The Agriculturists 12(1): 131-139 (2014) ISSN 2304-7321 (Online), ISSN 1729-5211 (Print)
A Scientific Journal of Krishi Foundation ***Indexed Journal***

Efficacy of Botanicals against *Helicoverpa armigera* (Hubner) in Tomato

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Received: 7 October 2013 Accepted: 14 June 2014

Abstract

Four botanicals viz., mahogany oil, mahogany seed extract, tobacco leaf extract, neem seed kernel extract along with one synthetic chemical, cypermethrin were tested for their efficacies against *H. armigera*. The lowest fruit infestation, both by number and weight, was observed in neem seed kernel extract (27.15%, 22.29%) treated plot which was statistically similar to tobacco leaf extract (27.71%, 23.31%) treated plot and cypermethrin (28.87%, 25.44%) treated fruits. While no significant difference was found among mahogany oil, mahogany seed extract and control treatments. Percent infestation reduction over control was the highest in neem seed kernel extract (30.08%) followed by tobacco leaf extract (28.68%). The highest yield (18.14 t/ha) and the highest MBCR (2.99) were also obtained from neem seed kernel extract treated fruits.

Keywords: *Helicoverpa armigera*, tomato, botanicals

1. Introduction

Tomato *Lycopersicon esculentum* Mill is a major winter crop of Bangladesh. The crop is cultivated on an area of about 20425.21 ha with an annual production of 150720 t and its national average yield is 7.38 t/ha during the year 2008-09 (Anon., 2009) while the world scenario shows a different picture such as: India, Japan, USA and China produces 9.57, 53.84, 50.33 and 16.05 t/ha, respectively (Anon., 2005). Tomato cultivation can be seriously affected by insect pests and diseases. A wide variety of insect pests attack tomato including: cutworms, hornworms, aphids, whiteflies, tomato fruitworms, flea beetles, red spider mite, etc. Among them tomato fruitworm *Helicoverpa* (*Heliothis*) *armigera* is the obnoxious and widely known globally. It is a polyphagous insect pest occurring on a variety of crops (Mehrvar, 2009; Chari *et al*., 1990). The four characteristics like polyphagy, high mobility, high fecundity, and facultative diapauses of *H. armigera* help attaining the status of a major pest (Fitt, 1989). 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 general, *Helicoverpa* species preferably feed on buds, flowers and fruits. The preference for 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).

Botanical pesticides are now emerging as a valuable component of IPM strategies in all crops due to their efficacy to insect pests and safety to their natural enemies (Srinivasa *et al*., 1999). Botanicals become promising tool against insect pests by offering many advantages compared to insecticides such as, host specific, non-toxic to mammals and beneficial organisms, less prone to insect resistance, readily biodegradable and less expensive (Wink, 1993). There had been a significant revival of interest in developing eco-friendly pesticide formulations from plant materials such as neem, *Azadirachta indica* (Schmutterer, 1990). Almost 2400 plant species having broad-spectrum insecticidal properties have been found to control more than 800 species of insect pests (Grainge and Ahmad, 1988). Among them, neem (*Azadirachta indica*), *Ageratum, Chrysanthemum* and *Karanj* have been used to manage *Helicoverpa* pest populations. Neem has emerged as the most potential source of botanical pesticides. 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). Sinha (1993) reported that the pungam oil and neem seed kernel extract of 5% gave yield equal to endosulfan applied on chickpea. Neem oil based formulation bio-bitters was useful as additives to conventional insecticides to manage the resistance development of *H. armigera* (Rao *et al.*, 1993).

Swietenia mahogani Jacq. (Mliaceae) is a large meliaceous mahogany closely related to the African genus *Khaya* and one of the most popular traditional medicines in Africa. The decoction of the bark of these mahoganies is extensively used as febrifuge which could be associated with its use as an antimalarial drug. Many mexicanolide-type compounds have been isolated from *S. mahogany* (Kadota *et al.*, 1990). Insecticidal properties of *S. mahogany* were reported by several researchers. According to Dadang and Kanju (2003) crude seed extract of *S. mahogani* at 5% solution completely inhibited feeding activity of third instar larvae of the diamondback moth, *Plutella xylostella*.

Tobacco, *Nicotiana tabacum*, is cultivated for use in the tobacco industry to make cigarettes, bidis and chewing tobacco. It has excellent insecticidal properties and farmers use for killing the insect pests since time immemorial. Govindon and Nelson (2008) treated pulse seeds with ten botanicals and found that tobacco leaf powder along with *Lictifers isora* attributed the lowest number of eggs of *Callosobruchus maculatus*. Considering the above facts the present study was undertaken to observe the efficacy of some botanicals against *H. armigera* on tomato.

2. Materials and Methods

The experiment was conducted at the experimental field of Entomology Division, BARI, Gazipur during late rabi season 2007-08. BARI tomato 2 (Ratan) seeds were collected from Olericulture Division, Horticulture Research Center (HRC), BARI, Gazipur. Tomato seeds were sown in beds (3m x 1m) 5 cm apart in 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, propping were followed during the study period (Rashid and Sing, 2000)

2.1. Treatments of the experiment

Four botanicals were tested for their efficacy against *H. armigera*. In addition, one chemical control treatment viz., cypermethrin and an untreated control were included for comparison. The treatments were: T_1= Mahogany oil @ 4ml/Lof water, T_2= Mahogany seed extract @ 25g/L of water, T_3= Tobacco leaf extract @ 12.5 g/L of water, T_4= Neem seed karnel extract @ 50 g/L of water, T_5= Cypermethrin @ 1.0 ml/L of water and T_6= Untreated control.

2.2. Collection and Preparation of botanicals

Botanicals were prepared and extracted following the methodology in the Entomology Division, BARI, Gazipur.

2.2.1. Mahogany oil

Mahogany oil was collected from local market.

2.2.2. Mahogany seed extract

Mahogany fruits were collected from BARI campus, Gazipur. After collection, fruits were dried for one week to collect seeds. Then the seeds were sun dried for two days. After that seeds were ground to powder by grinder. Five litre of water was added to 250 g seed powder and then boiled for 40 minutes. During boiling 50 g detergent, 10 g copper sulfate and 5 g borax or sodium borate were added as a buffer solution and stirred well with a stick. After cooling, 5 times water were added and filtered through muslin clothes. The filtered extract was then ready for spraying.

2.2.3. Tobacco leaf extract

Tobacco leaves were collected from Joydebpur local market, Gazipur. Collected tobacco leaves were dried well and ground it to powder. Now 125g tobacco leaf powder was mixed with 2.0 l of water and boiled for 30 minutes. The mixture was cooled and filtered through muslin cloths and then 15g detergent; 8 l of water and 0.25g lime powder were added as a pickling agent. Finally this product was ready for spraying.

2.2.4. Neem seed kernel extract

Neem seed pods were collected from Chapai Nawabganj. Collected seed pods were air dried properly and then seed with kernels were grinded into coarsely milled product by grinder. Then 250g grinded neem seed kernel was added to 5 l of water and mixed well and left for 12 hours to allow soaking. Finally, it was filtered through muslin clothes. The filtered extract was then ready for spraying.

2.2.5. Cypermethrin

Cymbush 10EC (Cypermethrin) was collected from the local market. Cypermethrin is one of the most widely used type II pyrethroid insecticide, first synthesized in 1974 (WHO, 1989; Patel *et al*., 2006). Chemical formula of cypermethrin is $C_{22}H_{19}Cl_2NO_3$ and molecular weight is 416.3.

2.3. Design and layout

The experiment was laid out in randomized complete block design (RCBD) with three replications. The unit plot size was 3.6m x 3m with a distance of 100 cm between the plots and 150 cm between blocks. In unit plots, row to row distance was 60 cm and plant to plant was 40 cm.

2.4. Procedure of treatment application

Treatment wise botanicals and insecticide were sprayed when first symptom of infestation observed at the time of flower initiation stage and then 2^{nd}, 3^{rd} sprays were done at 10 days intervals. At the time of spray the target plot was surrounded by temporary polythene walls to avoid drifting 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 avoid bright sun, strong wind and save pollinating bees.

2.4.1. Percent fruit infestations by number at in-situ condition

In this case the data recording were started just after first fruit set. Whole 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 using the following formula:

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

2.4.2. 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 (TF) and infested fruits (IF) the percent fruit infestation was calculated using the following formula:

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

2.4.3. Per cent fruit infestation by weight

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

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

2.4.4. Marginal Benefit cost ratio

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

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

2.5. Statistical Analysis

The recorded data of different parameters were analyzed statistically using MSTAT-C program (1989) to find out the variation among the treatments 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

Four botanicals viz., mahogany oil, mahogany seed extract, tobacco leaf extract, neem seed kernel extract along with cypermethrin were tested for their efficacies against *H. armigera.* Efficacy was assessed by measuring infestation status, per cent fruit infestation by number & weight, yield and calculating marginal benefit cost ratio.

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

The status of *H. armigera* infestation over time after the application of different botanicals was assessed. The per cent fruit infestation by number due to various treatments was ranged from 4.68 to 48.27% (Fig. 1). The trend of infestation was increased over time. The lowest fruit infestation was found in neem seed kernel extract (19.17%) treated plots followed by cypermethrin (20.07%), tobacco leaf extract (21.37%), mahogany seed extract (27.88%) and mahogany oil (28.99) treated plots. However, the highest fruit infestation was in the untreated control plots (29.10%).

3.2. Per cent infestation by number of infested fruits

The treatment effect on fruit infestation was the lowest (27.15%) in neem seed kernel extract treated plot which was statistically similar to tobacco leaf extract (27.71%) treated ones. This was followed by cypermethrin treated fruits (28.87%) (Table 1). There was no significant difference found among mahogany oil (34.13%) and mahogany seed extract (35.69%) treated fruits. However the highest fruit infestation obtained from untreated control plots (38.80%). Percent infestation reduction over control was the highest in neem seed kernel extract (30.03%) followed by tobacco leaf extract (28.58%), cypermethrin (25.59%), mahogany oil (12.04%) and mahogany seed extract (8.02).

3.3. Percent infestation based on weight of infested fruits

The lowest fruit infestation based on weight was found in neem seed kernel extract (22.29%) treated fruits which was statistically similar to tobacco leaf extract (23.31%) and cypermethrin treated fruits (25.44%). However highest infestation was observed in untreated control plot (32.82%) which was statistically similar to mahogany oil (28.33%) and mahogany seed extract (28.43%) treated plots (Table 1).

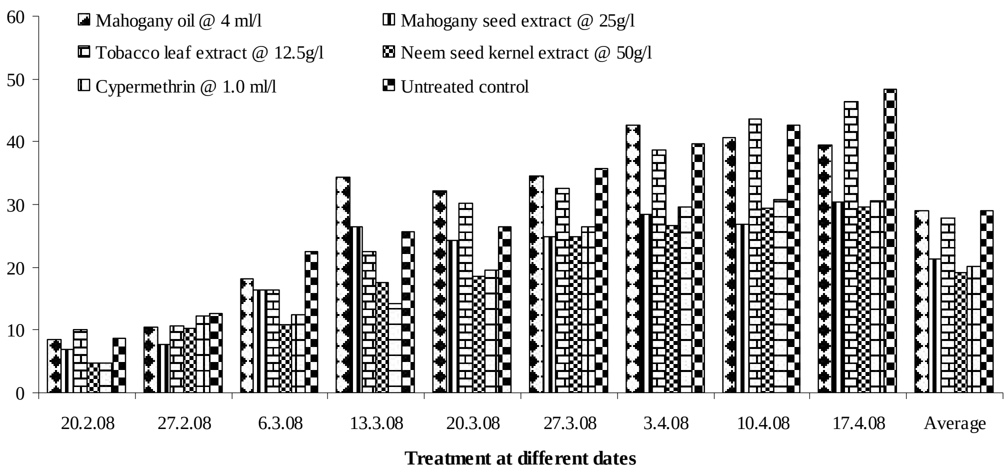

Fig. 1. Effect of botanicals on incidence of *H. armigera* (in-situ condition) during 2007-2008 Rabi season at Entomology research field, BARI, Gazipur, Bangladesh

Table 1. Effect of different botanicals against *H. armigera* infestation in tomato during 2007-2008 Rabi season at Entomology Research Field, BARI, Gazipur, Bangladesh

Treatments	% Fruit infestation. (number)	% Infestation reduction over control	% Fruit infestation (weight)	% Infestation reduction over control	Yield (t/ha)	%Yield increase over control
Mahogany oil @ 4ml/L	34.13ab (33.93)	12.04	28.33ab (30.04)	13.68	15.16ab	25.39
Mahogany seed extract @ 25g/L	35.69 a (35.11)	8.02	28.43ab (30.23)	13.38	14.58ab	20.60
Tobacco leaf extract @ 12.5 g/L	27.71bc (30.07)	28.58	23.31c (25.92)	28.97	15.95ab	31.92
Neem seed kernel extract @ 50g/L	27.15c (29.59)	30.03	22.29c (24.19)	32.08	18.14a	50.04
Cypermethrin @ 1.0 ml/L	28.87bc (30.03)	25.59	25.44bc (27.48)	22.49	12.77ab	5.62
Control	38.80a (36.99)	-	32.82a (33.23)	-	12.09b	-
$LSD_{0.05}$	3.983		3.826		3.898	
CV (%)	6.71		729		9.87	

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

Table 2. Effect of different botanicals application on net income and marginal benefit cost ratio in tomato 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)
Mahogany oil @ 4ml/L	15.16	3.07	30,700.00	8,024.00	22,676.00	2.83
Mahogany seed extract @ 25g/L	14.58	2.49	24,900.00	12,274.00	12,646.00	1.03
Tobacco leaf extract @ 12.5 g/L	15.95	3.87	38,600.00	14,163.00	24,437.00	1.72
Neem seed kernel extract @ 50g/L	18.14	6.05	60,500.00	15,154.00	45.346.00	2.99
Cypermethrin @ 1.0 ml/L	12.77	0.68	6,000.00	4,904.00	2,295.00	0.47
Control	12.09	-	-	-	-	-

Per cent infestation reduction over control was the highest in neem seed kernel extract (32.08%) treated plot which was followed by tobacco leaf extract (28.58%), cypermethrin (22.49%), mahogany oil (13.68%) and mahogany seed extract treated plots (13.38%).

3.4. Yield

The highest yield (18.14 t/ha) was obtained from neem seed kernel extract treated fruits which was statistically similar to that of tobacco leaf extract (15.95 t/ha), mahogany oil (15.16t/ha) and mahogany seed extract (14.58 t/ha) treated fruits followed by cypermethrin (12.77 t/ha) treated fruits. The highest yield increased over control was observed in neem seed karnel extract treated fruits (50.04%) followed by tobacco leaf extract treated fruits (31.92%), while significantly the lowest yield (12.09t/ha) was obtained from untreated control treated fruits (Table 1).

3.5. Income and marginal benefit cost ratio

Income and marginal benefit cost ratio are presented in (Table 2**)**. The highest net income (Tk 45,346/ha) was calculated from neem sceed kernel extract sprayed plot followed by tobacco leaf extract (Tk 24,437/ha) and mahogany oil (Tk. 22,676/ha) treated plots. The lowest net income (Tk 2295/ha) was calculated from cypermethrin applied plots.

The marginal benefit cost analysis of plant materials treated plots showed the highest monetary benefit particularly from neem seed kernel extract treated ones. For each taka spent, neem seed kernel extract gave on an average the profit of Tk 2.99 as against Tk 2.83, Tk 1.72 Tk 1.03 and Tk 0.47 calculated from mahogany oil, tobacco leaf extract, mahogany seed extract and cypermethrin treated plots, respectively (Table 2).

The treatment effect on fruit infestation, both by number and weight were the lowest in neem seed kernel extract treated plot (27.15% in number and 22.29% in weight) which was statistically similar to tobacco leaf extract and cypermethrin treated plots. The reasons of the lower infestation in neem seed kernel extract might be due to the presence of azadirachtin, a secondary metabolite worked as most potent insect repellent, antifeedant and an insect growth regulator. *Helicoverpa armigera* does not develop resistance to azadirachtin. On the other hand *H. armigera* developed resistant on huge number of insecticide including pyrithroieds which might be the probable cause for higher infestation in cypermethrin treated plot. While no significant difference in fruit infestation was found among mahogani oil, mahogani seed extract treated and untreated control plots.

The present findings are agreed with the findings of Rahman *et al*. (2011). They reported the lowest percentage of fruit infestation by number (5.72%) and weight (9.69%) in total cropping season using Marshal @ 6.0 ml/2 litre of water at 7 days interval which was statistically similar (6.22% in number and 10.03% in weight) to that of neem leaf extract @ 0.5 kg/2 litre of water applied at 7 days interval. Bhushan *et al.* (2011) also reported that Neem seed kernel extract (NSKE 5%) was found most effective in reducing the larval population and pod damage in chickpea. Weekly spray application of the extract of neem seed kernel has also been reported effective against borers (Karim, 1994, Sivaprakasam, 1996; Saibllon *et al*., 1995 and Reddy *et al.*, 1996) attacking vegetable crops due to the presence of azadirachtin. It was demonstrated that azadirachtin was effective systemically and where insects ingest azadirachtin it had a toxic effect, interrupting growth and development. In subsequent work, azadirachtin and triterpenoids having antifeedant effects were isolated in smaller amounts from the neem seeds (Kraus 2002).

The results also indicated that the highest net income (Tk 45,346/ha) and the marginal benefit cost analysis using botanicals showed the highest monetary benefit from neem seed kernel extract sprayed treatment. These findings also agreed with that of Rahman *et al.* (2011) who reported that the controlling of chilli fruit borer by using botanicals, the highest benefit cost ratio (BCR) (3.51) was recorded when neem leaf extract applied @ 0.5 kg/2 l of water at 7 days interval.

4. Conclusions

Among the four botanicals neem seed kernel extract applied @ 50g/l of water performed better against *H. armigera* in reducing the number and weight infested fruits. The highest monetary benefit and yield also obtained from neem seed kernel extract treatment. It was concluded from the studies that the neem products may be a good measure to overcome the insecticide resistance problem due to the diversified nature of azadirachtin applied against the *H. armigera.*

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