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DEVELOPMENT OF INTEGRATED PEST MANAGEMENT APPROACHES AGAINST *Helicoverpa armigera* (Hubner) IN TOMATO

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Abstract

Five IPM packages viz. T_1=Pheromone trap @ 70 traps ha^{-1} + Neem seed kernel extract @ 50 g L^{-1} of water; T_2=Pheromone trap + HaNPV @ 0.4 ml L^{-1} of water and *Bt* @ 2.0 g L^{-1} of water; T_3=Pheromone trap + Neem seed kernel extract + HaNPV and *Bt*; T_4=Pheromone trap + *Trichogramma chillnis* @ 50,000 ha^{-1} and *Bracon hebetor* @ 1200 ha^{-1}; T_5=Pheromone trap + Neem seed kernel extract + *T. chilonis* and *B. hebetor* were evaluated against *H. armigera* in tomato. The lowest fruit infestation by number (12.55%) was attained from T_5 followed by T_2 (15.49%). Significantly the lowest fruit infestation by weight was found in treatment T_2 (10.60%) followed by T_5 (11.73%). The highest yield was obtained from T_5 (29.74 t ha^{-1}) followed by T_2 (26.77 t ha^{-1}). The highest marginal benefit cost ratio was achieved from T_2 (3.41) followed by T_5 (3.35). Hence, considering benefit cost ratio, T_2 and T_5 packages may be the effective tools for managing *H. armigera* in tomato.

Keywords: IPM, pheromone trap, HaNPV, *Bt*, neem, *Helicoverpa armigera*, tomato.

Introduction

Tomato fruitworm, *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) is one of the most serious insect pests of tomato. It is widely distributed in Asia, Africa, Australia and the Mediterranean Europe (Mehrvar, 2009, Chari *et al*., 1990). The four chief characteristics i.e., polyphagy, high mobility, high fecundity, and facultative diapauses of *H. armigera* help attaining the status of a major pest (Fitt, 1989). Being polyphagous, this pest feeds on more than 500 plant species, including economically important crops such as cotton, maize, sorghum, chickpea, pigeon pea, sunflower, vegetables and fruits. It was reported that infestation range of *H. armigera* on tomato was up to 46.85 per cent at Jessore, Bangladesh (Alam *et al*., 2007). *Helicoverpa* species preferably feeding on buds, flowers and fruits. Zalucki *et al*. (1986) reported that the voracious larvae of *H. armigera* prefers to move from one fruit to another, often without consuming it completely and the lower number of large larvae may cause extensive damage of crops. An indiscriminate application of pesticides, during

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1980s and 1990s was responsible for severe outbreaks of *H. armigera* (Ahmad *et al*., 1997).

Now a days, Integrated Pest Management (IPM) is being used to find ecologically sound and environmentally safe ways of pest control. Botanical pesticides are now emerging as a valuable component of IPM strategies on all crops due to their efficacy to pests and safety to natural enemies (Srinivasa *et al.*, 1999). The use of neem seed kernel extract has given the most satisfactory control of *Helicoverpa* in pulse crops (Schmutterer, 1990). Sachan and Lal (1990) reported that extracts from neem and custard apple kernels were effective against *H. armigera* both in the laboratory and field conditions. Neem seed kernel extract and neem rind extract provided maximum protection to chickpea due to their antifeedant properties against *H. armigera* (Dubey *et al.*, 1991). A large number of parasitoids and predators have been recorded on *Helicoverpa* spp. and altogether 77 parasitoids have been reported in India. Seven species of Trichogrammatids have been recorded as egg parasitoids (Yadav *et al.*, 1981). Divakar and Pawar (1987) reported that release of *Trichogramma chilonis* Ishii, *Trichogramma brasiliensis* Parkins, *Trichogramma pretiosum* Riley caused 92.4 per cent reduction in *H. armigera* in tomato. *Bracon hebetor* is a common gregarious ecto-larval parasitoid. Female *Bracon* at first inject venom and thus paralyze insect larvae. A female *Bracon* can paralyze 500-1000 larvae and the paralyzed larvae cannot survive. Some of the microbial were effective for the control of *H. armigera* which included bacteria, *B. thuringiensis* (Chari *et al.*, 1995), nuclear polyhedrosis virus (Yearian *et al.*, 1986; Chand *et al.*, 1999). Two pathogens, Nucleopolyhedrosis viruses (NPV) and the bacterium *Bacillus thuringiensis* (commonly called *Bt*) are available commercially to control *Helicoverpa* larvae. *Bt* is available as a selective spray that only kills moth larvae. Sex pheromones are powerful chemical attractants which have aroused great interest because of their potential as pest control agents. Malik and Ali (2002) reported pheromone traps as a good tool to monitor and control lepidopterous pests. Knight (1995) found pheromone traps more economical than other controlling techniques. Hence, a study was envisaged to combat the *H. armigera* with an objective to develop sustainable and eco-friendly management option(s) against *H. armigera* in tomato.

Materials and Method

The experiment was conducted in the experimental field of the Entomology Division, BARI, Gazipur during *rabi* 2009-10. The tomato variety BARI Tomato 2 seeds were collected from Olericulture Division, Horticulture Research Center (HRC), BARI, Gazipur. Tomato seeds were sown in beds (3m × 1m) 5 cm apart in rows for raising seedlings.

Experimental design and raising of crops

The experiment was laid out in randomized complete block design (RCBD) with three replications. The unit plot size was 3.6m × 3m with a distance of 100 cm between the plots and 150 cm between the blocks. In unit plots, row to row distance was 60 cm and plant to plant was 40 cm. One month old healthy seedlings of equal height were selected for transplanting in the experimental plots. Standard agronomic practices such as watering, gap filling, application of fertilizer, weeding, propping were followed during the study period (Rashid and Singh, 2000)

Treatments and application

Five IPM packages were tested against *H. armigera*. In addition, one untreated control treatment was included for comparison. The package treatments were: T_1= Pheromone trap @ 70 traps ha^{-1} + Neem seed kernel extract @ 50 g L^{-1} of water at 10 days interval; T_2= Pheromone trap + alternate spraying of HaNPV (Heli-Cide 100 LE $1x10^9$ POB ml^{-1}) spraying @ 0.4 ml L^{-1} of water at 10 days interval and *Bt* (*Bacillus thuringiensis* Halt 5% WP) @ 2.0g L^{-1} of water at 10 days interval; T_3= Pheromone trap + Neem seed kernel extract + HaNPV and *Bt* (alternate spraying); T_4= Pheromone trap + *T. chilonis* (50,000 ha^{-1}) at 7 days interval and *B. hebetor* (@ 1200 ha^{-1}) at 7 days interval; T_5= Pheromone trap + Neem seed kernel extract + *T. chilonis* and *B. hebetor* and T_6= Untreated control. Among the treatments there were three dispersed replications at a distance of 200 m for the package of $T_{4,}$ T_5 and control. The rest of the packages were set up at the distance of 1.5m row to row and 1.0 m plot to plot.

Installation of pheromone trap: For all packages pheromone traps were set up at a distance of 12 m at 40 days after transplanting and continued up to last harvest. Soapy water of 3-4 cm height is maintained inside trap throughout the season. The pheromone lure is hung through the center of the lid inside the trap in such a way that it is 2 to 3 cm above the surface of the soapy water.

Release of bio-control agents: When tomato plant started flower initiation weekly release of egg parasitoids, *T. chilonis* (@ 50,000 ha^{-1}) and larval parasitoid *Bracon hebetor* (@ 1200 adults ha^{-1}) were ensured and continued seven times.

Preparation of neem seed extract and application: Neem seeds were collected from the farmer’s home of ChapaiNababgonj, Rajshahi. Collected seeds were air dried and then seeds with kernel were grinding into coarsely milled product by grinder. Two hundred fifty g grinded neem seed were added to 5 l of water, mixed well and left it to soak for 12 hours. Finally, it was filtered through moslin cloth. The filtered product was then ready for spraying. Neem seed kernel extract was first sprayed just before flower initiation stage and then 2nd, 3rd sprays were done at 10 days intervals.

Microbial application: *Bt* and HaNPV were first sprayed just before flower initiation stage and then 2nd, 3rd 4th and 5th sprays were done at 10 days intervals with the help of Knapsac sprayer.

Percent fruit infestations by number at in-situ condition: In this case the data recording were started just after first fruit set. All fruits of six plants per plot were considered for data recording. Data on percent fruit infestation by number were recorded at 7 days interval.

Per cent fruit infestation by number: At harvest, the total fruits were sorted into healthy and infested ones for each treatment. On the basis of the number of total fruits and infested fruits the percent fruit infestation was calculated.

Per cent fruit infestation by weight: Accordingly, the weight of infested (bored) and weight total fruits were recorded and the per cent fruit infestation by weight was determined

Marginal benefit cost ratio: The marginal benefit cost ratio was calculated on the basis of prevailing market prices of tomato, sex pheromone, botanicals, microbials, bio-control agents and their spraying cost. Marginal benefit cost ratio of different treatments was also determined following Ali *et al*. (1996) was calculated as follows:

$$\% \text{ Marginal BCR} = \frac{\text{Benefit on control}}{\text{Cost of treatment}}$$

Statistical Analysis

Data were analyzed statistically using MSTAT-C (1991) to find out the variation among the treatments by F-test. Treatment means were compared by DMRT.

Results and Discussion

Infestation status of *H. armigera* (In-situ condition)

The percent fruit infestation by number due to various packages ranged from 0 to 34.56% (Fig. 1). The trend of infestation increased over time. The lowest fruit infestation was found in package T_5 (Pheromone trap + Neem seed kernel extract + *T.chilonis* and *B. hebetor*) (11.07%) followed by package T_3 (Pheromone trap + Neem seed kernel extract + HaNPV and *Bt*) (11.66%), package T_2 (Pheromone trap + HaNPV and *Bt* (13.67%), Pheromone trap + *T. chilonis* and *B. hebetor*) (13.85%) and package T_1 (Pheromone trap + Neem seed kernel extract) (15.27 %). However, the highest fruit infestation was in the control plots (18.03%) (Fig. 1).

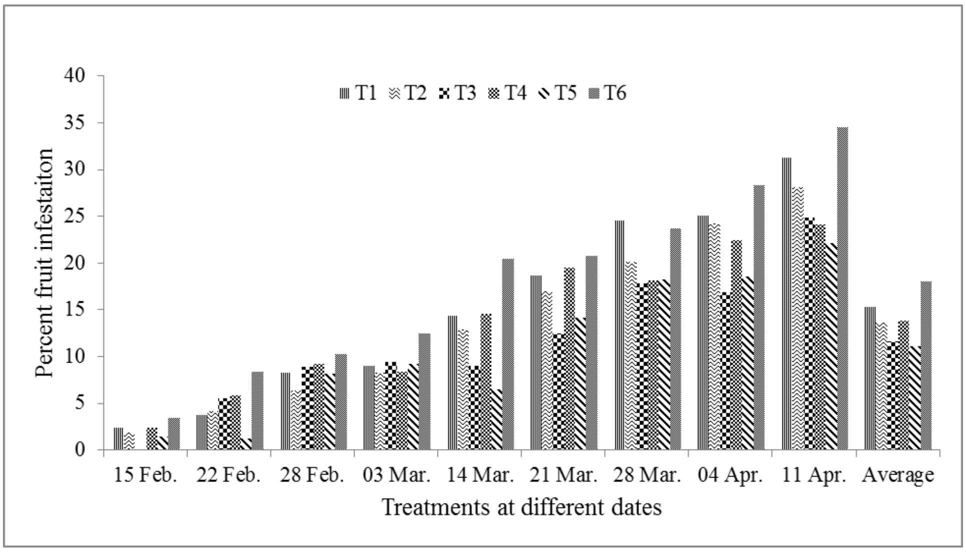

Fig. 1. Effect of IPM approaches on *H. armigera* (in-situ condition) during 2009-2010 Rabi season.

T_1= Pheromone trap + Neem seed kernel extract, T_2= Pheromone trap + HaNPV and *Bt*, T_3= Pheromone trap + Neem seed kernel extract + HaNPV and *Bt*, T_4= Pheromone trap + *T. chilonis* and *B. hebetor*, T_5= Pheromone trap + Neem seed kernel extract + *T. chilonis* and *B. hebetor*, T_6= Untreated control

Per cent infestation by number of infested fruits

The treatment effect on fruit infestation was the lowest (12.55%) in package T_5 (Pheromone trap + Neem seed kernel extract + *T. chilonis* and *B. hebetor*) treated plot which was statistically similar with package T_2 (Pheromone trap + HaNPV and *Bt*) (15.49%), T_3 (Pheromone trap + Neem seed kernel extract + HaNPV and *Bt*) (15.89%) and T_1 (Pheromone trap + Neem seed kernel extract) (17.43%). while, the highest infestation (24.15%) was observed in control plot which was statistically identical with package T_4 (Pheromone trap + *T. chilonis* + *B. hebetor*) (18.23%) treated plot. Percent infestation reduction over control was the highest in treatment package T_5 (48.03%) followed by T_2 (35.86%), T_3 (34.20%), T_1 (27.83%) and T_4 (24.51) (Table 1).

Per cent infestation by weight of infested fruits

The lowest fruit infestation based on weight (22.29%) was found in package T_2 (Pheromone trap + HaNPV and *Bt*) treated fruits which was statistically similar to package T_5 (Pheromone trap + Neem seed kernel extract + *T.chilonis* and *B. hebetor*) (11.73%) and T_3 (Pheromone trap + Neem seed kernel extract + HaNPV and *Bt*) while the highest fruit infestation (18.24%) was observed in control plot which was statistically similar with package T_1 (Pheromone trap + Neem seed kernel extract (14.88%) and T_4 (Pheromone trap + Neem seed kernel extract + *T. chilonis* + *B. hebetor*) (16.08%) (Table 1). Percent infestation reduction over control was highest in package T_2 (41.86%) followed by T_5 (35.69%), T_3 (29.06%), T_1 (18.42%) and T_4 (11.84%) (Table 1).

Table 1. Effect of different IPM packages on *H. armigera* during 2009-2010 Rabi seasons

Treatment	% Fruit infestation (number)	% Infestation reduction over control	% Fruit infestation (weight)	% Infestation reduction over control	Yield (t ha^{-1})	% Yield increase over control
T_1	17.43 bc (3.97)	27.83	14.88 ab (3.58)	18.42	23.04 cd	20.00
T_2	15.49 c (3.50)	35.86	10.60 c (2.98)	41.86	26.77ab	39.43
T_3	15.89 c (3.69)	34.20	12.94 bc (3.26)	29.06	24.66 bc	28.44
T_4	18.23 ab (4.33)	24.51	16.08 ab (3.80)	11.84	20.54 de	6.98
T_5	12.55 c (3.54)	48.03	11.73 bc (3.43)	35.69	29.74 a	54.90
T_6	24.15 a (4.65)	-	18.24 a (3.83)	-	19.20 e	_
CV (%)	6.62		7.96		3.40	

In a column, means followed by same letter(s) are statistically similar at 5% level by DMRT. Figure within parentheses are the transformed values based on SQRT transformation

T_1= Pheromone trap + Neem seed kernel extract, T_2= Pheromone trap + HaNPV and *Bt*, T_3= Pheromone trap + Neem seed kernel extract + HaNPV and *Bt*, T_4= Pheromone trap + *Trichogramma chillnis* and *Bracon hebetor*, T_5= Pheromone trap + Neem seed kernel extract + *Trichogramma chilonis* and *Bracon hebetor*, T_6= Untreated control.

Yield

The highest yield (29.74 t ha^{-1}) was obtained from the plot treated with package T_5 (Pheromone trap + Neem seed kernel extract + *T. chilonis* and *B. hebetor*) which was statistically similar to that of package T_2 (Pheromone trap + HaNPV and *Bt*) (26.77 t ha^{-1}) treated fruits. No significant difference was observed between package T_3 (Pheromone trap + Neem seed kernel extract + HaNPV and *Bt*) (24.66 t ha^{-1}) and T_1 (Pheromone trap + Neem seed kernel extract)

(23.04 t ha^{-1}). However, the lowest yield was obtained from control plots (19.20 t ha^{-1}) (Table 1). The highest yield increased over control was observed in package T_5 (54.90%) followed by T_2 (39.43%). T_3 (28.44%), T_1 (20.00%) and T_4 (6.98%). While, the lowest yield (12.09t/ha) was obtained from untreated control (Table 1).

Income and marginal benefit cost ratio

Income and marginal benefit cost ratio are presented in Table 2. The highest net income (Tk.79,656.00 ha^{-1}) was calculated from package T_5 (Pheromone trap + Neem seed kernel extract + *T. chilonis* and *B. hebetor*) treated plot followed by T_2 (Pheromone trap + HaNPV and *Bt*) (Tk 58,549.00 ha^{-1}), T_3 (Pheromone trap + Neem seed kernel extract + HaNPV and *Bt*) (Tk. 22,295.00 ha^{-1}) and T_1 (Pheromone trap + Neem seed kernel extract) (Tk. 19,654.00 ha^{-1}) treated plots. (Table 2).

Table 2. Effect of IPM package application on net income and marginal benefit cost ratio in tomato during 2009-2010 Rabi season

Treatments	Yield (t ha^{-1})	Additional yield over control (t ha^{-1})	Additional income over control (Tk ha^{-1})	Cost of treatment application (Tk ha^{-1})	Net income (Tk ha^{-1})	Marginal benefit cost ratio (MBCR)
T_1	23.04	3.84	38,400.00	18,754.00	19,654.00	1.04
T_2	26.77	7.57	75,700.00	17,151.00	58,549.00	3.41
T_3	24.66	5.46	54,600.00	32,305.00	22,295.00	0.69
T_4	20.54	1.34	13,400.00	8,590.00	4,810.00	0.56
T_5	29.74	10.34	103,400.00	23,744	79,656.00	3.35
T_6	19.20	-				

T_1= Pheromone trap + Neem seed kernel extract; T_2= Pheromone trap + HaNPV and *Bt*; T_3= Pheromone trap + Neem seed kernel extract + HaNPV and *Bt*; T_4= Pheromone trap + *T. chilonis* and *B. hebeto*; T_5 = Pheromone trap + Neem seed kernel extract + *T. chilonis* and *B. hebetor* ; T_6= Control.

From the marginal benefit cost analysis of IPM packages T_2 (Pheromone trap + HaNPV and *Bt)* treated plots showed the highest monetary benefit. For each taka spent, T_2 package gave on an average the profit of Tk. 3.41 as against Tk. 3.35, Tk. 1.41, Tk.0.69 and Tk. 0.56 calculated from T_5 (Pheromone trap + Neem seed kernel extract + *T. chilonis* and *B. hebetor*), T_1 (Pheromone trap + Neem seed kernel extract), T_3 (Pheromone trap + Neem seed kernel extract + HaNPV and *Bt*) and T_4 (Pheromone trap + *T. chillnis* and *B. hebetor*) treated plots, rrespectively (Table 2).

The present results are in partial agreement with Alam *et al.* (2011) who carried out an experiment at the farmers' field of Danakata and Malkadagga, Boda, Panchagarh during the year of 2010-11 for evaluating IPM package against fruits borers of late winter tomato. They showed that the lowest fruit infestation by number (5.47%) and weight (5.33%) was obtained from the IPM plots at both places whereas the highest fruit infestation by number (23.83%) and by weight (22.83%) was in non IPM plots. Comparatively higher yield was obtained from IPM plots (19.97 t ha^{-1}in Danakata and 18.02 t ha^{-1} in Malkadanga) than non IPM plots (13.63 t ha^{-1}in Danakata and 12.13 t ha^{-1} in Malkadanga) at both places. Alam *et al.* (2012) conducted another field experiment at the farmers' field of Tunirhat, Panchagarh during 2011-2012 for evaluating IPM package (weekly release of egg parasitoid *Trichogramma evanescens*, larval parasitoid *Bracon hebetor* and use of pheromone trap) against fruits borers of late winter tomato. They observed that IPM package resulting 74.5% reduction of fruit infestation over non-IPM package (spraying of Proclaim 5SG @ 1g l^{-1}). Comparatively higher yield was also obtained from IPM plots (39.90 t ha^{-1}) than non-IPM plots (30.48 t $ha^{-1).}$ The finding of the present study also partially supported by Gopalkrishnan and Ashokan (1998) and they reported that application of five rounds of *Ha*NPV @ 250 LE ha^{-1} at weekly intervals effectively controlled the fruit borer incidence. Reddy and Manjunatha (2000) reported combinations of nimbecidine 2% + NPV at 250 larval equivalents (LE) ha^{-1} and dipel 8 l + NPV @250 LE ha^{-1}were the most effective treatments *against H. armigera.* The integrated pest management components (*T. chilonis*, *C. carnea*, NPV, nimbecidine, dipel and synthetic chemicals) were imposed at different intervals on the basis of pheromone trap threshold level (7 moths/trap per night) on a consolidated block of 40 ha cotton (MCU-1) fields at two locations, Shankarabanda and Korlagundi. The results demonstrated a significant superiority of the IPM strategy in terms of both cost versus benefit and environmental safety over that used in the farmer's fields where only conventional control methods were followed. The main reason for the higher efficacy of IPM approaches on insect pest suppression probably due to the integration of different IPM options in a package under the study. Hence, considering efficacy and profitability, it is concluded that T_2 and T_5 packages may be the best options for efficient management of *H. armigera.*

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