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Management of brinjal shoot and fruit borer (*Leucinodes orbonalis* Guen.) using selected bio-rational insecticides

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ABSTRACT

An experiment was undertaken to know the effectiveness of different bio-rational insecticides for controlling brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenee) under field conditions during winter season 2017-18. The different treatments were Bioneem 1% EC (Azadirachtin 1000 ppm @ 1 mL L^{-1} (T1) Noclaim 5 SG (Emamectin benzoate) @ 1 mL L^{-1} (T2), Tracer 45 SC (Spinosad) @ 0.4 mL L^{-1} (T3), Suntec 1.8 EC (Abamectin) @ 1.2 mL L^{-1} (T4) and untreated control (T5). The results revealed that the treatments Spinosad (T3), Abamectin (T4) and Emamectin benzoate (T2) were effective to suppress brinjal shoot and fruit borer infestation in brinjal field. The rate of shoot infestation was observed 6.25% and 26.01% in Spinosad (T3) treated and control plot, respectively. The lowest fruit infestation (6.98%) by number and (9.32%) by weight was recorded in Spinosad (T3) treated plot. Reduction rate of fruit infestation over control was 82.82, 51.19, 41.15 and 38.17% by number and 66.11, 43.75, 33.13 and 24.44% by weight in Spinosad (T3), Emamectin benzoate (T2), Abamectin (T4) and Azadirachtin (T1), treated plot, respectively. The yield in different treatments ranged between 22.02 and 32.52 t ha^{-1}. Healthy fruits yield increase over control varied from 19.36 to 85.46%, where the highest increase was found in Spinosad (T3) treated plot and the lowest in Azadirachtin (T1). The highest adjusted net return and benefit-cost ratio (BCR) of Tk. 2,61,564 and 11.08, respectively were obtained from Spinosad (T3) treated plot. The lowest BCR was 2.66 in Azadirachtin (T1) treated plot. Among the four bio-rational inecticides Tracer 45 SC (Spinosad) showed the highest efficacy and it could be used against brinjal shoot and fruit borer in brinjal production.

Keywords: Brinjal, shoot and fruit borer, bio-rational insecticides, management

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1 Introduction

Brinjal (*Solanum melongena* L.) is a vital vegetables crop in South and South-East Asia (Thapa, 2010) and cultivated in summer and winter season (Hanson et al., 2006). It is the plant of Solanacae family and widely grown as fruit vegetables crop (Kantharajah and Golegaonkar, 2004). Its worldwide production is almost 50 million ton per annum from 1,600,000 ha of land (FAO, 2012). In respect of acreage and production, in Bangladesh brinjal is the second most significant vegetable crop next to potato (BBS, 2016). The total area of cultivation is 1,24,000 acres (50,220 ha) where 78,000 acres (31,590 ha) in Rabi season and 46000 acres (18,630 ha) in kharif season (BBS, 2016). Brinjal is cultivated throughout the country but plenty grown in Rajshahi, Bagura Jashore, kumilla, Dhaka and Narsinghdi districts (Azad et al., 2012) and commonly available in the lean period when the seasonal vegetables are scanty in the market. More than 20 varieties of brinjal are grown in different region in the country and approximately 8.0 million farmers are involved in brinjal cultivation in Bangladesh (BBS, 2016).

The limiting factor for brinjal cultivation is insect pest problem. In Bangladesh, around eight insect species are found as major pests in brinjal field (Biswas et al., 1992). Among these said insect pests the most injurious and destructive pest is brinjal shoot and fruit borer (BSFB), *Leucinodes orbonalis* (Guen.) (Lepidoptera: Pyralidae) (Butani and Jotwani, 1984; Chattopadhyay, 1987; Nair, 1986). The occurrence of the pest finds either infrequently or in outbreak each year in Indian subcontinent (Dhankar, 1988). At least one mite and fifteen insect pest damage in brinjal field, among them, epilachna, BSFB, and leafhoppers cause severe damage to the crop. In Bangladesh Brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenee) is most destructive pest, which caused 31-86% fruit damage (Alam et al., 2003).

Nursery phase to harvest period, Brinjal shoot and fruit borer causing more than 80% loss as a cosmopolitan field pest of brinjal (Chakraborti and Sarkar, 2011). In Bangladesh commonly 67% yield loss happened (Islam and Karim, 1994) and it might be increased 70∼92% due to severe attack of BSFB (Dhandapani et al., 2003). Brinjal shoot and fruit borer also decreases the content of vitamin C up to 80% in fruit (Sharma, 2002). The infested fruits due to lose their quality it become unfit for consume and hence, lose their market value. Considering the devastating attack of BSFB, a wide range of synthetic pyrethroids, carbamates and organophosphorus insecticides have been promoted various time to reduce the infestation (Parkash, 1988). Farmers are presently using countless insecticide nearly 140 times or more in one cropping season, during 6-7 months and 32% of total cost is contributed to crop production (Alam et al., 2006). A survey on insecticide, reported that within a year, 180 times insecticides were used to protect the brinjal against BFSB, in Bangladesh. For controlling BSFB, the indiscriminate uses of insecticides cause numerous problems *viz*., insecticides resistance, insecticide tolerance, killing of natural enemies, pest resurgence and secondary pest outbreak which making it more difficult to control (Akhtaruzzaman et al., 2019). The frequent use of insecticide is ecologically unsafe and economically unviable. It is not only costly but also detrimental to environment and beneficial flora and fauna of the ecosystem. This excessive pesticide usage cause severe health hazard to farmers and consumers. Maclntyre et al. (1989) stated that when the consumers over time to take the insecticide residues containing foodstuff it might cause teratogenesis, cancer, genetic damage and suppression of the immune system. In addition, to exports our vegetables in the overseas markets the residual toxicity of insecticides in brinjal is another great threat (Islam et al., 1999). Therefore, to reduce the environment pollution and health hazards as well as minimize the residual toxicity of pesticides an environment friendly bio-rational insecticides packages is indispensable. Bio rational insecticides is derived from different microorganisms' i.e. insect pathogens and extracts of plant. it is less detrimental to natural enemies and least or not harmful to the environment.

However, limited works have been done sporadically throughout the world on the bio-rational insecticides to control BSFB and very few research activities regarding eco-friendly management of BSFB have been reported so far in Bangladesh (Mamum et al., 2014). Therefore, this research was conducted to investigate the efficacy of selected bio-rational insecticides in suppressing BSFB and to select the best performing bio-rational insecticide against BSFB.

2 Materials and Methods

The experiment was set up in the experimental field of Agriculture Training Institute (ATI), Khadimnagor, Sylhet, in winter season 2017-18. The research field was made by ploughing, harrowing and proper leveling. The experiment comprised five treatments and was laid out in a randomized complete block design (RCBD) with four replications. Therefore, the entire area of the research field was separated into equal size 4 blocks and each block was sub-divided into 5 plots (3 m × 3 m) and between the two blocks and plots having 2 m and 1 m space, respectively. Brinjal variety 'BARI Begun-9' was used as experimental material. Seeds were collected from HRC, BARI, Gazipur and seedlings were raised in a small seed bed (5 m × 1 m) at Entomology experimental farm, Sylhet Agricultural University, Sylhet. 15 seedlings of 15-day old were planted plot^{-1} with 100 cm × 60 cm spacings between lines and plants, respectively. Cowdung and chemical fertilizers were used as recommended doses for brinjal production. Cowdung 15 t ha^{-1} and Urea, TSP and MoP @ 250, 150 and 125 kg ha^{-1}, respectively were applied (Rashid, 1999). The experimental plots were kept weed free and irrigation was done depending on the soil moisture condition.

Four biorational insecticides *viz*. Bioneem 1% EC (Azadirachtin 1000 ppm) @ 1 mL L^{-1} of water (T1), Noclaim 5 SG (Emamectin benzoate) @ 1 mL L^{-1} of water (T2), Tracer 45 SC (Spinosad) @ 0.4 mL L^{-1} of water (T3), and Suntec 1.8 EC (Abamectin) @ 1.2 mL L^{-1} of water (T4) were used to manage the BSFB in the field. A Control treatment (T5) was maintained where only water was sprayed. Knapsack sprayer was used to apply the insecticides in research field. All treatments were applied at ten days interval from the first incidence of the shoot infestation. For an individual spray in three plots 9 L of spray volumes were required. All spray materials were applied on lower and upper surfaces of the shoots and leaves to confirm the coverage of the whole plants evenly.

The spraying were done at afternoon to escape the heat of sun, omitting the drift of insecticides and defending the natural enemies and the pollinator like bees. The effect of various treatments in managing brinjal shoot and fruit borer infestation was observed to measure of the infestation of shoots and fruits of brinjal and yield ha^{-1}. Data collected on the healthy & infested shoot and fruit number $plot^{-1}$. The infested & healthy fruit weight was also measured. Then calculated the shoot infestation percentage from the collected data following Khatun et al. (2016). Similarly percent fruit infestation was estimated both by weight and number of healthy and infested fruits following Khatun et al. (2016). Percent reductions of fruit and shoot damage over control and percent increase of production over control were calculated. Economic analysis considering the total expenditure of growing the crop and the total return from that individual treatment were also done. In this experiment, benefit-cost ratio (BCR) was calculated for ha^{-1} of land. All the data collected and computed were analyzed statistically. The analysis of variance (ANOVA) of different parameters was completed and the means were alienated by using the Duncan's Multiple Range Test (DMRT).

3 Results and Discussion

3.1 Shoot infestation

Effects of different treatments on percent shoot infestation by BSFB is presented in Table 1.The minimum (6.25%) and maximum (26.01%) levels of shoot infestation waweres found and in Spinosad (T3) treated and control plots, respectively. All the treatments significantly reduced percent shoot infestation, but the highest reduction over control was recorded at Spinosad (T3) treated plot (Table 1).

3.2 Fruit infestation

Infested fruit number All treatments had shown the effective results on the percentage of fruit infestation. The lowest percent fruit damage by number was found in Spinosad 45 SC (6.98%) treated plot and it was significantly lower danage compared to all other treatments. The maximum fruit infestation by number was found in control (40.63%) (Table 2). Banerjee and Basu (1955) found that in reducing open boll damage and green boll damage Spinosad 48 SC @ 50 g a.i ha^{-1} was the most effective and it had good contribution in seed cotton production. Singh et al. (2009) found that Spinosad @ 0.01% and Profenofos @ 0.1% were highly effective in reduction of shoot damage of BSFB besides higher fruit yield of brinjal.

Infested fruit weight The percent fruit damage (weight/weight) was calculated on the basis of collective fruits weight of all fruiting stages. It also followed the same trend as observed for shoot infestation. The highest fruit damage was recorded in untreated control (27.50%) and the minimum percentage of fruit damage was found in Spinosad 45 SC (9.32%) sprayed plot (Table 3). These results were similar with previous studies of Kalawate and Dethe (2012) where they found percent fruit damage of 13.69 and 13.34, and 8.21 and 7.89 by weight and number basis in summer and kharif seasons, respectively in spinosad treated plots. Patra et al. (2009) reported that the lowest shoot and fruit damage (7.47 and 9.88%) was found in spinosad 2.5 SC (50 g a.i. ha^{-1}) treated plots.

3.3 Infestation protection over control

By fruit number The percentage protection of fruit over control by number all treatments reduced considerable amount of fruit infestation over control as shown in the Fig. 1. The treatments 1-4 caused 38.17, 51.19, 82.82 and 41.15 % reduction of fruit infestation over control, respectively. The lowest reduction of 38.17 % was found in Azadirachtin 1% EC and the highest in Spinosad 45 SC (82.82%) (Fig. 1).

By fruit weight The percentage protection of fruit over control by weight all treatments decreased considerable amount of fruit infestation over control as shown in the Fig. 1. The infestation reduction in fruit over control was 24.44, 43.75, 66.11 and 33.13 % under treatments 1, 2, 3 and 4, respectively. Treatment 3 Spinosad 45 SC gave the highest (66.11%) and treatment 1 Azadirachtin 1% EC showed the lowest (24.44%) reduction over control (Fig. 1).

3.4 Brinjal yield

The consequence of different treatments on production of brinjal was assessed in terms of total fruit harvest, marketing yield or healthy fruit yield and infested fruit harvest obtained in each treatment during the entire period of the crop (Table 4). The highest marketable fruit harvest (29.48 t ha^{-1}) was found from Spinosad 45 SC treated plots and it was higher

Table 1. Result of different bio-rational insecticides % shoot infestation caused by brinjal shoot and fruit borer

Treatment†	No. of healthy shoot plot^{-1}	No. of infested shoot plot^{-1}	% shoot infestation	% shoot infest. ↓ over control
T1	50.75cd	10.50b	17.14b	34.13
T2	57.75ab	6.50c	10.09d	61.22
T3	63.50a	4.25d	6.25e	75.98
T4	54.25bc	8.25c	13.15c	49.46
T5	47.00d	16.50a	26.02a	–
CV (%)	7.8	13.35	12.61	–

† T1 = Azadirachtin 1% EC @ 1 mL L^{-1}, T2 = Emamectin Benzoate 5 SG @ 1 mL L^{-1} , T3 = Spinosad 45 SC @ 0.4 1 mL L^{-1}, T4 = Abamectin 1.8 EC @ 1.2 mL L^{-1}, T5 = control; Means followed by similar letter(s) inside the column do not vary significantly (P = 0.05) as per DMRT.

Table 2. Result of different bio-rational insecticides on the percentage fruit damage caused by brinjal shoot and fruit borer

Treatment†	No. of healhty fruit plot^{-1}	No. of infested fruit plot^{-1}	% fruit damage
T1	71.25b	24.26b	25.12b
T2	74.87b	18.83c	19.83c
T3	95.25a	7.24d	6.98d
T4	73.01b	23.23bc	23.91bc
T5	55.79c	38.50a	40.63a
CV (%)	7.57	13.31	12.65

† T1 = Azadirachtin 1% EC @ 1 mL L^{-1}, T2 = Emamectin Benzoate 5 SG @ 1 mL L^{-1} , T3 = Spinosad 45 SC @ 0.4 1 mL L^{-1}, T4 = Abamectin 1.8 EC @ 1.2 mL L^{-1}, T5 = control; Means followed by similar letter(s) inside the column do not vary significantly (P = 0.05) as per DMRT.

Table 3. Effects of various bio-rational insecticides on fruit infestation by weight caused by brinjal shoot and fruit borer

Treatment†	Wt. of healhty fruit (kg plot^{-1})	Wt. of infested fruit (kg plot^{-1})	% Infested fruit
T1	17.08d	4.47ab	20.78b
T2	21.25b	3.90b	15.47c
T3	26.54a	2.73c	9.32d
T4	18.91c	4.25b	18.39bc
T5	14.30e	5.52a	27.50a
CV (%)	5.03	17.53	14.43

† T1 = Azadirachtin 1% EC @ 1 mL L^{-1}, T2 = Emamectin Benzoate 5 SG @ 1 mL L^{-1} , T3 = Spinosad 45 SC @ 0.4 1 mL L^{-1}, T4 = Abamectin 1.8 EC @ 1.2 mL L^{-1}, T5 = control; Means followed by similar letter(s) inside the column do not vary significantly (P = 0.05) as per DMRT.

Table 4. Effects of various bio-rational insecticides on fruit production

Treatment†	Healthy fruit		Infested fruit		Total fruit	
	Yield (t ha^{-1})	↑ over control (%)	Yield (t ha^{-1})	↓ over control (%)	Yield (t ha^{-1})	↑ over control (%)
T1	18.98d	19.36	4.97ab	18.8	23.95cd	8.75
T2	23.61b	48.5	4.33b	29.31	27.94b	26.84
T3	29.48a	85.46	3.03c	50.52	32.52a	47.63
T4	21.02c	32.22	4.72b	22.97	25.73c	16.85
T5	15.90e	–	6.13a	–	22.02d	–
CV (%)		5.02		17.52		4.94

† T1 = Azadirachtin 1% EC @ 1 mL L^{-1}, T2 = Emamectin Benzoate 5 SG @ 1 mL L^{-1} , T3 = Spinosad 45 SC @ 0.4 1 mL L^{-1}, T4 = Abamectin 1.8 EC @ 1.2 mL L^{-1}, T5 = control; Means followed by similar letter(s) inside the column do not vary significantly (P = 0.05) as per DMRT.

Table 5. Economic study of various bio-rational insecticides applied to control brinjal shoot and fruit borer

	Treatment†					CV (%)
	T1	T2	T3	T4	T5	
Cost of control (BDT)	17688	26580	23616	17095.2	0	–
Marketable yield (t ha^{-1})	18.98d	23.61b	29.48a	21.02c	15.90e	5.02
Gross return (BDT)	398580	495810	619080	441420	333900	–
Net return (BDT)	380892	469230	595464	424324.8	333900	–
Adjusted net return (BDT)	46992	135330	261564	90424.8	0	–
Benefit-cost ratio (BCR)	2.66	5.09	11.08	5.29		–

† T1 = Azadirachtin 1% EC @ 1 mL L^{-1}, T2 = Emamectin Benzoate 5 SG @ 1 mL L^{-1} , T3 = Spinosad 45 SC @ 0.4 1 mL L^{-1}, T4 = Abamectin 1.8 EC @ 1.2 mL L^{-1}, T5 = control; Means followed by similar letter(s) inside the column do not vary significantly (P = 0.05) as per DMRT.

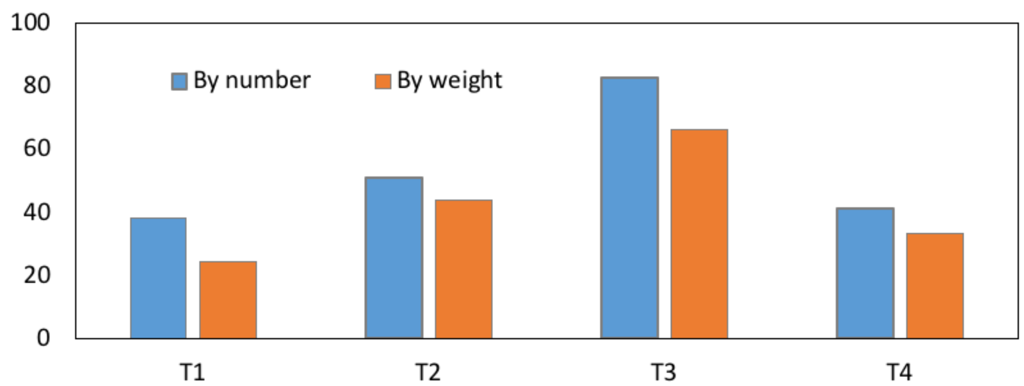

Figure 1. Effects of of various bio-rational insecticides on the percentage reduction of fruit infestation over control. T1 = Azadirachtin 1% EC @ 1 mL L^{-1}, T2 = Emamectin benzoate 5 SG @ 1 mL L^{-1} , T3 = Spinosad 45 SC @ 0.4 mL L^{-1}, T4 = Abamectin 1.8 EC @ 1.2 mL L^{-1}, T5 = control

than that of all other treatments and the second highest of healthy fruits was harvested from Emamectin benzoate 5 SG (23.61 t ha^{-1}) treated plots. The lowest yield of healthy fruits (15.90 t ha^{-1}) was recorded from untreated control plot (Table 3). Significantly the lowest infested yield (03.03 t ha^{-1}) was recorded from Spinosad 45 SC treated plot against the maximum (6.13 t ha^{-1}) being in untreated control (Table 3). According to the total production, the highest (32.52 t ha^{-1}) was in Spinosad 45 SC treated plot and the lowest (22.02 t ha^{-1}) was in untreated control plots. It was also found that Spinosad 45 SC provided the highest (85.46%) increase of healthy fruit weight over control but Azadirachtin1% EC showed the lowest (19.36%) increase of marketable fruit weight (Table 3). Conversely, maximum reduction (50.52%) of unhealthy fruit production over control was observed in Spinosad 45 SC treated plots whereas it was the minimum in Azadirachtin 1%EC (18.80%). Accordingly, as a collective effect, the maximum increase of total fruit yield over control was observed in Spinosad 45 SC (47.63%) but the minimum (8.75%) was in Azadirachtin 1% EC treated plots (Table 3).

The effectiveness of the treatments to inhibit brinjal shoot and fruit borer in various aspect, like as percent fruit and shoot infestation, healthy and total fruit yield and reduction of infestation over control, as observed in the current study were less or more inconformity with the results of some other alike studies. Mamum et al. (2014) showed the effects of spinosad 45 SC, to minimize the fruit infestation caused by *L. orbonalis* and found the minimum loss (24.1%) and maximum fruit protection over control (75.9%) in spinosad treated plot. Sharma et al. (2008) found that the main crop, boundary cropped with moreover radish or baby corn or guar along with two consecutive foliar sprays of spinosad 45 SC ha^{-1} was so effective in controlling the fruit borer occurrence.

3.5 Economic analysis

The benefit-cost ratio has worked on the base of the expenses acquired and price of crops attained against the treatments those were used in the current research for managing of brinjal shoot and fruit borer are showed in table 5. Here that incurred expenditures referred to those only spended for the pest manage. Thus it is revealed that the BCR was the highest 11.08 in treatment 3 Spinosad 45 SC. But the lowest BCR was in Azadiractin 1%EC.

4 Conclusions

The results of the current study found that Tracer 45 SC (Spinosad) 0.4 mL L^{-1} has the highest efficacy against BSFB and might be an effective, suitable and viable tool for controlling brinjal shoot and fruit borer (BSFB) in brinjal cultivation.

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Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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