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MANAGEMENT OF BRINJAL SHOOT AND FRUIT BORER *LEUCINODES ORBONALIS* GUENEE USING DIFFERENT APPROACHES

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Abstract

The present study was conducted during October 2014 to June 2015 in the farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur to find out the most effective management option (s) against brinjal shoot and fruit borer (BSFB) with 6 treatments namely, *Beauveria bassiana*, 1×109 CFU @ g l^{-1}, Bioneem 0.3 EC (Azadirachtin) @ 1.5 ml l^{-1}, Tracer 45 SC (Spinosad) @ 0.4 ml l^{-1}, Vertimec 1.8 EC (Abamectin) @ 1.2 ml l^{-1} of water, Mechanical control (hand picking) with clean cultivation and untreated control. Results revealed that shoot infestation at pre-fruiting stage was the lowest in Bioneem 0.3 EC (4.34%) and at fruiting stage in Tracer 45 SC treated plot (7.75%) and the highest was in untreated control plot (17.94% at pre-fruiting stage and 39.46 at fruiting stage). The lowest fruit infestation by BSFB was obtained with Tracer 45 SC (8.16% n/n and 10.0% w/w) followed by *B. bassiana*, 1×109 CFU (23.23% n/n and 18.27% w/w) and the highest infestation was observed under untreated control plot (48.59% n/n and 32.09% w/w). Percent reduction of infested fruit by number (83.21%) and weight (68.84%) over untreated control was higher in Tracer 45 SC treated plot resulting significantly higher marketable yield. Therefore, the significant highest marketable yield (34.39 t ha^{-1}) was harvested in the plot treated with Tracer 45 SC followed by 22.78 t ha^{-1} with *B. bassiana*, 1×109 CFU and 19.26 t ha^{-1} from Vertimec 1.8 EC treated plot. The highest benefit cost ratio of 3.05 was obtained from Tracer 45 SC followed by 2.93 in *B. bassiana*, 1×109 CFU and 2.89 with Vertimec 1.8 EC sprayed plot.

Keywords: *Leucinodes orbonalis*, microbial pesticide, biopesticide, mechanical control.

Introduction

Brinjal (*Solanum melongena* L.) is one of the popular vegetables favored by the people of many countries *viz.*, Central, South and South East Asia, some parts of Africa and Central America (Harish *et al.*, 2011). It is native to India and is grown all over Bangladesh (Pareet, 2006). Eggplant is extensively damaged by the brinjal fruit and shoot borer (BSFB) (*Leucinodes orbonalis*) which caused 31-86% fruit damage in Bangladesh (Alam *et al.,* 2003). It is the most noxious and

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destructive pest of brinjal. It is reported that BSFB attacks either sporadically or in outbreak every year throughout the Indian subcontinent (Chakraborti and Sarkar, 2011).

To overcome this loss, different types of insecticides are used by the farmers of Bangladesh and they apply indiscriminately even at fruiting stage (Zafar *et al*., 2012). Different combinations of management packages were used by our Bangladeshi farmer to manage BSFB. The combination of Chlorpyriphos 50% EC + Cypermethrin 5% EC, being the most effective and economically viable insecticide to manage *L. orbonalis* in eggplant crop (Sharma *et al.,* 2012). A survey of pesticide use in Bangladesh indicated that farmers sprayed chemical insecticides up to 180 times during a cropping season to protect their eggplant crop infested by the eggplant fruit and shoot borer, *L. orbonalis* (SUSVEG-Asia, 2007). Spraying frequency was reported 140 times or more in the 6-7 months cropping season and contributed to 32% of total cost of production (Alam *et al.*, 2003).

However, indiscriminate and non-judicious use of insecticides may result in a series problem related to both loss of their effectiveness and in the long run, it develops insect resistance (Alam *et al.,* 2003), pollution and health hazards (FAO, 2003). Again the question of residual toxicity of pesticides in brinjal is another big threat to our vegetable exports in the foreign markets (Islam *et al.*, 1999). Therefore, environment friendly management approach is a must to reduce environment and health hazards and to manage this pest eco-friendly. Various non-chemical approaches like biopesticides, botanicals, clean cultivation, mechanical control like hand picking and destroying of infested plant parts particularly shoots and fruits are common practices used for suppressing the insect pests (Hassan, 1994).

Due to lack of knowledge and unavailability of non-chemical pest management approaches, growers of Bangladesh mostly depend on insecticides to keep the crop production steady. Appropriate knowledge and availability of botanical pest management approaches and their integration with selective chemicals may give better results against brinjal shoot and fruit borer. Considering the circumstances, the present study was conducted to evaluate the effectiveness of some eco-friendly management approaches against *L. orbonalis* in brinjal field.

Materials and Method

The experiment was conducted in the experimental farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur during October 2014 to June 2015 following 6 treatment and three replications with Randomized Complete Block Design (RCBD). The treatments were as follows:

T_1= *Beauveria bassiana*, 1×109 CFU @ g l^{-1}, T_2= Bioneem 0.3 EC (Azadirachtin) @ 1.5 ml l^{-1}, T_3= Tracer 45 SC (Spinosad) @ 0.4 ml l^{-1}, T_4=

Vertimec 1.8 EC (Abamectin) @ 1.2 ml l^{-1} of water, T_5= Mechanical control (hand picking) with clean cultivation, T_6= Untreated control.

BARI Brinjal-2 (Tarapuri) were used in this study. Manures and fertilizers were applied according to Rashid (1999) and intercultural operations such as irrigation, weeding, mulching, thinning and other operations were done throughout the cropping season for proper growth and development of the plants.

When the pest caused approximately 2% shoot infestation, the application of treatments was started. All the treatments were applied at 10 days interval and repeated 6 times up to last harvest. Data on shoot and fruit infestation, yield by number and weight were recorded. Total number of shoots and the number of infested shoots were recorded from 5 plants randomly selected in each plot at before and after flowering to fruit initiation and at fruiting stages at 7 days interval. The number of healthy and infested fruits and their weight per plot were recorded at each harvest. The infestation of the pest was expressed in percentage based on total number of shoot and fruit (n/n) and weight (w/w) of fruit.

The cumulative yield in Kg per plot of healthy as well as infested fruits was computed. For economic analysis, Marginal Benefit Cost Ratio (MBCR) 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 by using MSTAT-C software for analysis of variance (ANOVA) and the means were separated by using Duncan's Multiple Range Test (DMRT) at 5% level.

Results and discussion

Rate of shoot infestation

Efficacy of the environment friendly management approaches to reduce the infestation varied appreciably at both pre-fruiting and fruiting stages. All the environment friendly management approaches significantly reduced percent shoot infestation in both stages compared to untreated control plot (Table 1). Shoot infestation ranged 5.08-17.94% at pre-fruiting and 7.75-39.46% at fruiting stages under different treatments. At pre-fruiting stage, the highest shoot infestation was recorded in untreated control plot (17.94%) and the lowest infestation (5.08%) was obtained with Bioneem 0.3 EC which was statistically similar to Tracer 45 SC (5.19%), and *B. bassiana*, 1×109 CFU (5.51%) treated plots followed by in Vertimec 1.8 EC (8.57%) and mechanical control (9.43%) plots. The highest shoot infestation reduction over untreated control was 71.68% under Bioneem 0.3 EC followed by Tracer 45 SC (71.05%) and *B. bassiana*, 1×109 CFU (69.29%) treated plots. The least shoot infestation reduction over untreated control was found in mechanical control plot (47.40%) followed by Vertimec 1.8 EC (52.23%) treated plot (Table 1).

At fruiting stage, the highest shoot infestation was observed in untreated control plot (39.46%) and the lowest infestation (7.75%) was obtained with Tracer 45 SC which was statistically significant from other approaches followed by *B. bassiana*, 1×109 CFU (16.20%), Vertimec 1.8 EC (20.69%) and Bioneem 0.3 EC (22.08%) treated plots followed by in mechanical control (30.33%) plots. The highest shoot infestation reduction over untreated control was 80.36% under Tracer 45 SC followed by *B. bassiana*, 1×109 CFU (58.95%), Vertimec 1.8 EC (47.57%) and Bioneem 0.3 EC (44.04%) treated plots. The least shoot infestation reduction over untreated control was found in mechanical control plot (23.14%) (Table 1).

Chatterjee *et al.* (2009) revealed that the lowest mean shoot as well as fruit infestation (7.47 and 9.88%) was recorded in the plots treated with Spinosad 2.5 SC (50 g a.i. ha^{-1}). Singh *et al.* (2009) observed that Profenofos @ 0.1% and Spinosad @ 0.01% were most effective in reducing shoot infestation by *L. orbonalis* and resulted higher brinjal fruit yield.

Islam *et al.* (1999) observed the minimum acceptable level of shoot infestation reduction over untreated control was 80.00% by applying different insecticides. Devi *et al*. (2014) conducted their experiment on comparative efficacy of some biorational insecticides for management of shoot and fruit borer (*Earies Vittella* Fab.) attacking okra. Pooled data of two years of experiment (2012 and 2013) expressed 8.30% shoot and fruit infestation and 59.88 (q ha^{-1}) yield was obtained due to application of *B. bassiana* @ 300 (g a.i. ha^{-1}).

Table 1. Effect of different treatments on brinjal shoot infestation by BSFB at pre-fruiting and fruiting stages during October 2014 to June 2015

Treatments	Pre-fruiting stage		Fruiting stage	
	% shoot infestation	% shoot infestation reduction over untreated control	% shoot infestation	% shoot infestation reduction over untreated control
Beauveria bassiana, 1×109 CFU	5.51cd	69.29	16.20c	58.95
Bioneem 0.3 EC	5.08d	71.68	22.08c	44.04
Tracer 45 SC	5.19d	71.05	7.75d	80.36
Vertimec 1.8 EC	8.57bc	52.23	20.69c	47.57
Mechanical control	9.43b	47.40	30.33b	23.14
Untreated control	17.94a	-	39.46a	-
CV (%)	9.65	-	8.42	-

Means within a column with a common letter(s) do not differ significantly (P=0.05) according to DMRT at 5% level.

Rate of fruit infestation (n/n and w/w)

In entire cropping season, significantly the lowest rate of fruit infestation (n/n) was found in Tracer 45 SC (8.16%) treated plot. The highest fruit infestation was obtained from untreated control plot (48.59%) followed by mechanical control plot (41.35%) with no significant difference between them. Percent infested fruit was recorded from *B. bassiana*, 1×109 CFU, Vertimec 1.8 EC and Bioneem 0.3 EC were 23.23%, 26.40% and 27.62%, respectively with no statistical difference among them. The percent reduction of fruit infestation (n/n) over control was 52.19%, 43.16%, 83.21%, 45.67% and 14.90% utilizing *B. bassiana*, 1×109 CFU, Bioneem 0.3 EC, Tracer (Spinosad) 45 SC, Vertimec 1.8 EC and mechanical control, respectively (Table 2).

In entire cropping season, the lowest rate of fruit infestation (w/w) was found in Tracer 45 SC (10.00%) treated plot. The highest fruit infestation was found in untreated control plot (32.09%) which was followed by mechanical control plot (26.47%), Bioneem 0.3 EC (24.08%), Vertimec 1.8 EC (23.57%) and *B. bassiana*, 1×109 CFU (18.27%) treated plot, respectively. No statistical difference was noted in fruit infestation (w/w) by the treatments of mechanical control, Vertimec 1.8 EC and Bioneem 0.3 EC. The percent reduction of fruit infestation (w/w) over control was 43.07%, 24.96%, 68.84%, 26.55% and 17.51% obtained in plots treated with *B. bassiana*, 1×109 CFU, Bioneem 0.3 EC, Tracer 45 SC, Vertimec 1.8 EC and mechanical control, respectively (Table 2).

The results of the present study can be compared to those obtained by the finding by Aparna and Dethe (2006) who studied the bioefficacy of Spinosad during Kharif 2005 and 2006. The lowest fruit infestation percentage was found of 13.34%, 13.69%, 7.89% and 8.21% on number and weight basis. The results of the mean fruit damage (%) by *L. orbonalis* in first (2005) and second (2006) trials indicated that Spinosad was found to be effective in suppressing the fruit damage among the treatments tested. The higher percent reduction of fruit damage over control was observed in Spinosad treated plants, which were 90.71% and 86.81% in 2005 and 2006, respectively.

Mamun *et al*. (2014) reported that the lowest fruit infestation was observed from the plot with Spinosad + pheromone trap. The combined management practices of setting pheromone trap with Spinosad spraying reduced the brinjal fruit infestation (5.95%) significantly than other treatments (14.09% for Spinosad and 19.18% for pheromone trap). 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 of Lepidoptera attacking various crops.

The present findings are comparable to the findings by Mittal and Ujagir (2005) who evaluated the newer molecule Spinosad (Tracer) 45% SC along with other insecticides. The results showed that among different treatments, the lower pod damage and lower number of *Helicoverpa armigera*, *Maruca vitrata* (Geyer) and *Melanagromyza obtusa* (Malloch) larvae were recorded in Spinosad 90 g ha^{-1} and Spinosad 73 g ha^{-1} treated plot.

Table 2. Effect of different treatments on the rate of brinjal fruit infestation by BSFB during October 2014 to June 2015

Treatments	Rate of fruit infestation (n/n)		Rate of fruit infestation (w/w)	
	% fruit infestation	% fruit infestation reduction over untreated control	% fruit infestation	% fruit infestation reduction over untreated control
Beauveria bassiana, 1×109 CFU	23.23 c	52.19	18.27 c	43.07
Bioneem 0.3 EC	27.62 c	43.16	24.08 b	24.96
Tracer 45 SC	8.16 d	83.21	10.00 d	68.84
Vertimec 1.8 EC	26.40 c	45.67	23.57 b	26.55
Mechanical control	41.35 b	14.90	26.47 b	17.51
Untreated control	48.59 a	-	32.09 a	-
CV (%)	7.83	-	5.28	-

Means within a column with a common letter(s) do not differ significantly (P=0.05) according to DMRT at 5% level.

Yield of brinjal (t ha^{-1})

All the treatments produced significant quantity of marketable yield and decreased the quantity of infested yield compared to untreated control plot. Significantly the highest marketable yield (34.39 t ha^{-1}) was recorded from Tracer 45 SC plot which was higher than that of other treatments. The second highest yield of healthy fruits was found in *B. bassiana*, 1×109 CFU sprayed plot (22.78 t ha^{-1}) which was statistically similar to Bioneem 0.3 EC (19.06 t ha^{-1}) and Vertimec 1.8 EC (19.26 t ha^{-1}) treated plots. The lowest yield of marketable fruits (15.94 t ha^{-1}) was recorded from untreated control which was statistically similar to that of mechanical control (17.28 t ha^{-1}), Vertimec 1.8 EC and Bioneem 0.3 EC plots (Table 03).

Significantly the lowest weight of infested yield was recorded from Tracer 45 SC treated plot (3.82 t ha^{-1}) which was statistically similar to that of *B. bassiana*, 1×109 CFU sprayed plot (5.09 t ha^{-1}). Weight of infested yield was found in Vertimec 1.8 EC, Bioneem 0.3 EC and mechanical control with clean cultivated plot were 5.94 t ha^{-1}, 6.05 t ha^{-1} and 6.22 t ha^{-1}, respectively. The highest weight of infested fruits was harvested from the untreated control plot (7.53 t ha^{-1}) which was statistically different from all other treatments (Table 3).

Significantly the highest total yield was recorded from Tracer 45 SC treated plot (38.21 t ha^{-1}) followed by *B. bassiana*, 1×109 CFU sprayed plot (27.87 t ha^{-1}) which was statistically similar to that of Bioneem 0.3 EC (25.11 t ha^{-1}) and Vertimec 1.8 EC (25.20 t ha^{-1}) treated plots. The lowest weight of healthy fruits yield was recorded from untreated control plot (23.47 t ha^{-1}) which was statistically similar to that of mechanical control (23.51 t ha^{-1}), Vertimec 1.8 EC and Bioneem 0.3 EC treated plots (Table 3).

Adiroubane and Raghuraman (2008) reported that Spinosad (45 SC @ 225 g a.i. ha^{-1}) was effective along with Oxymatrine (1.2 EC @ 0.2%) applied against *L. orbonalis*. Spinosad was superior in producing marketable yield as it reduced the fruit damage and was at par with oxymatrine. Similarly, Awal (2012) reported that the highest healthy fruit yield in brinjal 20.70 t ha^{-1} was obtained in the plots treated with IPM package comprising Tracer 45 SC 0.4 ml l^{-1} + Pheromone trap + Mechanical control and field sanitation followed by IPM packages consisting Tracer 45 SC 0.4 ml l^{-1} + Pheromone trap (18.56 t ha^{-1}), and in sole use of Tracer 45 SC @ 0.4 ml l^{-1} (16.78 t ha^{-1}). Similarly, Chatterjee *et al.* (2009) also reported that Flubendiamide, Spinosad and Chlorfenapyr were highly effective in reducing the damage caused by *L. orbonalis* on brinjal and led to increases in yield.

Effectiveness of Spinosad (Tracer) 45 EC along with other standard insecticides was tested against pigeon pea pod borer by Vishal and Ram (2005). Lower pod damage 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^{-1}), Spinosad 73g (1463 kg ha^{-1}), Spinosad 45g (1218 kg ha^{-1}) and Spinosad 56g (1213 kg ha^{-1}) treated plots as compared to untreated control (768 kg ha^{-1}) plot.

Table 3. Effect of different treatments against BSFB on fruit yield (t ha^{-1}) during October 2014 to June 2015

Treatment	Yield (t ha^{-1})		
	Marketable	Infested	% marketable yield increase over untreated control
Beauveria bassiana, 1×109 CFU	22.78b	5.09c	27.87b
Bioneem 0.3 EC	19.06bc	6.05b	25.11bc
Tracer 45 SC	34.39a	3.82c	38.21a
Vertimec 1.8 EC	19.26bc	5.94b	25.20bc
Mechanical control	17.28c	6.22b	23.51c
Untreated control	15.94c	7.53a	23.47c
CV (%)	9.67	6.78	-

Means within a column with a common letter(s) do not differ significantly (P=0.05) according to DMRT at 5% level.

Economic analysis

The management cost of different treatments used against brinjal shoot and fruit borer was calculated and presented in Table 4. The untreated control plot did not require any pest management cost. Although the marketable yield differed in various control measures but the calculated benefit cost ratio (BCR) provided separate scenarios for variation in pest management cost.

The highest gross return of Tk. 756637.00 ha^{-1} was found in Tracer 45 SC treated plot followed by Tk. 462799.00 in *B. bassiana*, 1×109 CFU applied plot and Tk. 423704.00 in Vertimec 1.8 EC sprayed plot. On the other hand, the lowest gross return Tk. 350696.00 was calculated in untreated control plot followed by Tk. 380247.00 in the mechanical control plot and Tk. 419412.00 in Bioneem 0.3 EC treated plot (Table 4).

The highest net return of Tk. 656443.00 ha^{-1} was found in Tracer 45 SC treated plot followed by Tk. 501111.00 in *B. bassiana*, 1×109 CFU applied plot and Tk. 404940.00 in Vertimec 1.8 EC sprayed plot. On the other hand, the lowest net return of Tk. 350696.00 was calculated in untreated control followed by Tk. 401188.00 in Bioneem 0.3 EC and Tk. 367927.00 in the mechanical control plot (Table 4).

The highest adjusted net return of Tk. 305747.00 ha^{-1} was found in Tracer 45 SC treated plot followed by Tk. 112103.00 in *B. bassiana*, 1×109 CFU applied plot and Tk. 54243.00 in Vertimec 1.8 EC sprayed plot. On the other hand, the lowest adjusted net return of Tk. 17231.00 was calculated in the mechanical control plot followed by Tk. 50492.00 in Bioneem 0.3 EC treated plot (Table 4).

The highest benefit cost ratio of 3.05 was obtained from the treatment with Tracer 45 SC and the second highest benefit cost ratio of 2.93 was recorded from the plot treated with *B. bassiana*, 1×109 CFU followed by Vertimec 1.8 EC sprayed plot (2.89). The lowest benefit cost ratio of 2.44 was found with the mechanical control and clean cultivated plot. The benefit cost ratio in the Bioneem 0.3 EC applied plot was 2.77 (Table 4).

Table 4. Benefit cost ratio analysis of selected treatments against BSFB during October 2014 to June 2015

Treatments	Management cost (Tk)	Gross return (Tk)	Net return (Tk)	Adjusted net return (Tk)	BCR
Beauveria bassiana, 1×109 CFU	38312.00	501111.00	462799.00	112103.00	2.93
Bioneem 0.3 EC	18224.00	419412.00	401188.00	50492.00	2.77
Tracer 45 SC	100194.00	756637.00	656443.00	305747.00	3.05
Vertimec 1.8 EC	18764.00	423704.00	404940.00	54243.00	2.89
Mechanical control	12320.00	380247.00	367927.00	17231.00	1.40
Untreated control	0.00	350696.00	350696.00	-	-

Market value of brinjal = 25Tk./kg, cost of *Beauveria bassiana*, 1×109 CFU per spay = 5628 Tk ha^{-1}, Bioneem 0.3 EC per spay = 2577 Tk ha^{-1}, Tracer 45 SC per spay = 16357 Tk ha^{-1}, Vertimec 1.8 EC per spay = 2667 Tk ha^{-1}, mechanical control = 2050 Tk ha^{-1}, Labor cost = 220 Tk. day^{-1}, sprayer rent = 20-25 Tk. day^{-1}.

The findings of the present study indicated that the Tracer 45 SC was most effective to manage infestation of BSFB in brinjal. The results of this study revealed that Tracer 45 SC, *B. bassiana*, 1×109 CFU and Vertimec 1.8 EC were also satisfactorily effective in suppressing BSFB infestation and found as cost effective. Benefit cost ratio studied by other researchers are also in agreement with this findings. Awal (2012) reported that in suppressing of BSFB, the BCR was the highest (7.15) in an IPM package consisting of Tracer 45 SC 0.4 ml l^{-1} + Pheromone trap + Mechanical control and field sanitation followed by BCR 6.72 and 5.47 in the IPM packages consisting of Tracer 45 SC 0.4 ml/liter + Pheromone trap and in sole use of Tracer 45 SC 0.4 ml l^{-1}, respectively which is comparable to the present findings.

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