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Efficacy of Microbials as Insecticides for the Management of Tomato (*Lycopersicon esculentum*) Fruitworm, *Helicoverpa armigera* (Hubner)

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Abstract

The experiment was conducted at the experimental field of Entomology Division, BARI, Gazipur during Rabi 2007-08. Two microbial insecticides HaNPV @ 0.4ml/L and *Bt* @ 2g/L along with their combination were tested against *H. armigera*. The lowest fruit infestation, both in number and weight, was obtained from treatment HaNPV and *Bt* alternate spraying (11.78%, 9.64%), followed by *Bt* (13.25%, 10.85%) and HaNPV (17.67%, 13.11%). The highest fruit yield (16.92 t/ha) was obtained from HaNPV and *Bt* alternate spraying plots followed by *Bt* (16.65 t/ha) and HaNPV (14.73 t/ha). In case of MBCR, the highest MBCR was obtained from HaNPV and *Bt* alternate spraying (5.30) followed by HaNPV (4.46) and *Bt* (3.37).

Keywords: *Helicoverpa armigera,* tomato, microbial

1. Introduction

Fruit borer, *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) is one of the most serious insect pests worldwide. It is widely distributed in Asia, Africa, Australia and the Mediterranean Europe. It is a polyphagous pest occurring on a variety of crops (Mehrvar 2009, Chari *et al*., 1990). The four chief characteristics 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. They cause an estimated loss of over US$ 5 billion annually despite application of pesticides costing over US$ 1 billion every year (Sharma, 2005). Losses caused by this pest in Pakistan were reported to be 35% in tomato (Latif *et al*., 1997) and 38% in India (Selvanarayanan and Narayanasamy, 2006).

In Bangladesh, *Helicoverpa armigera* is becoming an alarming pest in different vegetable crops. It was reported that infestation range of *H. armigera* on tomato was up to 46.85 per cent at Jessore (Alam *et al*., 2007). In recent years, crop production has been severely threatened by these insect pests as they have developed high levels of resistance to the commonly used insecticides worldwide. In general, *Helicoverpa* species preferable feed on buds, flowers and fruits. The preference of fruiting structures and the tendency to move from one fruit to another, often without consuming it completely results extensive damage to crops even when the number of larger larvae are relatively low (Zalucki *et al*.,1986).

Several microbial pathogens had been isolated from *Heliothis.* These include nuclear polyhedrosis virus, cytoplasmic polyhedrosis virus, granulosis virus, *Bacillus thuringiensis* Berliner, *Beauveria bassiana* (Bals.) Vuill., *Metarhizium anisopliae* (Metch.) Sorokin, *Nosema* sp., *Vairimorpha* sp. and the nematode *Ovomermis* sp. (Durairaj 1999). Some of the microbials were effective for the control of *H. armigera* which included bacteria, *B. thuringiensis* (Chari *et al.*, 1995), nuclear polyhedrosis virus (Yearian *et al.*, 1986 and Chand *et al.*, 1999), cytoplasmic polyhedrosis virus and granulosis virus (Jayaraj *et al.*, 1988), fungi *Nomuraea rileyi* (Yearian *et al.*, 1986) and protozoa includes *Nosema* sp. and *Vairimorpha* sp. (Jayaraj *et al.*, 1988). Minimum fruit damage of tomato on weight basis was recorded when *Bt* + endosulfan (1gm/l + 1ml/g) was applied which, appeared best treatment followed by endosulfan @ 2ml/l and *Bt* @ 2gm/l (Ram and Singh, 2011).

Two pathogens are commercially available to control *Helicoverpa* larvae: NPV and the bacterium *Bacillus thuringiensis* (commonly called *Bt*). *Bt* is available as a selective spray that only kills moth larvae. Nucleopolyhedrosis viruses (NPVs) are one of the most important entomopathogens being developed as microbial insecticides for pest control programs in forestry, agriculture, and horticulture (Hunter-Fujita *et al*., 1998); they are safe for non-target organisms, environmentally persistent, and highly virulent against target insect pests. NPV occurs naturally and frequently causes natural outbreaks (epizootics) in *Helicoverpa* populations. The commercial *Helicoverpa* NPV is a highly selective biopesticide that infects only *H. armigera* and *H. punctigera* larvae. NPV is harmless to humans, wildlife and beneficial insects.

Synthetic chemical insecticides provide many benefits to food production and human health, but they also pose some hazards. In many instances, alternative methods of insect management offer adequate levels of pest control and pose fewer hazards. One such alternative is the use of microbial insecticides which contain microorganisms or their by-products. Microbial insecticides are especially valuable because their toxicity to non-target animals and humans is extremely low. Compared to other commonly used insecticides, they are safe for both the pesticide user and consumers of treated crops. Microbial insecticides are also known as biological pathogens, and biological control agents. Considering the above facts the present study was undertaken to observe the efficacy of microbial as a vital component of Integrated Pest Management (IPM) against *H. armigera* on tomato.

2. Materials and Methods

2.1. Experimental sites, season and husbandry

The experiment was conducted at the experimental field of Entomology Division, BARI, Gazipur during Rabi 2007-08. BARI tomato 2 (Ratan) seeds were collected from Olericulture Division, Horticulture Research Center (HRC), BARI, Gazipur. Tomato seeds were sown in beds of 3m x 1m size in 5cm apart rows for raising seedlings. One month old healthy seedlings of equal height were selected for transplanting in the experimental plots. Standard agronomic practice such as watering, gap filling, application of fertilizer, weeding, stalking were followed in the study.

2.2. Design and treatments

The experiment was laid out in a randomized complete block design (RCBD) with three replications. The unit plot size was 3.6m x 3.0m 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.

Two microbial insecticides viz. HaNPV and *Bt* were used in this experiment.

The treatments were as follows:

T_1= HaNPV (Heli-Cide 100 LE $1x10^9$ POB/ml) spraying @ 0.4 ml/L of water at 10 days interval;

T_2= *Bt (Bacillus thuringiensis*, Halt 5% WP) spraying @ 2.0 g/L of water at 10 days interval;
T_3= HaNPV @ 0.4 ml/L of water and *Bt* @ 2.0 g/L of water alternate spraying at 10 days interval; and
T_4 = Control.

Microbial insecticides were first sprayed just before flower initiation stage and then 2nd, 3rd 4th and 5th sprays were done at 10 days interval with the help of Knapsac sprayer. Four liter of spray material was required to spray three plots before fruiting stage, subsequent applications required five liters each. At the time of spray the target plot was surrounded by temporary polythene walls to avoid dripping to the adjacent plots. The spray was done uniformly on entire plant to ensure complete coverage with Knapsack sprayer. Spraying was done in the afternoon to escape bright sun, strong wind and pollinating bees.

2.3. Collection of data

Data collection and calculation of percent fruit infestation by number at in-situ condition, percent fruit infestation by number and weight at harvest, and yield data at each harvest.

2.3.1. 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 fruit infestation by number were recorded at 7 days interval. Percent fruit infestation by number at in-situ was determined as:

$$\text{\% Fruit infestation by number} = \frac{\text{Number of infested fruits}}{\text{Total number of fruits}} \times 100$$

2.3.2. Percent 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 (TF) and infested fruits (IF) the percent fruit infestation was calculated as:

$$\text{Fruit infestation by number (\%)} = \frac{\text{Number of infested fruits}}{\text{Total number of fruits}} \times 100$$

2.3.3. Per cent fruit infestation by weight

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

$$\text{\% Fruit infestation by weight} = \frac{\text{Weight of infested fruits}}{\text{Weight of total fruits}} \times 100$$

2.3.4. Marginal benefit cost ratio

The marginal benefit cost ratio was calculated on the basis of prevailing market prices of tomato, microbials and spraying cost. Marginal benefit cost ratio was calculated as:

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

2.4. Statistical analysis

The recorded data on different parameters were analyzed statistically using MSTAT-C program to find out the variation among the treatment by F-test. Treatment means compared by LSD and standard error, coefficient of variation (CV %) were also estimated and presented as pair comparison for each character.

3. Results and Discussion

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

The per cent fruit infestation by number was calculated by counting the number of infested fruits and healthy fruits at in-situ condition on different dates. The fruit infestation in all treatments ranged from 1.02 to 26.88%. The trend of infestation was increased over time during the study period. Considering average infestation (Fig. 1) the lowest fruit infestation was found in the treatment of HaNPV and *Bt* alternate spraying (8.72%) followed by *Bt* treated plots (11.19%) and HaNPV treatment (13.77%). However, the highest fruit infestation obtained from control plots (17.54%) (Fig. 1).

3.2. Per cent infestation based on number of infested fruits (during harvest)

The lowest fruit infestation was recorded (11.78%) in the treatment of HaNPV and *Bt* alternate spraying, which was statistically similar to *Bt* treated fruits (13.25%). While, the highest infestation (18.32%) was observed in control which was statistically identical with HaNPV (17.67%). HaNPV and *Bt* alternate spraying treated plots showed the highest (35.70%) reduction over control in number of fruit infestation followed by *Bt* treated fruits (27.67%) (Table 1).

3.3. Percent infestation based on weight of infested fruits (during harvest)

The lowest fruit infestation (9.64%) was found in HaNPV and *Bt* alternate spraying fruits which was statistically similar to *Bt* (10.85%) and HaNPV treated fruits (17.67%) separately. The highest fruit infestation (17.04%) was observed in control plot which was statistically similar to HaNPV treated plots (13.11%). The highest infestation reduction over control (43.43%) was also observed in HaNPV and *Bt* alternate spraying treated fruits followed by *Bt* spraying fruits (36.33%) (Table 1).

3.4. Yield

The highest yield (16.92 t/ha) was obtained from HaNPV and *Bt* alternate spraying treated plants which was statistically similar with *Bt* (16.65 t/ha) and HaNPV treated plants (14.73 t/ha), while the lowest yield (10.69 t/ha) was obtained from untreated plants. The highest (58.28%) yield increase over control was observed in HaNPV and *Bt* alternate spraying plants followed by *Bt* treated plants (55.75%) (Table 1).

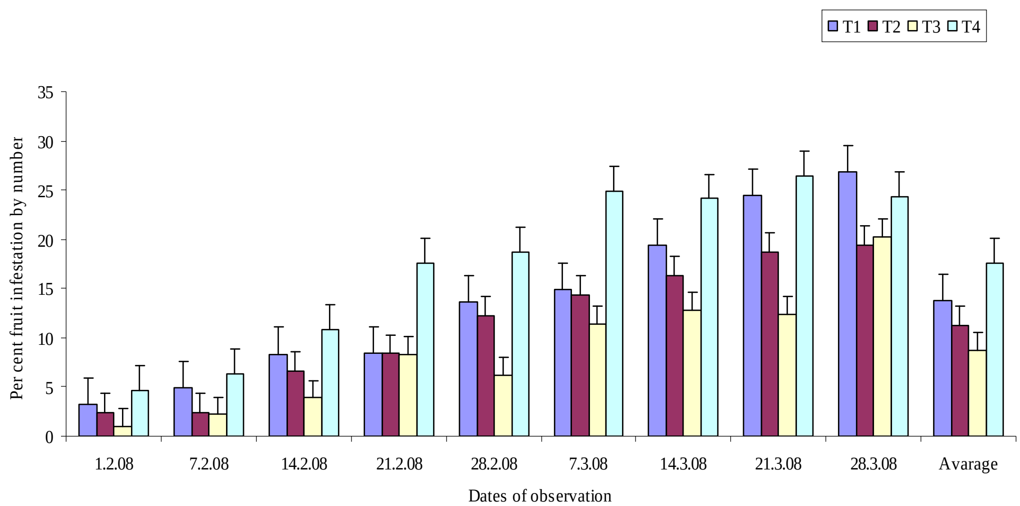

Fig.1: Effect of microbials on incidence of *H. armigera* (in-situ condition) during 2007-2008 Rabi season at Entomology Research field, BARI, Gazipur, Bangladesh

T_1= HaNPV spraying @ 0.4 ml/L of water at 10 days interval

T_2= *Bt* spraying @ 2.0g/L of water at 10 days interval

T_3= HaNPV and *Bt* alternate spraying

T_4 = Control

Table 1. Effect of different microbial treatments on *H. armigera* during 2007-2008 Rabi season at Entomology Research field, BARI, Gazipur, Bangladesh

Treatments	% Fruit infestation (number)	% Reduction of infestation over control	%Fruit infestation (weight)	% Reduction of infestation over control	Yield (t/ha)	%Yield increase over control
HaNPV @ 0. 4 ml/L	17.67 a (4.20)	3.55	13.11 ab (3.61)	23.06	14.73 a	37.79
Bt @ 2g/L	13.25 ab (3.64)	27.67	10.85 b (3.28)	36.33	16.65 a	55.75
HaNPV & *Bt* alternate spraying	11.78 b (3.42)	35.70	9.64 b (3.10)	43.43	16.92 a	58.28
Untreated control	18.32 a (4.26)	-	17.04 a (4.12)	-	10.69 b	-
LSD value at alpha 0.05	0.6474		0.5825		0.5361	
CV %	8.34		8.25		7.04	

Means in each column followed by different letter(s) are significantly different at 5% level of significance (*p>0.05*) by LSD. Figure within parentheses are the transformed values based on SQRT transformation.

Table 2. Effect of microbials on net income and marginal benefit cost ratio in *H. armigera* during 2007-08 Rabi season at Entomology research field, BARI, Gazipur, Bangladesh

Treatments	Yield (t/ha)	Additional yield over control (t/ha)	Additional income over control (Tk/ha)	Cost of treatment application (Tk/ha)	Net income (Tk/ha)	Marginal benefit cost ratio (MBCR)
HaNPV @ 0.40 ml/L of water	14.73	4.04	40,400.00	7,386.64	33,013.36	4.46
Bt @ 2g/L of water	16.65	5.96	59,600.00	12,387.60	47,212.40	3.81
HaNPV & *Bt* alternate spraying	16.92	6.23	62,300.00	9,887.12	52,412.88	5.30
Untreated control	10.69	-	-	-	-	-

Note: Farm gate price of tomato: Tk. 10.00 per Kg, Treatment HNPV: Cost of HNPV: Tk. 240.00 per 100 ml bottle, required amount of HNVP: 2777.77 ml/ha (Five times spray @ 0.4ml/L), Cost for HNPV: 2777.77 x 2.4 = Tk. 6666.65, Labour Cost: Tk. 720.00, Total Cost for HNPV: Tk. 7,386.64; Treatment Bt: Cost of Bt: Tk.840.00 per Kg, Required amount of Bt = 13.89 kg/ha (Five times spray @ 2.0g/L), Cost for Bt = 13.89 x Tk 840.00 = Tk. 11,667.60, Labor cost = Tk.720.00/ha, Total cost for Bt = Tk. 12,387.60; Treatment HNPV + Bt (alternate spraying): Cost per ha: (7,386.64 + 12,387.60)/2 = Tk. 9,887.12

3.5. Income and marginal benefit cost ratio

Income and marginal benefit cost ratio (MBCR) are presented in Table 2. The highest net income (Tk. 52,412.88/ha) was recorded from HaNPV and *Bt* alternate sprayed treatment followed by *Bt* (Tk 47,212.40/ha). The lowest net income (Tk 33,013.36/ha) was recorded from HaNPV applied treatment. The marginal benefit cost analysis of microbials application revealed that the highest monetary benefit was obtained from HaNPV and *Bt* alternate spraying. For each taka spent, HaNPV and *Bt* alternate spraying gave an average profit of Tk 5.30 as against Tk 4.46, and Tk 3.81 in HaNPV and *Bt*, respectively (Table 2).

Two microbial pesticides HaNPV and *Bt* were tested either alone or in combinations as alternative spray. It was found that *Bt* was better in reduction of fruit infestation both in number and weight and also obtained higher yield compared to HaNPV. However, considering MBCR, HaNPV was more economic than *Bt*. However, HaNPV in combination with *Bt* was found to be the best among the treatments considering reduction of fruit infestation both in number and weight. It was found that HaNPV and *Bt* alternative spray obtained the highest yield and MBCR. These findings agreed with the observation of Padua *et al.*, (1998), who conducted field trials in Bongabon, Nueva Ecija and found that NPV, *Bt*, and NPV+*Bt* were more effective against *Spodoptera* larvae, than Karate insecticide application. Larval counts were significantly lower in the microbial treatments than the control or Karate treatment later in the season.

This findings of the present study is also partially supported by Pawar *et al.* (1987); Vyas and Lakhohaura (1996); Satish *et al*. (1998); Pokharkar *et al*. (1999) and Hossain *et al*. (2001). These workers reported the effectiveness of HNPV to be as good as standard chemical insecticides in controlling pod borer in chickpea. HaNPV either alone or in combination with *Bt* may therefore, be suggested as alternative spray in controlling *H. armigera*.

4. Conclusions

Alternate spraying of two microbials viz. HaNPV @ 0.40ml/L and *Bt* @ 2.0g/L found to be most effective and economic against *H. armigera*. It was concluded from the present study that HaNPV and *Bt* may simultaneously be considered as a good approach in controlling *H. armigera*.

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