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BIO-RATIONAL MANAGEMENT APPROACHES OF FRUIT BORER, *HELICOVERPA ARMIGERA* (HÜBNER) INFESTING TOMATO

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Abstract

The present study was conducted during November 2014 to June, 2015 with bio-rational approaches for combating tomato borer, *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) using Vertimec 1.8EC (Abamectin), Tracer 45SC (Spinosad), mechanical control (hand picking), 3 Neem products and an untreated control following Randomized Complete Block Design with 3 replications. The lowest level of fruit borer infestation (11.05% by number) at entire fruiting seasons and at early (11.05%), mid (10.88%) and late (11.28%) fruiting season was obtained from Tracer 45EC treated plot. The highest marketable yield (46.00 t/ha) was produced in the plot treated with Tracer 45SC sprayed @ 0.4 ml/L of water at 15 days interval. The marketable yield in plots treated with Vertimec 1.8EC @ 1.2 ml/L of water at 15 days interval was 37.67 t/ha and the plot sprayed with neem seed kernel extract @ 50 g/L of water at 15 days interval yielded 36.17 t/ha. The highest benefit cost ratio of 6.84 was obtained from the plot applied with Tracer 45SC followed by 6.39 obtained in the plots using Vertimec 1.8EC and this was followed by 6.18 found in neem seed kernel extract treated plot. Tracer 45SC was the most effective against tomato fruit borer.

Keywords: Bio-rational pesticides, neem, *Helicoverpa armigera*, mechanical control

Introduction

Tomato (*Solanum lycopersicum*) is one of the most popular and important vegetable grown in Bangladesh during *rabi* season and round in many countries globally. In Bangladesh, Tomato yield is not satisfactory enough compared to other tomato growing countries of the world (Aditya *et al.,* 1999). Different limiting factors are responsible for the low yield of tomato in Bangladesh. Among them the attack of insect pest from seeding to fruiting stage is the important factor for low yield of tomato because all the plant parts including leaves, stems, flowers and fruits are subjected to attack.

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The tomato plant is attacked by different species of insect pests such as fruit borer, white fly, aphid and leaf miner in Bangladesh. Among them tomato fruit borer, *Helicoverpa armigera* (Hübner) is one of the serious pests. It has been reported to cause damage to an extent of 50-60 % fruits (Singh and Singh, 1977). Fruit damage by this pest might be up to 85-93%. Due to severe infestation, fruit as well as seed maturation hampered greatly and the viability of the seeds reduced (Tewari, 1985).

Though the tomato fruit borer (*H. armigera*) is a major pest in status, the management of this pest through non-chemical tactics including cultural, mechanical, biological and host plant resistance undertaken by the researcher throughout the world is limited. Generally the farmers of Bangladesh combat this pest by the application of chemical insecticides. In Bangladesh, it was reported that cypermethrin, deltamethrin, fenvalerate and quinalphos @ 1.5 ml/L of water gave the better result in controlling tomato fruit borer (Alam *et al.,* 2003). However, indiscriminate and non-judicious use of insecticides may result in a serious problem related to both loss of their effectiveness and in the long run, it develops insect resistance, pollution and health hazards (FAO, 2003). Moreover, continuous use of chemical insecticides develops cross and multiple resistant strains in many important insect species (Geiger *et al*., 2010) including this fruit borer. Indiscriminate and haphazard use of these chemicals, particularly at fruiting stage, leads to its accumulation in the vegetables which consequently cause hazards to human health through food chain (Nafees *et al.,* 2009). As the tomato is mostly consume in raw, so the problems is more serious than any other vegetables. Again the question of residual toxicity of pesticides is another big threat to our vegetable exports in the foreign markets (Islam *et al.,* 1999). Therefore, eco-friendly management approach is must to reduce the environment and health hazards. Various non-chemical approaches like use of environment friendly biopesticides, botanicals, clean cultivation, mechanical control like hand picking and destroying of infested plant parts are common practices used for suppressing the insect pests (Hassan, 1994). Appropriate knowledge and availability of botanical pest management approaches and their integration with selective chemicals may give better results against tomato fruit borer. Considering the circumstances, the present study was conducted to evaluate the effectiveness of some bio-rational management approaches against *H. armigera* in tomato field.

Materials and Methods

Experimental site and design

The study was conducted in the experimental farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur during November 2014 to June 2015. The experiment was laid out in a Randomized Complete Block Design (RCBD) with 3 replications. The unit plot size was 3m × 3m and separated by 1m and block to block distance was 2m.

Growing of tomato

The seeds of 'BARI tomato-3' were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. Seeds were sown in a seed tray. The seedlings were germinated in the seed tray and 10 days after germination, all the seedlings were transplanted into poly bags. From poly bags 30 days old seedlings were transplanted in the experimental plot of each treatment. A total 315 seedlings were transplanted in 21 plots at the rate of 15 seedlings per plot with the distance of 1m between lines and 60 cm between plants. Gap filling was done by transplanting seedlings from the stock. Manures and fertilizers were applied according to Rashid (1999) and intercultural operations such as irrigation, weeding, mulching, and other operations were done throughout the cropping season for proper growth and development of the plants.

Application of treatments

The experimental field was monitored regularly to observe the initiation of infestation. When the pest caused approximately 2% fruit infestation, the application of treatments was started. The experimental treatments were Vertimec 1.8EC (Abamectin) @ 1.2 ml/L, Tracer 45 SC (Spinosad) @ 0.4 ml/L, Neem seed kernel extract (Azadirachtin) @ 50 g/L, Neem leaf extract (Azadirachtin) @ 50 g/L, Neem oil (Azadirachtin) @ 5.0 ml/L of water and Mechanical control (hand picking) with clean cultivation.

For preparing Neem (*Azadirachta indica*) seed karnel extract, mature seeds were collected, sun dried and grounded into powder. The powder was soaked in water @ 50g/300 ml of water for overnight. The mixture was filtered through nylon net and maintained the volume of 1000 ml. For neem leaf extract, fresh leaves were collected one day before application and were cut into small pieces and 500g leaves were blended thoroughly in an electric blender. The blended leaves were mixed with two liters of water and the mixture was kept overnight to enhance extraction. The mixture was then sieved and maintained the volume at 5 liters. All the treatments were applied at 15 days interval by knapsack sprayer and repeated 4 times up to last harvest.

Collection and analysis of data

Data on fruit infestation and fruit yield by number and weight per plot were recorded at early, mid and late fruiting stages on each harvest by number of the harvests sequentially. The infestation of the pest was expressed in percentage based on total number of fruit (n/n) and weight (w/w) of fruit. The cumulative yield (kg) per plot of healthy as well as infested fruits was computed. The final yield was expressed in ton per hectare. For economic analysis, benefit cost ratio (BCR) was calculated on the basis of total expenditure of the respective spray schedule along with the total return from that particular spray schedule. The data

were analyzed statistically by analysis of variance (ANOVA) and the means were separated by using Duncan's Multiple Range Test (DMRT).

Results and discussion

Rate of fruit infestation by number at different fruiting stages

All the bio-rational management approaches significantly reduced percent fruit infestation (n/n) in early, mid and late fruiting stages compared to untreated control plot (Table 1). Significantly the lowest fruit infestation by number (11.05%) was found in Tracer 45 SC treated plot. At early fruiting stage, significantly the highest fruit infestation was found in untreated control plot (31.71%) followed by neem leaf extract (23.76%), neem oil (23.66%) and Vertimec 1.8EC (22.62%) sprayed plots and these were statistically similar to each other. Percent infested fruit by number recorded from neem seed kernel extract treated plot and mechanical control (hand picking) with clean cultivation were 18.17% and 17.37%, respectively and these were statistically similar with each other (Table 1).

At mid fruiting stage, significantly the highest fruit infestation was found in untreated control plot (24.00%) followed by Vertimec 1.8EC sprayed plot (18.89%). Percent infested fruit recorded from the plot treated with neem seed kernel extract, neem leaf extract, neem oil and mechanical control (hand picking) with clean cultivation were 15.82%, 12.67%, 14.59% and 13.25%, respectively and these were statistically similar with each other. Significantly the lowest fruit infestation by number was found in Tracer 45SC sprayed plot (10.88%) (Table 1).

At late fruiting stage, significantly the lowest rate of fruit infestation (11.28 %) was found in Tracer 45SC treated plot followed by mechanical control (hand picking) with clean cultivated plot (16.66%). Significantly the highest fruit infestation by number was found in untreated control plot (30.76%) followed Vertimec 1.8EC (25.08%) sprayed plot. Percent infested fruit recorded from neem oil, neem seed kernel extract and neem leaf extract treated plot were 20.53%, 21.42% and 23.28%, respectively and these were statistically significant with each other (Table 1).

Mittal and Ujagir (2005) evaluated newer molecule Spinosad 45SC along with other insecticides. Among different treatments lower number of *H. armigera*, *Maruca vitrata* (Geyer) and *Melanagromyza obtusa* (Malloch) larvae were recorded in Spinosad 90 g/ha and Spinosad 73 g/ha and also recorded lower pod damage compared to other treatments. Mechanical control comprising removal of infested fruits is a safe and cheap control technique. It was found that the larvae of *H. armigera* can be controlled successfully by this methods following every alternate day during marble size tomato to before ripen period. Report revealed that about 75% control is possible only by this method. But better result

was obtained by mechanical method + spraying of botanical pesticides (Uddin, *et al.*, 2002).

Table 1. Tomato fruit infestation by *H. armigera* at early, mid and late fruiting stages in different management practices

Treatment	Rate of fruit infestation (%)		
	Early fruiting stage	Mid fruiting stage	Late fruiting stage
Vertimec 1.8EC	22.62b	18.89b	25.08b
Tracer 45SC	11.05d	10.88c	11.28e
Neem seed kernel extract	18.17bc	15.82bc	21.42c
Neem leaf extract	23.76b	12.67bc	23.28bc
Neem oil	23.66b	14.59bc	20.53c
Mechanical control	17.37bc	13.25bc	16.66d
Untreated control	31.71a	24.00a	30.76a
CV (%)	8.56	6.85	6.18

Means within a column followed by same letter(s) do not differ significantly (P=0.05) according to Duncan's Multiple Range Test (DMRT).

Fruit infestation in total cropping season

In total cropping season, the lowest rate of fruit infestation by number was found in Tracer 45SC treated plot (11.05%) as against (27.63%) the highest fruit infestation in untreated control plot (27.63%). Percent infested fruit recorded from Vertimec 1.8EC, neem oil, neem seed kernel extract, neem leaf extract, and mechanical control (hand picking) with clean cultivation were 21.15%, 17.78%, 17.70%, 17.04% and 16.88%, respectively. The increase in number of healthy fruit over untreated control was 23.45%, 60.00%, 35.93%, 38.32%, 35.64% and 38.90% with Vertimec 1.8EC, Tracer 45SC, neem seed kernel extract, neem leaf extract, neem oil and mechanical control (hand picking) with clean cultivation, respectively (Table 2).

In total cropping season, the lowest rate of fruit infestation by weight was found in Tracer 45SC treated plot (8.85%). The highest fruit infestation was found in untreated control plot (36.29%) followed by plot sprayed with neem seed kernel extract (18.79%). Percent infested fruit recorded from Vertimec 1.8EC, neem leaf extract, neem oil treated plot and mechanical control (hand picking) with clean cultivated plot were 15.66%, 15.64%, 18.67% and 18.67%, respectively. The reduction percentage of weight of infested fruit over untreated control was 39.86%, 63.53%, 27.89%, 49.89%, 42.44% and 50.34% with Vertimec 1.8EC, Tracer 45SC, neem seed kernel extract, neem leaf extract, neem oil and mechanical control (hand picking) with clean cultivation, respectively (Table 2).

Sparks *et al*. (1995) reported that Spinosad has relatively broad spectrum activity and has been effectively used for the control of many species of insect pests in the order of Lepidoptera in various crop systems. The results on the mean percent fruit damage by *L. orbonalis* indicated that Spinosad was found to be effective in checking the fruit damage.

Botanical pesticides are becoming popular day by day. Now a days, these are using against many insects. It was found that Lepidopteran insect is possible to control by botanical substances. Weekly spray application of the extract of neem seed kernel showed effective against *H. armigera* (Karim, 1994).

Table 2. Effect of different management practices on fruit infestation by tomato fruit borer at entire cropping season

Treatment	Rate of infestation (n/n)		Rate of infestation (w/w)	
	% infestation	% reduction over untreated control	% infestation	% reduction over untreated control
Vertimec 1.8EC	21.15b	23.45	15.66b	39.86
Tracer 45SC	11.05d	60.00	8.85c	63.53
Neem seed kernel extract	17.70c	35.93	18.79b	27.89
Neem leaf extract	17.04c	38.32	15.64b	49.89
Neem oil	17.78c	35.64	15.26b	42.44
Mechanical control	16.88c	38.90	18.67b	50.34
Untreated control	27.63a	-	36.29a	
CV (%)	12.37	-	8.19	-

Means within a column followed by same letter(s) do not differ significantly (P=0.05) according to Duncan's Multiple Range Test (DMRT).

Yield of tomato

All bio-rational management approaches produced significant quantity of marketable yield and decreased the quantity of infested yield compared to untreated control plot. Significantly the highest marketable yield was recorded from Tracer 45SC treated plot (46.00 t/ha) (Table 3). The second highest yield of healthy fruits was found in Vertimec 1.8EC (37.67 t/ha) followed by neem seed kernel extract (36.17 t/ha), neem oil (35.08 t/ha), and neem leaf extract (33.16 t/ha) which were statistically similar to each other. The lowest weight of healthy fruits per plot was recorded from untreated control plot (21.49 t/ha) having significance difference with mechanical control (hand picking) with clean cultivation (26.49 t/ha).

Significantly the lowest infested yield t/ha was recorded from Tracer 45SC treated plot (4.47 t/ha) having no significance difference with mechanical control (hand picking) with clean cultivated plot (6.08 t/ha) and neem leaf extract (6.16

t/ha). Statistially similar infested fruit yield was obtained from in Vertimec 1.8EC treated plot (7.36 t/ha), neem seed kernel extract (8.83 t/ha) and neem oil treated plot (7.06 t/ha). The highest weight of infested fruits (12.24 t/ha) was observed in untreated control plot which was statistically different from all other treatments (Table 3).

Significantly the highest total yield/ha was recorded from Tracer 45SC treated plot (50.47 t/ha). The second highest yield was found in neem seed kernel extract (45.00 t/ha) which was statistically similar to Vertimec 1.8EC (45.03 t/ha), neem leaf extract (39.32 t/ha) and neem oil (42.14 t/ha). The lowest total yield (t/ha) was recorded from mechanical control (hand picking) and clean cultivated plot (32.57 t/ha) which was statistically similar to that of control plot (33.73 t/ha) and also with Neem Leaf Extract sprayed plot (39.32 t/ha) (Table 3).

Awal (2012) reported that the highest healthy fruit yield in brinjal 20.70 t/ha was obtained in the plots treated with IPM package comprising Tracer 45SC @ 0.4 ml/L + pheromone trap + mechanical control and field sanitation followed by IPM packages consisting Tracer 45SC 0.4 ml/L + pheromone trap (18.56 t/ha), and in sole use of Tracer 45SC @ 0.4 ml/L (16.78 t/ha). He also reported, the highest percent healthy fruit yield increased (116.60%) over control was recorded in the plots treated with IPM package consisting of Tracer 45SC 0.4 ml/L + pheromone trap + mechanical control and field sanitation followed by IPM package consisting of Tracer 45SC @ 0.4 ml/L + pheromone trap (94.20%) and then in sole use of Tracer 45SC @ 0.4 ml/L (75.57%) and IPM package consisting Bactoil @ 2.0 ml/L + pheromone trap + mechanical and field sanitation (68.36%).

Table 3. Fruit yield of tomato in different management approaches applied against tomato fruit borer

Treatment	Yield (t ha^{-1})		
	Marketable	Infested	Total yield
Vertimec 1.8EC	37.67b	7.36b	45.03b
Tracer 45SC	46.00a	4.47c	50.47a
Neem seed kernel extract	36.17b	8.83b	45.00b
Neem leaf extract	33.16b	6.16bc	39.32bc
Neem oil	35.08b	7.06b	42.14b
Mechanical control	26.49c	6.08bc	32.57c
Untreated Control	21.49c	12.24a	33.73c
CV (%)	7.45	8.97	10.43

Means within a column followed by same letter(s) do not differ significantly (P=0.05) according to Duncan's Multiple Range Test (DMRT).

Effectiveness of Spinosad 45EC along with other standard insecticides was tested against pigeon pea pod borer by Vishal and Ram (2005). Lower pod damage in pigeon pea was observed in Spinosad 90g, Spinosad 73g, Spinosad 56g and Spinosad 45g treated plots compared to untreated control plot over two years. Accordingly, greater grain yields were also obtained in Spinosad 90g (1741 kg/ha), Spinosad 73g (1463 kg/ha), Spinosad 45g (1218 kg/ha) and Spinosad 56g (1213 kg/ha) treated plots as compared to untreated control (768 kg/ha) plot.

Economic analysis

The management cost of different management approaches is presented in Table 4. The highest gross return of Tk. 460000.00 per hectare was found in Tracer 45SC treated plot followed by Tk. 376700.00 in Vertimec 1.8EC applied plot, Tk. 361700.00 in neem seed kernel extract sprayed plot and Tk. 350800.00 in neem oil sprayed plot. On the other hand, the lowest gross return Tk. 214900.00 was calculated in untreated control plot followed by Tk. 264900.00 in the mechanical control plot and Tk. 331600.00 in neem leaf extract treated plot (Table 4).

The highest net return of Tk. 428770.00 per hectare was found in Tracer 45SC treated plot followed by Tk. 354830.00 in Vertimec 1.8EC applied plot and Tk. 341270.00 in neem seed kernel extract sprayed plot. On the other hand, the lowest net return Tk. 214900.00 was calculated in untreated control plot followed by Tk. 253200.00 in the mechanical control plot, Tk. 311170.00 in neem leaf extract treated plot and Tk. 311370.00 in neem oil sprayed plot (Table 4).

The highest adjusted net return of Tk. 213870.00 per hectare was found in Tracer 45SC treated plot followed by Tk. 139930.00 in Vertimec 1.8EC applied plot and Tk. 126370.00 in neem seed kernel extract sprayed plot. On the other hand, the lowest adjusted net return Tk. 38300.00 was calculated in the mechanical control plot followed by Tk. 96470.00 in neem oil treated plot and Tk. 96270.00 in neem leaf extract sprayed plot (Table 4).

The highest benefit cost ratio of 6.84 was obtained from the treatment with Tracer 45SC and the second highest benefit cost ratio of 6.39 was recorded from the plot treated with Vertimec 1.8EC followed by neem seed kernel extract treated plot (6.18). The lowest benefit cost ratio of 2.44 was found in the treatment with neem oil. The benefit cost ratio in the mechanical control (hand picking) and clean cultivated plot and neem leaf extract sprayed plot were 3.27 and 4.71, respectively (Table 4).

The findings of the present study indicated that the insecticide Tracer 45SC, Vertimec 1.8EC and neem seed kernel extract are effective to manage infestation of tomato fruit borer in tomato. The result of this study reveal that Tracer 45SC, Vertimec 1.8EC and neem seed kernel extract showed effective result in suppressing tomato fruit borer infestation and also found as cost effective.

Spinosad and Emamectin benzoate have given good control of the southern armyworm and tomato pinworm (Stansly *et al.*, 2001). Dandale *et al.* (2000) studied the efficacy of Spinosad 48 SC against cotton bollworm and found effective.

Awal (2012) reported that in suppression of BSFB, the BCR was the highest (7.15) in an IPM package consisting of Tracer 45SC @ 0.4 ml/L + pheromone trap + mechanical control and field sanitation followed by 6.72 and 5.47 in the IPM packages consisting of Tracer 45SC @ 0.4 ml/L + pheromone trap and in sole use of Tracer 45SC 0.4 @ ml/L, respectively which is similar to the present findings. Patel *et al.* (1991) observed the highest BCR 5.26 by spraying Endosulfan against *H. armigera* attacking tomato.

Table 4. Benefit cost ratio analysis of different management practices applied against tomato fruit borer

IPM package	Management cost (Tk)	Gross return (Tk)	Net return (Tk)	Adjusted net return (Tk)	BCR
Vertimec 1.8EC	21870.00	376700.00	354830.00	139930.00	6.39
Tracer 45SC	31230.00	460000.00	428770.00	213870.00	6.84
Neem seed kernel extract	20430.00	361700.00	341270.00	126370.00	6.18
Neem leaf extract	20430.00	331600.00	311170.00	96270.00	4.71
Neem oil	39430.00	350800.00	311370.00	96470.00	2.44
Mechanical control	11700.00	264900.00	253200.00	38300.00	3.27
Untreated control	0.00	214900.00	214900.00	0.00	-

Market value of tomato=10Tk./kg, The cost of Vertimec 1.8EC @ Tk. 90/50 ml bottle, Tracer 45SC @ Tk 695/25ml bottle, Neem Seed Kernel Extract @ Tk 200/kg, Neem oil @ 120Tk/100 ml, Insecticide preparation and application @ 3 labor/ha, Labor wage @ Tk. 260/day, Sprayer rent @ Tk. 30/day.

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