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LETHAL AND REPELLENT EFFECTS OF SELECTED BIOPESTICIDES AGAINST BRINJAL SHOOT AND FRUIT BORER AND THEIR IMPACT ON BRINJAL PRODUCTION

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ABSTRACT

The study was undertaken from June 2021 to February 2022 in the field and laboratory of the Department of Entomology, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh to assess the effect of four biopesticides (Fytomax PM, Neem oil, Spinomax SC 44.03%, and Bio-chamak 1% EW) and one conventional insecticide (Ripcord 10 EC). Investigation was carried out on the repellency and mortality effects of tested insecticides against brinjal shoot and fruit borer (BSFB) (*Leucinodes orbonalis*) and their impact on brinjal production. The repellency rate of adult BSFB at 24 hours after treatment (HAT)was the highest (72.2%) on Spinomax SC 44.03% while the lowest (17.7%) was on Fytomax PM. Mortality rates of the BSFB larvae at 24 and 48 HAT with Spinomax SC 44.03% were 23 to 38%, respectively which were statistically similar to that of Ripcord 10 EC (19.1% and 33.4%, respectively). Spinomax SC 44.03% revealed higher mortality rates of the larvae at 72, 96 and 120 HAT. Spinomax SC 44.03% and Ripcord 10 EC treated plants revealed statistically similar mortality and provided the highest plant height, branches and fruits per plant, fruit length, diameter and weight. Among the insecticides, Spinomax SC 44.03% showed the highest yields (15.5 t ha^{-1}) and benefit cost ratio (3.9). The findings indicated that application of Spinomax SC 44.03% to control BSFB infestation was the best one ensuring maximum yield.

Keywords: *Leucinodes orbonalis,* mortality, pesticide, *Solanum melongena.*

INTRODUCTION

Bing one of the most common and popular vegetables, brinjal or eggplant (*Solanum melongena* Linn.), a member of the Solanaceae family, is cultivated all over the world. In Bangladesh, brinjal is one of the most important vegetable crops,

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occupying about 15% of the total vegetable cultivation area. The crop is susceptible to nine insect species from seven families and four orders: Coleoptera, Lepidoptera, Hemiptera, and Thysanoptera (Amin *et al*. 2018). Among them, the brinjal shoot and fruit borer (BSFB) (*Leucinodes orbonalis* Guenee, Lepidoptera: Crambidae) is a major pest in Asia, including Bangladesh (Rahman 2006). The infestation of *L. orbonalis* is a significant factor causing low average yield of brinjal resulting 60-70% yield loss (Kumar *et al*. 2010). This pest is particularly active during the rainy and summer seasons and has a specific feeding behavior that damages the fruit, reducing its market value and quality.

The extent of yield loss due to *L. orbonalis* can vary from 70-92%, depending on the season, location, variety, and age of the plant (Javed *et al*., 2017; Reddy and Srinivas, 2004). Effective management of this pest is essential for maintaining high yields and quality. Pesticides play a crucial role in controlling *L. orbonalis* by lethal effects, which reduce pest populations, and repellency effects, which prevent further infestations. However, pesticide use must be carefully managed to balance effective pest control with minimizing adverse effects on the environment, non-target organisms, and human health. Integrating lethal and repellent properties in pesticide formulations can enhance the sustainability of brinjal production, providing prolonged protection against this destructive pest and ensuring better crop yields and quality. With this point in view, this study investigated the repellency and mortality effects of four biopesticides and a synthetic insecticide on brinjal shoot and fruit borer, and also assessed the production of brinjal, and benefit-cost ratio of the management.

MATERIALS AND METHODS

Study period and location: The study was conducted from June 2021 to February 2022 at the Department of Entomology, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh, using the BARI Begun-1 variety. Seeds were collected from the Horticulture Research Centre, Bangladesh Agricultural Research Institute, and seedlings were grown under shade before transplanting in the field.

Experimental setup and treatment application for pest management: Four biopesticides (Fytomax PM, Neem oil, Spinomax SC 44.03%, Bio-chamak 1% EW) and one conventional pesticide (Ripcord 10 EC) were used (Table 1).

Seedlings were transplanted on July 28, 2021, with care to minimize transplant shock. Fertilizers were applied as per the Fertilizer Recommendation Guide (FRG 2018), and intercultural operations such as mulching, weeding, and irrigation were performed as needed. The experiment was set up in a randomized complete block design with three replications. Each plot was prepared 3.0 m × 2.0 m. Distance maintained between plant to plant 60 cm, row to row 80 cm while 1 m in block and plot. Each plot accommodated 15 plants. There were five treatments, having five insecticidal treatments and one untreated control.

Table 1. Details of the insecticide treatments applied to brinjal plants for controlling BSFB

Active ingredient	Trade name	Application dose	Mode of action
Azadirachtin 0.1 %	Fytomax PM	7.5 ml/ 1L	Growth regulator and antifeedant
Azadirachtin	Neem oil	5 ml/ 1L	Systemic and contact
Spinosad 44.03%w/w	Spinomax SC 44.03%	3 ml/ 1L	Contact and ingestion
Cypermethrin	Ripcord 10 EC	1 ml/ 1L	Contact and stomach action
Sesquiterpinoids	Bio-chamak 1% EW	2.5 ml/ 1L	Antifeedant

Insecticide spray: Just after initiation of shoot infestation, insecticide was sprayed on experimental field for three times maintaining 7 days interval. The treatments viz., Fytomax PM, Neem oil, Spinomax SC 44.03%, Bio-chamak 1% EW and Ripcord 10 EC were applied with the help of a knapsack sprayer. The applied doses of Fytomax PM, neem oil, Spinomax SC 44.03%, Bio-chamak 1% EW, and Ripcord 10 EC were 7500, 5000, 3000, 2500, and 1000 ppm, respectively (Table 2).

Table 2. Repellency effect of different insecticides on adult brinjal shoot and fruit borer

Treatment	Dose*	Repellency rate (%)		
		1 HAT	2 HAT	3 HAT
Fytomax PM	7500 ppm	17.7±3.6b	27.4±8.3ab	26.2±11.9b
Neem oil	5000 ppm	30.2±8.4ab	19.1±12.6b	19.1±12.6b
Spinomax SC 44.03%	3000 ppm	72.2±14.7a	56.1±12.2ab	78.3±11.7a
Ripcord 10 EC	1000 ppm	53.2±7.1ab	71.0±2.4a	82.1±9.0a
Bio-chamak 1% EW	2500 ppm	40.0±13.9ab	42.2±8.9ab	42.2±8.9ab

*Recommended dose. Data expressed as mean±S.E. Means within a column followed by no common letter(s) are significantly different by Tukey posthoc statistic at $P \leq 0.05$. HAT: Hours after treatment.

Observation of repellency effect of pesticides on adult fruit borer of BSFB: Fresh brinjal fruits were cut into pieces and treated with the insecticides at the recommended doses (Fytomax PM, neem oil, Spinomax SC 44.03%, Bio-chamak 1% EW, and Ripcord 10 EC were 7500, 5000, 3000, 2500, and 1000 ppm, respectively). The fruit pieces were air dried. Treated and untreated fruit pieces were placed in separate Petri dishes. The Petri dishes containing treated and untreated fruit pieces were then kept in two sides of insect rearing cage which was divided by a hard paper keeping the upper portion open so that the adult insect could freely change its side. Ten adult insects were released in the cage. Number of adult insects in each side of a cage was counted at one, two and three hours after treatment. Observation for each treatment was repeated three times and repellency data were recorded and calculated into percentage.

Observation of the mortality of insect larvae: Newly emerged larvae were collected from the infested fruit by cutting the fruit carefully with a knife. Fresh brinjal fruit were collected from the field, cut into pieces, and then treated with insecticides with their recommended doses (Fytomax PM, neem oil, Spinomax SC 44.03%, Bio-chamak 1% EW, and Ripcord 10 EC were 7500, 5000, 3000, 2500, and 1000 ppm, respectively). The insecticide-treated fruit pieces were placed separately on Petri dishes that contained larvae. Each Petri dish had seven larvae, which were fed on pesticide-treated fruit pieces. The untreated control observation was taken with untreated fruit pieces. The numbers of dead larvae in each Petri dish were recorded at 24, 48, 72, 96, and 120 h after treatment and percentage mortality was calculated.

Observation of plant morphological characteristics: Plant characteristics namely number of branch plant^{-1}, fruit plant^{-1}, and plant height were recorded at full blooming stage from selected three plants of each plot.

Observation of fruit characteristics: Three matured fruits from each plot under the treatments were collected and brought to the laboratory. Weight of individual fruit was recorded and then fruit length and diameter was measured. Digital electric weighing balance was used to measure fruit weight, and scale was used to measure fruit length. Digital slide caliper was used to measure fruit diameter.

Harvesting and yield assessment: After 7 weeks of transplanting, first harvest was done. Marketable mature fruits from each plot were handpicked and measured weight. Harvesting was done seven times at one week of intervals. The yield of each treatment was converted into t ha^{-1} using the following formula:

$$\text{Fruit yield (ton ha}^{-1}) = \frac{\text{Weight of fruits in kg plot}^{-1} \times 10000}{\text{Plot area in m}^2 \times 1000}$$

Calculation of benefit cost ratio (BCR): At every harvest, the harvested fruits of each treatment were separated into marketable and infested categories, and weighed. The yield of each plot was converted into t ha^{-1}. The economic analysis and benefit-cost ratio (BCR) were calculated based on the total expenditure for each treatment and total return per hectare. The total expenditure for treatment includes the costs for labor and inputs. The gross of treatment is the total price obtained from the total yield of the treatment. The net return was calculated by subtracting the expenditure of treatment from its gross return. The adjusted net return of each treatment was calculated by subtracting the net return of the untreated control from the net return of the treatments. The BCR values were calculated using the following formula:

$$\text{Benefit Cost Ratio} = \frac{\text{Adjusted net return}}{\text{Total cost}}$$

Data analysis: One-way analysis of variance followed by Tukey's HSD posthoc test (at 5% level of significance) for determining the effects of insecticides on repellency of adult, and mortality of the larvae of shoot and fruit borer, plant agronomic characteristics, fruit characteristics and yield. All the analyses were performed using IBM SPSS 20.0.

RESULTS AND DISCUSSION

The repellent effects of different treatments against adult brinjal shoot and fruit borer were assessed at different hours after treatments (HAT) and found significant variation. Among the treatments, Spinomax showed the highest repellency (72.2%) while Fytomax PM exhibited the lowest (17.9%) at one hour after treatment. At two hours after treatment, Ripcord 10 EC had the highest repellency (71.0%) but Neem

oil had the lowest (19.1%). At three hours after treatment, Ripcord 10 EC again showed the highest repellency (82.1%) and Neem oil continued to show the lowest repellency (19.1%).

The study showed significant variations in mortality rates of brinjal shoot and fruit borer larvae after treatment with various insecticides (Table 3). Spinomax SC 44.03% demonstrated the highest efficacy, reaching 95.2% mortality after 120 hours. Ripcord 10 EC also proved highly effective, with 80.9% mortality rate after 120 hours. Fytomax PM, Neem oil, and Bio-chamak 0.1% EW showed moderate effectiveness, with final mortality rates between 57.1% and 66.7±9.6%. These results suggest that Spinomax SC 44.03% and Ripcord 10 EC are the most effective insecticides for controlling brinjal shoot and fruit borer larvae, comparable to the findings of Latif *et al*. (2010) who found carbosulfan and flubendiamide to be highly effective against *L. orbonalis*, reducing shoot and fruit infestation by over 80% in field trials. Fytomax PM and Neem oil, both contained Azadirachtin but differed in application dose and mode of action. Spinomax SC 44.03%, contained Spinosad that acts through contact and ingestion. Ripcord 10 EC contained Cypermethrin that functions through contact and stomach action. The varied ingredients contained in the insecticides and different amount of the dose exerted different levels of repellency and mortality effects on the insect.

Table 3. Effects of different insecticides on the mortality rate of brinjal shoot and fruit borer larvae at different times after treatments

Treatment	Mean mortality (%)				
	24 h	48 h	72 h	96 h	120 h
Fytomax PM	14.3 ± 0.0 a	19.1 ± 4.8 ab	33.4 ± 4.8 bc	47.6 ± 4.7 b	57.1 ± 8.2 b
Neem oil	9.5 ± 4.8 a	19.1 ± 4.8 ab	23.8 ± 4.8 cd	38.1 ± 4.8 b	57.1 ± 0.0 b
Spinomax SC 44.03%	23.8 ± 4.8 a	38.1 ±4.8 a	57.1 ± 0.0 a	76.2 ± 4.8 a	95.2 ± 4.8 a
Ripcord 10 EC	19.1 ± 4.8 a	33.4 ± 4.8 a	47.6 ± 4.7 ab	61.9 ± 4.8 ab	80.9 ± 4.8 ab
Bio-chamak 0.1% EW	16.7 ± 0.0 a	22.2 ± 5.5 ab	38.9 ± 5.6 ac	55.6 ± 5.6 ab	66.7 ± 9.6 b
Untreated control	5.6 ± 5.6 a	5.6 ± 5.6 b	11.1 ± 5.6 d	11.1 ± 5.6 c	16.7 ± 0.0 c

Data are expressed as mean ± S.E. Means within a column followed by no common letter(s) are significantly different by Tukey's post hoc test at $P \leq 0.05$. DAS = Days after spraying.

The plant height and number of branches per plant was the highest in plot treated with Ripcord 10 EC (110.3cm and 16.7 per plant, respectively) followed by plot treated with Spinomax SC 44.03% (108.4 cm and 16.5 per plant, respectively) (Table 4). The lowest plant height and number of branches were in untreated control plot (79.9 cm and 8.0 per plant, respectively). The number of fruits per plant was the highest in plot treated with Ripcord 10 EC (16.0) as well as plot treated with Spinomax SC 44.03% (16.0). The lowest number of fruits was obtained in untreated control plot (8.7). These findings are consistent with previous research by Mony *et al*. (2019). They also reported reduced plant vigor and fruit yield in control plots. Studies by Yasmin *et al*. (2021, 2022) suggested a significant positive correlation between insect abundance and plant characteristics like height, branches, and leaf area. Additionally, variations in fruit yield have been observed with different organic fertilizers and botanical extracts, such as neem leaf and oil (Mehraj *et al*. 2014, Azad *et al*. 2012, Haque *et al*. 2023).

Effect of different insecticides on the fruit characteristics is presented in Table 5. The study revealed that there was significant variation in the fruit characteristics such as fruit length, fruit diameter and fruit weight. Results showed that the highest fruit length (8.3 cm) was observed in Ripcord 10 EC treated plot followed by the plot treated with Spinomax SC 44.03% (7.8 cm). The lowest fruit length (4.1cm) was observed in untreated control plot followed by plot treated with Neem oil (5.5 cm). Fruit diameter was the highest in plot treated with Ripcord 10 EC (6.8 cm) followed by plot treated with Spinomax SC 44.03% (6.5 cm) and Bio-chamak 1% EW (5.9 cm). The lowest fruit diameter was observed in untreated control plot (3.1 cm). Fruit

Table 4. Effect of different insecticides on plant morphological characteristics of brinjal

Treatment	Plant height(cm)	Branch plant^{-1}	Fruit plant^{-1}
Fytomax PM	86.8±4.3b	8.4±0.4c	10.3±0.9bc
Neem oil	84.1±1.3b	9.0±0.6c	10.0±0.6bc
Spinomax SC 44.03%	108.4±1.9a	16.5±0.3a	16.0±1.0a
Ripcord 10 EC	110.3±1.2a	16.7±0.9a	16.0±1.2a
Bio-chamak 1% EW	103.4±3.3a	13.3±0.9b	13.7±0.9ab
Untreated control	79.9±0.7b	8.0±0.6c	8.7±0.3c

Data expressed as mean± S.E. Means within a column followed by no common letter(s) are significantly different by Tukey posthoc statistic at $P \leq 0.05$.

weight was the highest in plot treated with Ripcord 10 EC (88.2 g) followed by plot treated with Spinomax SC 44.03% (78.3 g). The lowest fruit weight was observed in untreated control plot (43.6 g). According to Shalaby and Gad (2016), insects and insecticide residues affect the quality and characteristics of fruit.

The study revealed that the brinjal yields from plots treated with different insecticides, showing significant variation. Yield ranged from 7.3 to 15.5 t ha^{-1}, with Spinomax SC 44.03% had the highest (15.5 t ha^{-1}), followed by Ripcord 10 EC (13.7 t ha^{-1}). The untreated control plot had the lowest (7.3 t ha^{-1}) yield (Fig. 1). These results are similar to previous findings indicating that effective insecticide treatments, such as Spinomax SC 44.03% and Ripcord 10 EC, enhance brinjal yields compared to untreated controls (Tripura *et al*. 2017).

The management cost, gross return, net return, adjusted net return of different insecticides applied against shoot and fruit borer are presented in Table 6.

Table 5. Effect of different insecticides on fruit characteristics

Treatment	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)
Fytomax PM	6.0±0.6b	4.9±0.3ab	54.3±0.6bc
Neem oil	5.5±0.3bc	5.4±0.7ab	47.4±1.1c
Spinomax SC 44.03%	7.8±0.2a	6.5±0.3a	78.3±1.4a
Ripcord 10 EC	8.3±0.6a	6.8±0.2a	88.2±0.5a
Bio-chamak 1% EW	7.1±0.2ab	5.9±0.6a	63.4±5.6b
Untreated control	4.1±0.1c	3.1±0.7b	43.6±0.9c

Data expressed as mean± S.E. Means within a column followed by no common letter(s) are significantly different by Tukey's posthoc statistic at $P \leq 0.05$.

Table 6. Marginal benefit cost ratio (MBCR) of the treatments against brinjal shoot and fruit borer

Treatments	Management cost (TK)	Gross return (Tk)	Net return (Tk)	Adjusted net return (TK)	MBCR
Fytomax PM	49900	336000	286100	92100	1.8
Neem oil	44380	300000	255620	61620	1.4
Spinomax SC 44.03%	55180	465000	409820	215820	3.9
Ripcord 10 EC	51820	411000	359180	165180	3.2
Bio-chamak 1% EW	47500	369000	321500	127500	2.7
Untreated control	25000	219000	194000	-	-

Management cost was the highest (Tk. 55180.0) with Spinomax SC 44.03%, followed by Ripcord 10 EC (Tk. 51820.0), Fytomax PM (Tk. 49900.0) Bio-chamak 1% EW (Tk. 47500.0) and Neem oil treatment (44380.0). The lowest management cost (Tk. 25000.0) was found in untreated control. The highest gross return (Tk. 465000.0) was found with Spinomax SC 44.03% followed by Tk. 411000.0 with Ripcord 10 EC, Tk. 369000.0 with Bio-chamak 1% EW and Tk. 336000 with Fytomax PM. The lowest gross return (Tk. 219000.0) was found in untreated control followed by Neem oil (Tk. 300000.0). The highest net return (Tk. 409820.0) was recorded with Spinomax SC 44.03% followed by Tk. 359180.0 with Ripcord 10 EC, Tk. 321500.0 with Bio-chamak 1% EW,Tk. 286100 with Fytomax PM and Tk. 255620.0 with Neem oil, and the lowest Tk. 194000.0 in untreated control. The highest adjusted net return (Tk. 2158200.0) was recorded with Spinomax SC 44.03% followed by Tk. 165180.0 with Ripcord 10 EC, Tk. 127500.0 with Bio-chamak 1% EW and Tk. 92100.0 with Fytomax PM**.** The lowest adjusted net return (Tk. 61620.0) was recorded with Neem oil whereas untreated control had no adjusted net return. The highest MBCR of 3.9 was obtained from the plot treated with Spinomax SC 44.03% followed by 3.2 with Ripcord 10 EC, 2.7 with Bio-chamak 1% EW and 1.8 with Fytomax PM. The lowest marginal benefit cost ratio (1.4) was found from the plot treated with Neem oil.

The study found that Spinomax SC 44.03% and Ripcord 10 EC were the most effective insecticides for controlling brinjal shoot and fruit borer, significantly enhancing plant growth, fruit characteristics, and yield compared to other treatments and untreated control plots. Both insecticides exhibited high repellency and larval mortality rates, with Spinomax SC 44.03% had the highest benefit-cost ratio. Neem oil was the least effective, demonstrating lower repellency, plant growth, and fruit yield.

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