 90 × 75 cm in BR-14 and 90 × 90 cm in Kashi Sandesh (according to size of canopy of foliage). All the agronomic practices were similar for three assessed regimes. The weeds were removed mechanically twice at 30 and 60 days after transplanting with a small spade. The clipping of infested shoots by hand was initiated once the drooping and drying of twigs took place. The application of insecticides was done by back pack sprayers.

Field trials were conducted in two successive cropping seasons (2010-11 and 2011-12) at farmers' fields. The field trials were carried out in a randomized complete block design with five replications. The unit plot size was 12 × 7 m for each regime where the seedlings were transplanted.

Pheromone traps were used in both R2 and R3 regimes to monitor the number of insects. The traps were installed at a distance of 1.5 m in R2 and R3. However, the trap installed in R1 was 100 m apart from R2 and R3. Here, the present investigation envisaged only assessing the efficacy of R2 and R3, in terms of reduction of fruit damage, yield and economics over farmers' practice (R1) so that a cost effective IPM regime may be developed. The inclusion of the installation of pheromone traps under R2 and R3 was to assess the additive effect along with chemicals and without chemicals in the management of shoot and fruit borer. One trap was placed per unit plot.

Data collection

Since the date of installation of pheromone traps (in September-vegetative stage), the observations of trap catches were recorded at weekly intervals throughout the growing season (ended the last week of March-full maturity of the crop).

Ten plants were randomly selected from each plot and tagged for the periodical observations on fruit damage and yield. Starting with the first picking/harvesting (in the second week of October-initiation of fruiting), healthy and infested fruits were categorized and counted separately from each plot at each harvest (ended last week of March-full maturity of the crop). The infested fruits were marked on the basis of holes burrowed by *L. orbonalis* larvae in the fruits. The number of healthy, infested and total fruits per plant was recorded and percentage fruit damage was estimated throughout the cropping period by using the following formula:

$$Percentage\ of\ infested\ fruits = \frac{Sum\ of\ infested\ fruits\ in\ each\ picking}{Total\ no.\ of\ fruits\ harvested\ in\ each\ picking} \times 100$$

The weight of healthy and infested fruits was recorded separately per plot. The plot yield of each harvesting was recorded as healthy, infested and total yield per hectare in tons. Total yield was calculated by summing the weights of each harvest including the infested fruits, as the infested (with holes) fruits were also marketed at lower price.

The data obtained from monthly catches per trap was assessed to determine the abundance of *L. orbonalis*. The trap was installed in the month of September and the lure was changed after 25 days. Considering the days to change of lure, month wise catches per trap were presented. To know about the minimum and maximum activity of *L. orbonalis*, the difference between months was statistically analyzed (month as a treatment). The observed monthly catches per trap under the regimes R2 and R3 were utilized only to know the monthly abundance of shoot and fruit borer.

The yield of healthy and infested fruits was recorded separately and converted into marketable yield (t/ha). To justify the economic viability of the appropriate regime management against *L. orbonalis*, the benefit: cost (B: C) ratio was calculated from the marketable yield, regarding cost of treatments incurred in the regime management. The market price of eggplant fruits, rate of insecticides and labor cost were undertaken as approved by the Govt. to compute the B: C ratio by using following formula (Baral *et al.*, 2006):

$$BC\ ratio = \frac{Value\ of\ yield\ over\ control\ (USD\ \$\ /\ t)}{Total\ cost\ of\ production\ (USD\ \$\ /\ ha)}$$

The cost of production comprised of two costs: 1) cost of production: including costs for seed, nursery raising, field preparation, transplanting, fertilizer application, irrigation, weeding and harvesting; and 2) cost of crop protection including costs for insecticides, spraying, trap, lures, installation of pheromone traps and replacement of lures and shoot clipping of infested twigs.

To compute the total return, the value of healthy and infested fruits obtained in each regime was calculated separately as per the market rate and by summing both returns total return was obtained. In case of infested fruits, only 40% fruits were marketable in each regime with a quite lower price. The market price of eggplant was at USD $ 78.84/t (farmers' practice), at USD $ 94.61/t (IPM regimes) and at USD $ 31.54/t (bored fruits) during 2010-11. However, the market price of eggplant was at USD $ 86.73/t (farmers' practice), at USD $ 102.50/t (IPM regimes) & at USD $ 31.54/t (bored fruits) during 2011-12. Net return was also calculated by subtracting the total cost from total return.

Statistical analysis

The homogeneity of the data was first tested through chi-square test and then subjected to Analysis of variance (ANOVA). Fisher's protected least significant difference (LSD) or critical difference (CD) test was used to determine the difference between the treatments at the probability level of $P < 0.05$ using the GLM procedure of SAS software for windows (version 9.3).

Results

The effect of different regimes on the damage of fruits was significant during both the years (Table

1). Maximum damage was recorded in R1 (32.06%) followed by R2 (27.03%) and R3 (20.46%), respectively, during both years. However, there was 15.69% fruit damage prevented over farmers' practice in R2 and 36.18% in R3 during 2010-11. Similarly, damage of fruits caused by *L. orbonalis* was maximum (31.48%) in R1 and minimum (20.46%) in R3 with a 19.57% in R2 and 35.01% prevention in R3 during 2011-12. Intensity of fruit damage was higher in 2010-11 in R1 and R2, but was identical in R3 during both the years.

The lure was replaced on monthly basis that is why per trap monthly catches of *L. orbonalis* from September to February were presented in Figure 1. The trend of population fluctuation was studied with the trap catches of *L. orbonalis*. During 2010-11, the highest (5.40) trap catch was recorded in October and the lowest (2.60) was recorded in January. There was a marked decrease in trap catch in December but was statistically superior to September, February and January (P = 0.25 and 0.29). In addition, there was negligible difference in trap catches of September and February. During 2011-12, the maximum (5.25) catch was recorded in November followed by October and December.

There was a significant effect of different regimes on yield during both years. In 2010-11, a maximum yield of 37.00 t/ha was recorded in R3 followed by R2 (32.82 t/ha) and R1 (30.00 t/ha) with an additional gain over R1, 9.40% in R2 and 23.33% in R3. However, R3 was significantly superior to R2 and R1. Similar observations were recorded during 2011-12. The lowest yield was recorded from R1 during both years (Table 2).

Table 1 Fruit damage caused by *Leucinodes orbonalis* and percent prevention over farmers' practice (i.e., R1)**.**

Regimes assessed	2010-11		2011-12	
	Fruit damage (%)	Prevention over farmers' practice (%)	Fruit damage (%)	Prevention over farmers' practice (%)
R1	32.06[a]	-	31.48[a]	-
R2	27.03[b]	15.69	25.32[b]	19.57
R3	20.46[c]	36.18	20.46[c]	35.01
LSD (CD) (P = 0.05)	3.20		3.53	
CV	8.18		9.30	

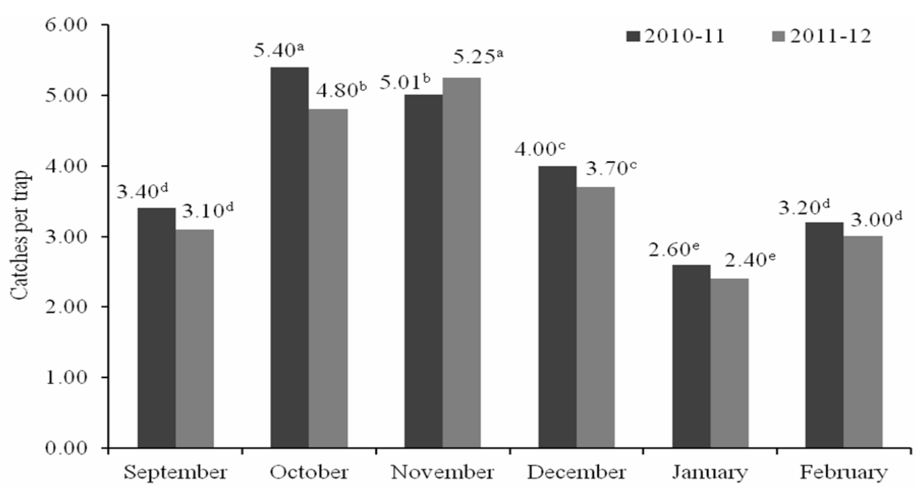

Figure 1 Monthly catches of *Leucinodes orbonalis* per trap.

The total cost incurred with the use of the various agro-technologies was USD $ 701.70/ha in R1 (farmers' practice), USD $ 735.61/ha in IPM regime R2 and USD $ 788.43/ha in IPM regime (R3) during 2010-11 (Table 3(a)). Table 3 (b) shows that the total cost incurred during 2011-12 was USD $ 1067.53/ha in R1 (farmers' practice), USD $ 1051.77/ha in IPM regime (R2) and USD $ 1119.57/ha in IPM regime (R3). Although the total cost in IPM plots were higher than the farmers' plot, however, due to reducing insecticide application and marketable yield the IPM regimes proved to be cost effective. The frequency of sprays was 15 and 17 in the farmers' practice during 2010-11 and 2011-12, respectively, however only 5 and 6 sprays were applied in the IPM regimes during 2010-11 and 2011-12, respectively.

Overall economic assessment for the tested management regimes showed that both years followed similar trend (Table 4). The total return in 2010-11 was USD $ 2879.65/ha (R3), followed by USD $ 2377.58/ha (R2) and by USD $ 1728.70/ha (R1); and in 2011-12 USD $ 4789.69/ha, USD $ 4395.71/ha and USD $ 2938.31/ha for R3, R2 and R1, respectively. The benefit: cost ratio was observed to be higher in R3 (3.65) followed by R2 (3.23) and R1 (2.46) during 2010-11 and R3 (4.27), R2 (4.17) and R1 (2.75) during 2011-12. The highest additional income over R1 (the difference of net return between R3 and R1) was USD $ 1064.22 in open pollinated cultivar and USD $ 1799.35 in hybrid cultivar per hectare by reducing chemical sprays 10 to11 times which also reduced the cost of production and increased net return per unit area.

Table 2 Total marketable yield of eggplant and percent gain over farmers' practice (i.e., R1).

Regimes assessed	2010-11		2011-12	
	Yield (t/ha)	Gain over farmers' practice (%)	Yield (t/ha)	Gain over farmers' practice (%)
R1	30.00^c	-	46.34^c	-
R2	32.82^b	9.40	55.12^b	18.95
R3	37.00^a	23.33	56.94^a	22.87
LSD (CD) (P = 0.05)	0.92		1.03	
CV	1.89		1.34	

Table 3 (a) Economic parameters of field trials during 2010-11.

Agro-technologies	IPM regimes		Farmers' practice	
	Cost incurred (USD $)	Unit	Cost incurred (USD $)	Unit
Field preparation	44.15	Four ploughings	44.15	same
Seed (BR-14)	3.94	500 g	6.31	same
Nursery raising	15.77		15.77	
Transplanting	47.31		47.31	
Fertilizer	31.54	120:60:80 (N:P:K)	34.69	160:60:0 (N:P:K)
Irrigation	88.30	8 times	88.30	same
Weeding	126.15	2 (40 labours/ha)	126.15	same
Harvesting	126.15	20 (Four labours/ha/picking)	126.15	same
Cost of insecticides	37.05		165.57	
Cost of spraying	15.77	5 (Two labours/ha)	47.3	15 (Two labours/ha)
Cost of traps	47.31	100		
Cost of lures	94.61	600		
Installation of pheromone trap	1.58	100 (One labour/ha)		
Lure replacement	7.88	5 (One labour/ha)		
Shoot clipping of infested twigs	100.92	32 (Two labours/ha)		
Total cost	788.43		701.70	

* Cost of labour at USD $ 1.58/day

Table 3 (b) Economic parameters of field trials during 2011-12.

Agro-technologies	IPM regimes		Farmers' practice	
	Cost incurred (USD $)	Unit	Cost incurred (USD $)	Unit
Field preparation	50.46	Four ploughings	50.46	same
Seed (Kashi Sandesh)	6.31	400 g	26.81	same
Nursery raising	18.92		18.92	
Transplanting	70.96		70.96	
Fertilizer	93.03	180:80:100 (N:P:K)	78.84	200:60:0 (N:P:K)
Irrigation	126.15	8 times	126.15	same
Weeding	189.22	2 (40 labours/ha)	189.22	same
Harvesting	189.22	20 (Four labours/ha/picking)	189.22	same
Cost of insecticides	39.42		236.53	
Cost of spraying	28.38	6 (Two labours/ha)	80.42	17 (Two labours/ha)
Cost of traps	47.31	100 traps		
Cost of lures	94.61	600 lures		
Installation of pheromone trap	2.37	100 (One labour/ha)		
Lure replacement	11.83	5 (One labour/ha)		
Shoot clipping of infested twigs	151.38	32 (Two labours/ha)		
Total cost	1119.57		1067.53	

* Cost of labor at USD $ 2.37/day

Table 4 Overall economic assessment of field trials.

Year	Benefit: Cost assessments	R1	R2	R3
2010-11	Cost of production (USD $)	488.82	483.31	483.31
	Cost of protection (USD $)	212.88	252.30	305.12
	Total Cost (USD $)	701.70	735.60	788.43
	Total Return (USD $)[1]	1728.70	2377.58	2879.65
	Net Return (USD $)	1027.00	1641.98	2091.22
	Benefit/Cost ratio	2.46	3.23	3.65
2011-12	Cost of production (USD $)	750.58	744.27	744.27
	Cost of protection (USD $)	316.95	307.49	375.29
	Total Cost (USD $)	1067.53	1051.76	1119.57
	Total Return (USD $)[2]	2938.31	4395.71	4789.69
	Net Return (USD $)	1870.78	3343.95	3670.13
	Benefit/Cost ratio	2.75	4.17	4.27

[1] Market price of eggplant at USD $ 78.84/t (farmers' practice), at USD $ 94.61/t (IPM regimes) & at USD $ 31.54/t (bored fruits) during 2010-11.
[2] Market price of eggplant at USD $ 86.73/t (farmers' practice), at USD $ 102.50/t (IPM regimes) & at USD $ 31.54/t (bored fruits) during 2011-12.

Discussion

The management of *L. orbonalis* by using sex pheromones, botanicals and reduced-risk chemicals is the cornerstone of integrated pest management. Tested cultivars, open pollinated and hybrid, are used by farmers (Rai *et al.*, 2005), and performed similarly during the study. Fruit damage percentage was higher and percent prevention against *L. orbonalis* was lower under a continuous series of pesticide applications, i.e., farmers' practice. This might be due to a reduction of the population of natural enemies of *L. orbonalis* and the development of resistance in *L. orbonalis* against different groups of insecticides. In contrast, both of the IPM regimes provided a better level of control than the farmers' practice. The phenomenon partly related to the pheromone trap catch, which may have played a crucial role in preventing the adult *L. orbonalis* mating which leads to a poor egg load on the eggplant crop. The reduced selection pressure of the insecticides used in the IPM regimes might be another reason behind the better control obtained in the IPM regimes. Similar results were obtained by various workers. Sharma *et al*. (2012) reported that shoot and fruit infestation caused by *L. orbonalis* was reduced and marketable yield increased from 0.42 to 0.60 t/ha, when the insecticide sprayings were combined with cultural methods. Likewise; Sardana *et al.* (2004) reported that among 5 different crop protection regimes, the regime comprising of cultural and mechanical and biointensive and chemical was found to be superior over all other regimes to manage *L. orbonalis*. Chakraborti (2001) also studied the effectiveness of biorational integrated approach for management of brinjal fruit and shoot borer. It was found highly effective with 4.92 and 5.32 per cent mean shoot and fruit infestations, respectively. The biorational integrated approach was markedly superior to conventional chemical method when the crop had 20.42 and 25.24 percent mean shoot and fruit infestations, respectively, and suffered only 2 percent yield loss as compared to 50 percent and 45 percent in chemical management and untreated control, respectively. The potentiality of different regimes assessed under the present study is in similar approach.

The findings on trap catches from the present study were supported by the findings of Alam *et al*. (2003) and FAO (2003), who reported that *L. orbonalis* was highly active during the rainy season and the peak population was observed from June to October. The trend might be due to high temperature and relative humidity that favored the pest population. Chatterjee (2009) found similar results to the present study. It was shown that an IPM module consisting of pheromone trap, mechanical removal and botanicals was effective enough to replace the farmers' regular practice of pesticide application as well as an increase of marketable yield. Other workers (e.g., Alam *et al* (2006), Dutta *et al* (2011) and Mathur *et al* (2012) reported similar results.

Application of NSKE and weekly removal of damaged shoot and fruit increased marketable yield due to reduction in pest numbers. Similarly, other workers reported that prompt removal of *L. orbonalis* infested shoots and fruits at regular intervals, either weekly (Alam *et al.,* 2003; Miller *et al.,* 2003) or fortnightly (Rahman *et al.*, 2002; Srinivasan and Huang 2008) was an important component of the shoot and fruit borer IPM strategy (Talekar, 2002; Arida *et al.*, 2003; Satpathy *et al.*, 2005). Murugesan and Murugesh (2009) reported that neem oil and nimbecidine were moderately effective against this pest and gave higher protection and yields than the standard check, i.e., farmers' practice (application of carbaryl at 0.1%). Naitam and Mali (2001) also recorded the least number of fruit borer infestation when applied cartap hydrochloride and monocrotophos.

Two IPM regimes (R2 and R3) showed a significant increase in crop yield over the R1 (farmers' practice). Based on the benefit: cost ratio. R3 (weekly shoot clipping of infested twigs at the time of infestation along with installation of pheromone traps at 100/ha (lure was changed at 25 days interval) and need based application of NSKE at 4% and cartap hydrochloride at 1 g/l in alternate manner) proved the most economical. The frequency of chemical sprayings was reduced from 15 and 17 in R1 (farmers' practice) to 5 and 6 in R3 during 2010-11 and 2011-12, respectively, along with a better benefit: cost ratio in IPM regime. Baral *et al* (2006) reported similarly that the IPM adopters reduced the pesticide applications by 52.6%, which produced a benefit: cost ratio of 2.78. Sole reliance on chemical insecticides was found to be highly uneconomical, as less return per rupee invested was obtained. This was mainly due to the high cost of insecticide and the labor charges engaged in their sprayings.

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کارایی راهبردهای مدیریت تلفیقی برای کنترل کرم میوه‌خوار بادمجان (*Leucinodes orbonalis* Guenee)

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چکیده: کرم میوه‌خوار بادمجان (*Leucinodes orbonalis* Guenee) زیان قابل‌توجهی به بادمجان وارد می‌کند. در پژوهش حاضر، عملیات کنترلی انجام شده توسط کشاورزان (راهبرد اول: استفاده مداوم از انواع حشره‌کش‌ها شامل سایپرمترین، مونوکروتوفوس، کلرپیریفوس و تریوزوفوس یک یا دو بار در هفته) با دو راهبرد مدیریت تلفیقی طی سال‌های ۲۰۱۰ تا ۲۰۱۲ مورد مقایسه قرار گرفت. راهبردهای مدیریت تلفیقی عبارت بودند از ۱) راهبرد دوم: هرس هفتگی ساقه‌های مربوط به شاخه‌های آلوده به هنگام آلودگی به‌همراه نصب تله‌های فرمونی به تعداد ۱۰۰ تله در هکتار (کپسول‌های فرمون هر ۲۵ روز یک‌بار تعویض می‌شدند). ۲) راهبرد سوم: هرس هفتگی ساقه‌های مربوط به شاخه‌های آلوده به هنگام آلودگی به‌همراه نصب تله‌ای فرمونی به تعداد ۱۰۰ تله در هکتار (کپسول‌ای فرمون هر ۲۵ روز یک‌بار تعویض می‌شدند) و به‌کارگیری NSKE چهار درصد و هیدروکلراید کارتاپ یک گرم بر لیتر در مواقع لزوم. کم‌ترین میزان خسارت به میوه (۲۰/۴۶ درصد) در راهبرد سوم مشاهده شد. با استفاده از این راهبرد مدیریت تلفیقی در مقایسه با استفاده تنها از آفت‌کش‌های شیمیایی، میزان خسارت به میوه به میزان ۳۵/۰۱ تا ۳۶/۱۸ درصد کاهش و میزان عملکرد محصول بین ۲۲/۸۷ تا ۲۳/۳۳ درصد افزایش یافت. به‌کارگیری راهبرد سوم باعث افزایش درآمد به‌میزان ۱۰۶۴/۲۲ دلار در هکتار در ارقام دگرگشن و ۱۷۹۹/۳۵ دلار در هکتار در ارقام هیبرید و هم‌چنین منجر به کاهش ۱۰ تا ۱۱ برابری در مصرف سموم شیمیایی شد. راهبرد برگزیده نه‌تنها منجر به کاهش هزینه‌های تولید محصول شد بلکه افزایش درآمد خالص در واحد سطح را نیز به دنبال داشت. این پژوهش ثابت کرد که برنامه مدیریت تلفیقی (راهبرد سوم) که از راهکارهای زراعی، مکانیکی و شیمیایی بهره می‌برد راهبرد مناسبی برای کنترل کرم میوه‌خوار بادمجان بوده و نسبت فایده به هزینه ۳/۶۵ به ۴/۲۷ را به‌دنبال داشت.

واژگان کلیدی: هیدروکلراید کارتاپ، میوه و ساقه‌خوار بادمجان، مدیریت تلفیقی، NSKE، تله فرمونی