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Evaluation of Some Management Options against Brinjal (*Solanum melongena* L.) Shoot and Fruit Borer (*Leucinodes orbonalis* [Guenee])

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Abstract

A field study was conducted to find out the effectiveness of five management options: i) *Bacillus thuringiensis* (Bt), ii) Tracer 45 SC (Spinosad), iii) Proclaim 5 SG (Emamectin benzoate), iv) mechanical control, and v) untreated control for suppressing brinjal shoot and fruit borer (BSFB) during-2012 at Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU). The treatments were arranged in a randomized complete block design with four replications. Results indicated that Tracer 45 SC performed the best in reducing 85.60% shoot infestation over control, which was followed by Proclaim 5 SG **(**76.62%), *Bacillus thuringiensis* (66.41%) and mechanical control (22.02%). The best performance of fruit infestation reduction over control by number and by weight was also obtained in Tracer 45 SC treated plots and reduced 88.80 and 89.46%, respectively. This was followed by Proclaim 5 SG (65.58 and 67.29%), *Bacillus thuringiensis* (52.63 and 54.28%) and mechanical control (31.88 and 19.04%). The highest yield of 11.20 t ha^{-1} and highest benefit cost ratio of 5.32 were recorded in Tracer 45 SC treated plots.

Keywords: Brinjal shoot and fruit borer, microbials, chemical and mechanical control, *Bacillus thuringiensis.*

1. Introduction

Brinjal (*Solanum melongena* L.) is one of the most important and popular vegetable crops grown in Bangladesh and also in South and South-East Asia. Bangladesh produced 0.238 million tons of brinjal from an area of 28631.509 hectares with an average yield 8.00 t ha^{-1}, which is approximately 15 and 13% of the total vegetable area and production of our country, respectively (Anon., 2011).

Brinjal cultivation is seriously constrained by different insect pests. It is attacked by 53 species of insect pests, out of which 8 species are considered as major pests causing serious damage to the crop. Among the insect pests the most destructive and serious pest of brinjal is brinjal shoot and fruit borer (BSFB), *Leucinodes orbonalis* Guenee (Lepidoptera: Pyralidae) (Biswas *et al.,* 1992). It remained as major pest of brinjal since two decades. BSFB is a monophagous insect. The genus *Leucinodes* includes three species *L. orbonalis* Guenee, *L. diaphana* Hampson, *L. apicalis* Hampson. In Bangladesh, *L. orbonalis* Guenee is active throughout the year but its activity can be reduced by severe cold (Alam *et al*., 1964). The larvae of *L. orbonalis* can cause damage to shoot from 12.00-20.00% and fruit from 20.00-60.00%

in a crop season (Maureal *et al*., 1982). It is very active during the rainy and summer seasons and the yield loss has been estimated up to 86.00 percent in Bangladesh (Ali *et al.*, 1980).

Farmers mostly depend on chemical insecticides to manage the pest and synthetic chemical insecticides dominate over other means for controlling of BSFB (Singh and Singh, 2003). A survey in Jessore district of Bangladesh reported that 98.00% of the farmers relied exclusively on insecticides and 60.00% farmer sprayed their crop 140 times or more in the 6-7 months of cropping season (Alam *et al*., 2003). The insecticides used by the farmers belong to the groups' organophosphates, carbamates and synthetic pyrethroides.

Many of the insecticides have been reported to fail to control the pest effectively (Alam *et al.*, 2003, Kabir *et al.*, 1993). In most of the cases, the farmers either ignore the label instructions or do not care to follow those instructions and use insecticides at their own choice or experience. According to Pesticides Association of Bangladesh 2005, pesticide use for growing brinjal was 1.41 kg/ha whereas for all other vegetables it was 1.12 kg/ha, while it was only 0.20 kg/ha in rice. The abuse of pesticides, including the use of excessive rates and non-registered chemicals, as well as disregard of ET and delayed harvest, have resulted both loss of effectiveness of pesticides as well as damage to the environment and human health (Rashid *et al*., 2004). The indiscriminate use of chemical insecticides also creates adverse effects on natural enemies, encourage pest resistance and secondary pest outbreak, health hazards and environmental pollution (Bhadauria *et al.*, 1999). Non judicious use of insecticides frequently kills the natural enemies and affects arthropod biodiversity. Some insecticides are less toxic, more selective and less harmful to arthropod biodiversity and the environment as well. In an AVRDC study conducted in Jessore, Bangladesh utilizing IPM strategy consisting of weekly removal of BSFB damaged shoots, installation of pheromone traps to catch males and withholding of chemical pesticides to allow natural enemies to control BSFB (Alam *et al.,* 2003). This study lowered production costs and increased net incomes for farmers. Combination of 4 cultural practices such as flooding the field at dry season as irrigation, pruning of older leaves and use wide spacing (1m x 1.5m), sanitation and proper disposal of BSFB infested plant materials and fertilizers use as per recommended rate suppressed 70.00% BSFB infestation in brinjal (FAO, 2003).

The present studies were, therefore, conducted to develop environment-friendly approach for the control of BSFB by using microbials, chemical insecticide and mechanical control.

2. Materials and Methods

The experiment was conducted at the experimental farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur. The location of the study site is 24.09Â°N latitude and 90.26Â° E longitude with an elevation of 8.2 from sea level (Anon., 1989). Previously the land was under "Shal forest" and amended later for research purpose. The experimental plot is surrounded by forest trees in the north and east and different crops in the west and the south. Crops include wheat, bitter gourd and musk melon. The experiment was conducted during November 2011 to April 2012 to evaluate the effect of *Bacillus thuringiensis* (Bt), Tracer 45 SC (Spinosad), Proclaim 5 SG (Emamectin benzoate), mechanical control, and an untreated control with recommended dose viz., *Bacillus thuringiensis* 0.4g/l, Tracer 45 SC (Spinosad) 0.4 ml/l, Proclaim 5 SG (Emamectin benzoate) 1 g/l for the management of BSFB and its effects on yield. Details of the insecticides used with their doses are given in Table 1. The experiment was laid out in RCB design with four replications. The whole field was divided into 4 blocks of equal size having space of 2 meters between blocks and 1 meter between plots. Each block was subdivided into 5 equal plots including one control plot.

Table 1. List of insecticides and their groups, trade names, chemical names and concentrations used in various treatments

Class	Common name	Trade name	Chemical name	Concentration
Microbial Pesticide	*Bacillus thuringiensis*	-	Bacillus thuringiensis (Bt)	0.4g/ liter
Microbial Pesticide	Spinosad	Tracer -45 SC	* Spinosad: Spinosyn A + Spinosyn D	0.4 ml/liter
Biopesticide	Emamectin benzoate	Proclaim -5 SG	4"-epi-methylamino-4"deoxyavermectin B1 benzoate	1 g/liter

***** 2-((6-deoxy-2, 3, 4-tri-*O*-methyl-a-Lmannopyranosyl) oxy)-13-(((5-dimethylamino) tetrahydro-6-methyl-2*H*-pyran-2-yl) oxy)-9-ethyl- 2,3,3a,5a,5b,6,9,10,11,12,13,14,16a,16 b-tetradecahydro-14-methyl-1*H*-asindaceno (3,2-d)oxacyclododecin-7,15-dione 2-((6-deoxy-2,3,4-tri-*O*-methyl-a-Lmannopyranosyl) oxy)-13-(((5-dimethylamino) tetrahydro-6-methyl-2*H*-pyran-2-yl)oxy)-9-ethyl-,3,3a,5a,5b,6,9,10,11, 12,13,14,16a,16 b-tetradecahydro-4,14-dimethyl -1*H*-asindaceno(3,2-d)oxacyclododecin-7,15-dione.

The unit plot size was 3m x 2m accommodating 10 pits per plot. The distance between rows was 1m and that of plants was 60 cm. A total of 200 seedlings were planted in 20 plots @ 10 seedlings per plot.

The first application of insecticides was made after 8th week of transplantation and subsequent applications in each treatment were made at twelve days intervals. Four liters of spray volumes were required to spray four plots at each spraying before fruiting stage while subsequent applications during fruiting required five liters each to ensure cover spray. Mechanical control was done manually at twelve days intervals only in mechanical control treatment plots. Infested shoots and fruits were clipped off by scissors and removed from the field and buried for killing the larvae. Urea, TSP, MP and cow dung were applied in the field @ 250 kg, 150 kg, 125 kg and 15 kg ha^{-1} respectively as recommended by Rashid (1993). Other recommended agronomic practices were also followed.

The effect of different treatments on BSFB infestation was evaluated by determining the level of infestation of shoots and fruits by BSFB and calculating the yield per hectare. Other relevant data e.g., number of infested and healthy shoots, infested and healthy fruits, weight of fruit per plot, fruit infestation by number and weight, marketable and infested yield, total yield and BCR were taken.

Data were analyzed by using MSTAT-C software for analysis of variance (ANOVA). Mean separation was performed by using Duncan Multiple Range Test (DMRT) (Gomez and Gomez 1984).

3. Results and Discussion

3.1 Effectiveness of five treatments on shoot and fruit infestation

The comparative effectiveness of five treatments on percent shoot infestation caused by BSFB is presented in Table 2. Among the five selected treatments, the percent shoot infestation was the lowest (2.5%) in the plots treated with Tracer 45 SC followed by Proclaim 5 SG (4.06%) being statistically similar. The highest percent shoot infestation (17.37%) was recorded in the untreated control plots followed by Mechanical control (13.54%) and *Bacillus thuringiensis* (Bt) (5.83%) treated plot and all of them were statistically identical. In terms of percent shoot infestation reduction over control, the highest percent reduction of shoot infestation over control (85.60) was recorded in Tracer 45 SC treated plots followed by Proclaim 5 SG (76.62%), Bt (66.41%) treated plots (Table 2).

The results indicated that Tracer 45 SC was the most effective against BSFB in terms of lower shoot infestation (2.5%) and higher shoot infestation reduction over control (85.60%), while Proclaim 5 SG and Bt were moderately effective. Mechanical control showed less effectiveness in winter season.

The comparison of the results of present study with the existing findings suggests that Tracer-45 SC (Spinosad) was able to exceed the standard level of 80.00% reduction in shoot infestation over control which was similar with the findings of Adiroubane and Raghuraman (2006). They recorded the percent reduction of shoot damage over control ranged between 84.36 to 93.82 in Spinosad and 75.41 to 85.38 in Carbaryl + Wettable sulphur. In a field experiment during kharif 2006, among different insecticides, 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 ai/ha) followed by Indoxacarb 14.5 SC 50 g ai/ha (8.89 and 13.13%) and Emamectin benzoate 5 SG 15 g ai/ha (10.95 and 16.66%), respectively (Patra *et al.*, 2009).

Percent fruit infestation (by number) caused by BSFB as presented in Table 3 indicated that, the lowest percent of fruit infestation (8.43%) was recorded in the plots treated with Tracer 45 SC followed by Proclaim 5 SG (25.92%) and Bt (35.67%) treated plots. However, the highest fruit damage (75.30%) was observed in the untreated control plots followed by mechanical control treated plots (51.30%) which were statistically similar.

The percent fruit infestation reduction over control was varied in different treatments (Table 3). The highest reduction of fruit damage (88.80%) over control was recorded in Tracer 45 SC treated plots followed by Proclaim 5 SG (65.58%), Bt (52.63%) and mechanical control (31.88%) treated plots.

Percent fruit infestation (by weight), caused by BSFB as presented in Table 3 indicated that, the lowest fruit infestation (7.45%) was recorded in Tracer 45 SC followed by Proclaim 5 SG (23.10), being statistically similar. The highest fruit infestation (70.63%) was observed in untreated control plots followed by mechanical control (57.18%) and Bt (32.29%) treated plots, being statistically similar.

The percent fruit infestation reduction (by weight) over control as presented in Table-3 indicated that, the highest percent reduction of fruit infestation (89.46) was observed in Tracer 45 SC treated plots followed by Proclaim 5 SG (67.29%), Bt (54.28%) and mechanically controlled plots (19.04%).

The above results indicated that, Tracer 45 SC was highly effective in protecting the brinjal fruits against BSFB, while Proclaim 5 SG and Bt were moderately effective. Mechanical control was less effective in protecting brinjal against BSFB. The findings also indicated that, BFFB preferred fruits than the shoots. The comparison of the results of present study suggest that Tracer 45 SC was able to exceed the standard level of 80.00% reduction in fruit infestation over control which was 89.46% performing relatively better in terms of fruit damage reduction than the other treatments. The results thus obtained in the present study suggested that Tracer 45 SC was the most effective insecticide in protecting the brinjal crop against BSFB.

In a field experiment during kharif 2006, the lowest mean percent fruit infestation (9.88%) was recorded in the plots treated with Spinosad 2.5 SC followed by Indoxacarb 14.5 SC (13.13%), Emamectin benzoate 5 SG (16.66%) (Patra *et al.*, 2009). Sparks *et al.* (1995) observed higher percent reduction of fruit damage over control in Spinosad treated plants, which were recorded 90.71 and 86.81 percent during 2005 and 2006, respectively. The results on effectiveness of Spinosad in the present studies were in accordance with the reports of Dandale *et al*. (2001). They reported that Spinosad was found to be effective in suppressing the bollworm complex damage in green fruiting bodies of cotton up to 14 DAT.

3.2 Effectiveness of the treatments on yield (t ha^{-1})

The effects of different treatments on fruit infestation ultimately have direct influence on yield of brinjal, which was evaluated in terms of marketable yield, infested yield and total yield and presented in Table 4.

It is revealed that the marketable fruit yield was the highest (11.20 t ha^{-1}) in Tracer 45 SC treated plots which differed significantly from all other treatments followed by Proclaim 5 SG (8.04 t/ha) and Bt (5.15 t ha^{-1}) having no significant difference between them. The lowest healthy fruit (marketable) yield was obtained from untreated control plot (1.10 t ha^{-1}) followed by mechanically controlled plots (1.33 t ha^{-1}).

The lowest infested fruit yield (0.89 t/ha) was observed in Tracer 45 SC treated plots followed by mechanically controlled plots (1.71 t ha^{-1}) and they are not statistically different. The highest infested fruit yield was observed in Proclaim 5 SG (2.88 t ha^{-1}) followed by Bt (2.55 t ha^{-1}) and untreated control (2.35 t ha^{-1}) plots, but were statistically similar.

Table 2. Effect of different treatments on per cent shoot infestation in brinjal during 2011-2012 season

Treatments	% Shoot infestation	% Shoot infestation reduction over control
Bacillus thuringiensis (Bt) (0.4g/l)	5.83ab	66.41
Tracer 45 SC (0.4 ml/l)	2.50c	85.60
Proclaim 5 SG (1 g/l)	4.06bc	76.62
Mechanical Control (infested shoot & fruit clipping)	13.54ab	22.02
Untreated Control	17.37a	-
LSD value	13.54	-
CV (%)	6.55	-

Table 3. Effect of different treatments on per cent fruit infestation in brinjal during 2011-2012 season

Treatments	% Fruit infestation		% Fruit infestation reduction over control	
	By number	By weight	By number	By weight
Bacillus thuringiensis (Bt) (0.4g/l)	35.67b	32.29ab	52.63	54.28
Tracer 45 SC (0.4 ml/l)	8.43bc	7.45bc	88.80	89.46
Proclaim 5 SG (1 g/l)	25.92b	23.10bc	65.58	67.29
Mechanical Control (infested shoot & fruit clipping)	51.30ab	57.18ab	31.87	19.04
Untreated Control	75.30a	70.63a	-	-
LSD value	21.25	25.74	-	-
CV (%)	6.55	6.55	-	-

Accordingly, total fruit yield was the highest (12.10 t ha^{-1}) in Tracer 45 SC treated plots followed by Proclaim 5 SG (10.92 t ha^{-1}) and Bt (7.69 t ha^{-1}), the last two being statistically identical. The lowest yield observed in mechanically controlled plots (3.04 t ha^{-1}) followed by untreated control plots (3.45 t ha^{-1}), being statistically similar.

Almost similar findings were reported by some researchers supporting the results of the present study. Patra *et al*. (2009) conducted a field experiment during kharif 2006, with Emamectin benzoate 5 SG, Lufenuron 10 EC, Spinosad 2.5 SC, Indoxacarb 14.5 SC and Methoxyfenozide 24 SC for suppressing brinjal shoot and fruit borer, *Leucinodes orbonalis*, all the insecticidal treatments were significantly effective in reducing brinjal shoot and fruit borer infestation resulting increasing fruit yield over the untreated control. The highest marketable fruit yield of 6.91 t ha^{-1} was recorded in Spinosad followed by Indoxacarb and Emamectin benzoate with 6.11 and 5.84 t ha^{-1}, respectively. Puranik *et al.* (2002) evaluated different Bt formulations in comparison with neem and chemical insecticides against brinjal shoot and fruit borer. Among the different treatments, five sprays of Dipel 8l (Bt) @ 0.2 percent at 10 days interval resulted maximum yield of marketable fruits (9.49 t ha^{-1}) and proved to be the most effective treatment.

3.3 Benefit cost ratio (BCR)

The benefit cost ratio (BCR) as worked out based on the expenses incurred and value of crops obtained against the treatment used in the present study for the control of brinjal shoot and fruit borer and are presented in Table 5. It is to be noted here that expenses incurred referred to those only on pest control. The cost and the return from the yield were estimated based on the prevailing market price at that time. The highest gross return Tk. 336000 per ha were obtained from Tracer 45 SC treated plot followed by Tk. 241200, Tk. 76200 and Tk. 39900 per ha from Proclaim-5 SG, Bt and mechanical control respectively.

From Table 5, it was evident that, Tracer 45 SC treatment showed higher benefit cost ratio (5.32) which was followed by that of Proclaim 5 SG (3.96), mechanical control (2.00) and Bt (1.42) treated plots. The above findings related to higher healthy fruit yield and higher BCR are in partial conformity with the findings of other researchers. Maleque *et al*. (1998) found benefit cost ratio of 3.4:1 and 3.3:1 by using mechanical control + application of Cypermethrin at 5% ET and scheduled spray of Cypermethrin at 7 days intervals, respectively. While, Islam *et al.* (1999) observed the highest BCR (37.77) in plots treated with Shobicron (mixture of Cypermethrin and Profenofos) at 10% ET with only 3 applications. In the mechanical control plots, the BCR was 14.61. The benefit cost ratio (BCR) of IPM, non-IPM and IPM + spray farmers were 5.3, 1.7, and 4.1, respectively in summer trials and that were 3.4 and 1.7 in IPM and non-IPM farmer, respectively in winter trials (Alam *et al.*, 2006).

Table 4. Effect of different treatments on yield of brinjal (t/ha) grown during winter season 2012

Treatments	Mean value of		
	Marketable yield (t/ha)	Infested yield (t/ha)	Total yield (t/ha)
Bacillus thuringiensis (Bt)	5.15b	2.55ab	7.69b
Tracer 45 SC	11.20a	0.89c	12.10a
Proclaim 5 SG	8.04b	2.88a	10.92b
Mechanical control	1.33c	1.71b	3.04c
Untreated Control	1.10c	2.35ab	3.45c
LSD value	1.18	0.37	1.28
CV (%)	9.34	7.87	7.56

Table 5. Economic analysis of different treatments used for suppressing BSFB attacking brinjal grown during November 2011 to April 2012

Treatment	No. of appli-cation	Variable management cost (Tk/ha)			Marketable fruit yield (t/ha)	Gross return (Tk/ha)	Net return (Tk/ha)	Adjusted net return (Tk/ha)	Benefit cost ratio (BCR)
		Insecticide	Labor	Total					
Bacillus thuringiensis (Bt)	6	12000	6000	18000	2.54	76200	58200	25500	1.42
Tracer-45 SC	6	42000	6000	48000	11.20	336000	288000	255300	5.32
Proclaim-5 SG	6	36000	6000	42000	8.04	241200	199200	166500	3.96
Mechanical control	6	-	2400	2400	1.33	39900	37500	4800	2.00
Untreated Control	-	-	-	-	1.09	32700	32700	-	-

Cost of insecticides : Bt @ 2000.00/kg, Tracer-45SC @ 7000.00/kg, Proclaim-5 SG @ 6000.00/kg
Cost of spray : Two laborers/spray/ha @ Tk 200.00/day. Spray volume required: 500 l/ha (Islam *et al.*, 1999).
Cost of field sanitation : Two laborers/ha @ Tk 200.00/day.
Market price of brinjal : Healthy fruit Tk 30.00/kg.

4. Conclusions

From the study, it could be concluded that Tracer 45 SC (Spinosad) is the most effective insecticide for suppressing brinjal shoot and fruit borer (BSFB) in the field to protect brinjal crop and ensured the highest healthy fruit yield per unit area in winter season. Proclaim 5 SG and Bt was moderately effective while mechanical control is least effective against BSFB. Tracer 45 SC was found as the most effective treatment for the management of BSFB successfully providing the highest marketable yield (11.20 t ha^{-1}) and the highest BCR (5.32).

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