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Effectiveness of bio-rational insecticides against pod borer of yard long bean and their effect on natural enemies

Amol Mrong[1], Md. Ruhul Amin[1], Emrul Kayesh[2], Pabitra Sutradhar[3] and Md. Shamim Hossain[1*]

[1] Department of Entomology, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur 1706, Bangladesh.
[2] Department of Horticulture, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur 1706, Bangladesh.
[3] Bangladesh Agricultural Research Institute, Gazipur 1701, Bangladesh.

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ABSTRACT

Pod borer, *Euchrysops cnejus* (Fab.) is the most destructive pest of yard long bean. A study was conducted during March to July 2022 in the experimental field of the Department of Entomology, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh to evaluate the effectiveness of some bio-rational insecticides against pod borer of yard long bean. The experiment was conducted following Randomized Complete Block Design (RCBD) with 3 replications. The treatments were Vermitec 1.8 EC (Abamectin) @ 1.0 ml/L, Tracer 45 SC (Spinosad) @ 0.4 g/L, Bio-Action 1.5 SL (Matrine) @ 1.5 ml/L of water, Ecomec 1.8 EC (Azadiractin) @ 1.5 ml/L and Phytoclean (Potassium salt of fatty acid 40%) @1.5 ml/L of water were applied thrice at 15 days interval along with an untreated control for comparison. The tested insecticides had no adverse effects on lady bird beetle, syrphid fly, black ant and spider. The study revealed that, the lowest rate of pod infestation at 3 and 7 days after each spray as well as the highest marketable yield (10.7 MT/ha) and marginal benefit cost ratio (7.7) were recorded with management approach comprising Tracer 45 SC (Spinosad) @ 0.4 g/L of water at 15 days interval which might be recommended for suppressing pod borer of yard long bean.

Introduction

Yard long bean, *Vigna unguiculata* subsp. *sesquipedalis* L.) is a popular summer vegetable crop profitably grown all over the world including Bangladesh (Srinivasan *et al*., 2019). In our country, it is mostly grown Kharif season in Chittagong, Chittagong Hill Tracts, Kustia, Dhaka, Khulna, Jessore and Rangpur districts (BBS, 2020). Although this is a summer vegetable but farmers cultivate this crop year round due to high market demand. The total area dedicated to this crop was 17307 hectares with production of 28469 metric tons in 2018-2019 (BBS, 2019). It is also rich of carbohydrates, vitamins, minerals and unsaturated fatty acids such as linoleic and oleic acids contain high

[*]**Corresponding Author:** Department of Entomology, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur-1706, Bangladesh. Email: shamim.ent@bsmrau.edu.bd

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percentage of calories (50 g), digestible protein (3 g), carbohydrates (9 g), fat (0.2 g), minerals (0.8 g) like folate, calcium, phosphorus, sodium, potassium, zinc, magnesium, manganese, cobalt as well as vitamin A, thiamin, riboflavin and vitamins C (Ano and Ubochi, 2008; Vaughan and Geissler, 2008). They are also active source of fodder for livestock (Chandra & Kushwaha, 2013), green manure (Ewansiha *et al*., 2016) and atmospheric nitrogen fixer (Singh *et al*., 2023).

But this crop is threatened by number insect pests, resulting in low yield and inferior quality. The yield loss in yard long bean due to insect pests is reported about 12-30%. It is especially attractive to pod borers, jassid, whitefly, aphids, epilachna beetle, hairy caterpillar, green stink bug and red spider mite (Hossain and Awrangzeb, 1992). Among them, legume pod borer, *Maruca vitrata* F. (Lepidoptera: Crambidae) and *Euchrysops cnejus* (Lepidoptera: Lycaenidae) both are the major constraints for bean production in Bangladesh (Dutta *et al*. 2004; Ali, 2006). It is the most notorious pest as an extensive host range, high potential and wide-ranging distribution (Margam *et al*., 2011).

They exhibited high levels of voracity, extensively spread, and possess a broad range of hosts, causing damage by creating perforations in flowers and tunneling within the pods (Ali, 2006). So, the infestation of pod borer complex *E. cnejus*, *M. vittata* is involved here in yard long bean and their nature of damage is also similar.

Farmers in Bangladesh are mostly relying on synthetic pesticides against these pests (Rahman *et al*., 2012). The utilization of these insecticidal measures not only costly but also creates residual effects on crop surfaces or in the soil, leading to the elimination of natural predators. This issue raises significant concerns related to human health and environmental contamination (Rikabdar, 2000), eventually contributing to pest resurgence due to the eradication of natural enemies (Devi *et al*., 2017). Additionally, synthetic insecticides pose a substantial risk to both public health and the environment. Hence, researchers are looking to adopt alternatives of broad-spectrum synthetic insecticides that are eco-friendly and effective.

Bio-rational insecticides encompass a variety of environmentally friendly as well alternatives of broad-spectrum insecticides. For examples of the new generation insecticides molecules as Emamectin Benzoate, Abamectin, Spinosad and Azadirachtin etc. are eco-friendly (Ahad *et al*., 2016). They offered numerous advantages over conventional pesticides like high selectivity, incredible efficacy at low dosage, safe to beneficial insects and environment as well (Kodandaram *et al*., 2010). Considering the merits, a field trial was conducted to evaluate the efficacy of different bio-rational insecticides as Emamectin Benzoate, Abamectin, Spinosad and Azadirachtin and phytoclean against the legume pod borer, *M. vitrata* and *E. cnejus* on yard long bean and their impact on natural enemies.

Materials and Methods

Experimental design and cultivation of crop

The study was conducted in the experimental field of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh during March to July 2022. The experimental field was contained 18 plots (3 m × 2 m). Space between two plots was maintained 1m and block to block 2m. The experimental plots were laid out in Randomized Complete Block Design (RCBD) with 3 replications. The seeds of yard long bean (var. Toky) were collected from the East-West Seed Company and sown at 15 March 2022 in the well-prepared field after 7 days of plot preparation. Seeds were sown in two rows with 75 cm distance between row to row while 30 cm between plant to plant accommodate 9 pits in each row. Seeds were sown in poly bags for gap filling in the field. Manures and fertilizers were applied at the recommended doses for yard long bean (FRG, 2012). Intercultural operations like thinning and gap filling, staking, mulching, weeding and irrigation were done when necessary.

Treatments and methods of application

The experimental treatments constituted with five biorational insecticides and untreated control. Details of the treatments are listed in Table 1.

The experimental plots were observed weekly and the treatments were applied when the borer infestation first appeared, and repeated three times at 15-days intervals.

Data collection and analysis

The application of treatments was started at the initial stage of pod infestation. The number of healthy and infested pods per plot were recorded at 3 and 7 days after each treatment (DAT) and worked out percent infestation. Subsequently, the aggregate yield of sound pods per plot was weighed in kilograms and converted to metric tons per hectare. The Marginal Benefit Cost Ratio (MBCR) was computed by overall cost of the specific treatment with the total revenue generated from treatment (Efad *et al*., 2021). The population levels of various beneficial arthropods such as ladybird beetles, syrphid flies, black ants, spiders, and bees were monitored using a sweep net at seven-day intervals throughout the entire growing season. The beneficial arthropods were promptly released back into the field after counting. All the data analyses were performed for analysis of variance (ANOVA) using IBM SPSS 20.0 and the means were separated by Tukey HSD Posthoc test (at 5% level of significance).

Results and Discussion

Efficacy of bio-rational insecticides on pod infestation

The tested bio-rational insecticides showed significant effects on pod infestation by pod borer of yard long bean after spray (Tables 2 and 3). After the first spray at 3 DAT, among the treatments, the highest pod infestation was recorded in untreated control plot (35.3±2.7%), followed by Phytoclean (20.2±1.6%) at 1.5 ml/L water treated plots. Conversely, the lowest pod infestation (4.6±1.1%) was obtained with Tracer 45 SC at 0.4 ml/L water, followed by Bio-Action 1.5 SL at 1.5 ml/L water (11.1±1.4%) treated plots (Table 2). After the second spray, similarly, the untreated control plot had the highest pod infestation (36.9±2.7%) followed by Phytoclean (22.0±1.9%) @1.5 ml/L after second spray. Conversely, the lowest infestation (2.2±0.7%) was obtained with Tracer 45 SC @0.4 g/L followed by Bio-Action @1.5 SL (10.6±3.4%) at @1.5 ml/L treated plots.

Again, after the third spray, the highest pod infestation was recorded in untreated control plot (46.0±2.3%), followed by Phytoclean (20.6±1.1%) @1.5 ml/L. Conversely, the lowest infested (1.3±0.2%) was obtained with Tracer 45 SC @0.4 g/L followed by Bio-Action 1.5 SL (9.2±3.2%) @1.5 SL treated plots (Table 2).

Spinosad is both a nerve poison and a stomach poison, so it kills pests that it contacts and those that consume it on the foliage they eat. It has a novel mode of action which will help prevent cross-resistance with organophosphates and carbamates (which are

Table 1. Details of the insecticidal treatments applied to control pod borer

Treatment	Active ingredient	Recommended dose	Mode of action
Vermitec 1.8 EC	Abamectin	1.2 ml/L	Contact and stomach action
Tracer 45 SC	Spinosad	0.4 g/L	Contact and stomach action
Bio-Action 1.5 SL	Matrine	1.5 ml/L	Contact poison, ingestion or gastric poison
Ecomec 1.8 EC	Azadirachtin	5.0 ml/L	Antifeedant
Phytoclean	Potassium salt of fatty acid 40%	1.5 ml/L	Disrupt the lipoprotein matrix of the insects cellular membranes

acetylcholinesterase inhibitors). Feeding stops within minutes and death occurs within 48 hours (Anonymous, 1999). Chatterjee *et al.* (2009) revealed that the lowest mean shoot as well as fruit infestation (7.47 and 9.88%) in brinjal was recorded in the plots treated with Spinosad 2.5 SC (50 g a.i./ha).

After the first spray at 7 DAT, the highest pod infestation by pod borer was also recorded in untreated control plot (39.5±5.8%), followed by Phytoclean (24.2±1.6%), Vertimec 1.8 EC (22.5±1.1%) and Ecomec 1.8 EC (20.4±2.0%) treated plots. On the other hand, the lowest pod infestation (4.5±1.0%) was obtained with Tracer 45 SC which was followed by Bio-Action 1.5 SL (10.1±3.6%) treated plot (Table 3).

After the second spray, the highest pod infestation by pod borer was also recorded in untreated control plot (37.4±2.8%), followed by Phytoclean (26.5±1.5%) and Vertimec 1.8 EC (24.1±1.9%) treated plots. Conversely, Tracer 45 SC treated plot showed the lowest infestation (3.2±0.6%), followed by Bio-Action 1.5 SL (13.4±3.0%) treated plot (Table 3).

After the third spray, again untreated control plot had the highest pod infestation by pod borer (47.1±2.3%) which was followed by Phytoclean (22.5±1.7%) and Vertimec 1.8 EC (22.4±1.4%) treated plots. Conversely, the lowest infestation (1.2±0.2%) was obtained with Tracer 45 SC followed by Bio-Action 1.5 SL (12.4±2.6%) treated plots (Table 3).

Randhawa and Saini (2015) tested the efficacy of different insecticides viz. Spinosad 48 SC, Cypermethrin 25 EC, Profenophos 50 EC and Indoxacarb 15 EC @ 150, 250, 1250 and 500 ml/ha, respectively against pod borer, *Maruca vitrata* (Geyer) in pigeon pea. All the tested insecticides significantly decreased the larval population of pod borer, number of flowers, pod damage and increased the grain yield as compared to untreated control. But, Spinosad 48 SC @ 150 ml/ha was found to be most effective against test insect and it was closely followed by Indoxacarb 15 EC and Cypermethrin 25 EC. The pod damage ranged from 16.75 to 33.50 and 21.25 to 36.50% with different insecticidal treatments as compared with untreated control in two consecutive years. The minimum pod damage with mean of 16.75 and 21.25% was recorded in case of two sprays of Spinosad 48SC which was closely followed by Indoxacarb 15 EC (19.00 and 22.50%) and Cypermethrin 20 EC (24.25 and 26.75%).

Mittal and Ujagir (2005) evaluated Spinosad (Tracer) 45% SC 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 also recorded lower pod damage compared to other treatments.

Table 2. Effect of bio-rational insecticides on pod infestation rate against pod borer of yard long bean at 3 days after treatments

Treatment	Pod infestation (%) at 3 DAT		
	1st Spray	2nd Spray	3rd Spray
Vertimec 1.8 EC	19.6±1.6b	21.3±1.5b	18.8±1.5b
Tracer 45 SC	4.6±1.1d	2.2±0.7d	1.3±0.2d
Bio-Action 1.5 SL	11.1±1.4c	10.6±3.4c	9.2±3.2c
Ecomec 1.8 EC	19.2±2.1b	16.9±3.5bc	14.5±3.0bc
Phytoclean	20.2±1.6b	22.0±1.9b	20.6±1.1b
Untreated control	35.3±2.7a	36.9±2.7a	46.0±2.3a

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 ≤ 0.05.

Effect of tested insecticides on natural enemies

The impact of tested bio-rational insecticides on the abundance of beneficial insects on yard long bean fields is presented in Table 4. Results evident that number of beneficial insects due to tested bio-rational insecticides and untreated control did not show any heterogeneity. This indicated that tested insecticides had no adverse effects on lady bird beetle, syrphid fly, black ants and spiders. Although the number of natural enemies per plot under tested insecticides was variable with higher range.

According to Smith and Krischick (2000), horticultural oil had no impact on the survival of lady beetles; however, Azatin, an extract from the Neem tree containing azadirachtin, caused less death to lady beetles than carbaryl. However, due to the clear effects of azadirachtin as an insect growth regulator when used in high concentrations, it should be used with caution (Qi *et al*., 2001).

Matrine and Azadirachtin, two botanical pesticides, had no effect on the quantity of helpful arthropods such coccinellids, spiders, and parasitoids in tea fields. According to the criteria of the International Organization of Bio-control, Hwang *et al*. (2009) reported that plant extract comprising Matrine and Neem displayed low deadly to predatory and parasitic natural enemies (IOBC).

In brinjal field, Efad *et al*. (2021) found that Spinomax 44.3 SC are biorational with the beneficial arthropods like lady bird beetle, syrphid fly, black ant and spider's presence on field during entire season in brinjal. In their study, the number of lady bird beetle and black ant was with the least significant statistical variation in Spinomax 44.3 SC and untreated control plot but no statistical variation was found with syrphid fly and spiders among the treatments including untreated control.

Effect of bio-rational management approaches on yield

Treatments with bio-rational insecticides had profound effects on the yield of yard long bean (Figure 1). The lowest marketable yield was obtained from untreated control (4.2 MT/ha) plots while the highest from Tracer 45 SC @0.4 g/L treated plot (10.7 MT/ha).

Hossain (2011) studied the relationship between pod borer infestation and yield (healthy pods) of yard-long bean. The result revealed that pod borer infestation was negatively correlated with yield of yard-long bean. The relationship was significant and about 15% yield would be affected due to pod borer infestation.

Yield loss of yard long bean due to insect pests is reported to be about 12.30% (Hossain and Awrangzeb, 1992). Hossain (2011) found that the highest yield of healthy pod (12.62 MT/ha) was recorded in Mechanical

Table 3. Effect of bio-rational insecticides on pod infestation rate against pod borer of yard long bean at 7 days after treatments

Treatment	Pod infestation (%) at 7 DAT		
	1st Spray	2nd Spray	3rd Spray
Vertimec 1.8 EC	22.5±1.1b	24.1±1.9b	22.4±1.4b
Tracer 45 SC	4.5±1.0d	3.2±0.6d	1.2±0.2d
Bio-Action 1.5 SL	10.1±3.6c	13.4±3.0c	12.4±2.6c
Ecomec 1.8 EC	20.4±2.0b	18.4±3.2bc	17.4±1.2bc
Phytoclean	24.2±1.6b	26.5±1.5b	22.5±1.7b
Untreated control	39.5±5.8a	37.4±2.8a	47.1±2.3a

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 ≤ 0.05.

Table 4. Effects of different bio-rational insecticides on the abundance of beneficial arthropods per plot (3 m × 2 m) during entire cropping season (Mean of 12 observations)

Treatments	Number of lady bird beetle/plot	Number of syrphid fly/plot	Number of black ants/plot	Number of spiders /plot
Vertimec 1.8 EC	9.0±2.6a	3.3±0.2a	44.3±0.7a	4.3±0.6a
Tracer 45 SC	8.0±1.1a	3.3±0.2a	44.2±0.3a	4.3±0.3a
Bio-Action 1.5 SL	5.6±0.6a	3.0±0.1a	40.6±0.5a	4.6±0.6a
Ecomec 1.8 EC	7.3±0.7a	3.7±0.1a	42.3±1.5a	5.0±0.6a
Phytoclean	7.6±1.2a	3.7±0.1a	43.6±0.8a	4.6±0.6a
Untreated control	10.3±2.3a	4.7±1.9a	50.3±2.5a	6.6±0.6a

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

control (hand picking) with 2 sprays of Ripcord (Cypermethrin) 10 EC @ 1 ml/L of water at 15 days interval which was statistically identical with 2 sprays of Ripcord (Cypermethrin) 10 EC @ 1 ml/L of water at 15 days interval (10.50 MT/ha).

Economic analysis of different bio-rational approaches

The calculation of management cost, gross return, net return, and adjusted net return for various treatments utilized against the pod borer in yard long beans presented in Table 5. The plot treated with Tracer 45 SC @0.4 g/L. exhibited the highest Marginal Benefit Cost Ratio (MBCR) of 7.7, followed by Bio-Action 1.5 SL @1.5 ml/L. Conversely, the lowest MBCR of 3.0 was observed in the plot treated with Vertimec 1.8 EC @1.2 ml/L.

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 without any harmful effect to other arthropods. Efad *et al*. (2021) found the highest MBCR of 4.08 from the treatment Tracer 45 SC amongst selected environment friendly approaches against brinjal shoot and fruit borer which was comparatively lower than the present study.

Alam *et al*. (2021) found that the highest benefit cost ratio (12.81) was estimated for Voliam Flexi (Thiamethoxam + Chlorantraniliprole) @ 0.25 ml/L of water at 10 days interval and the lowest (4.16) for Allion 2.5 EC (Lamda-Cyhalothrin) @ 2.0 ml/L of water at 10 days interval under the trial. The highest BCR found in the treatment Voliam Flexi, may be due

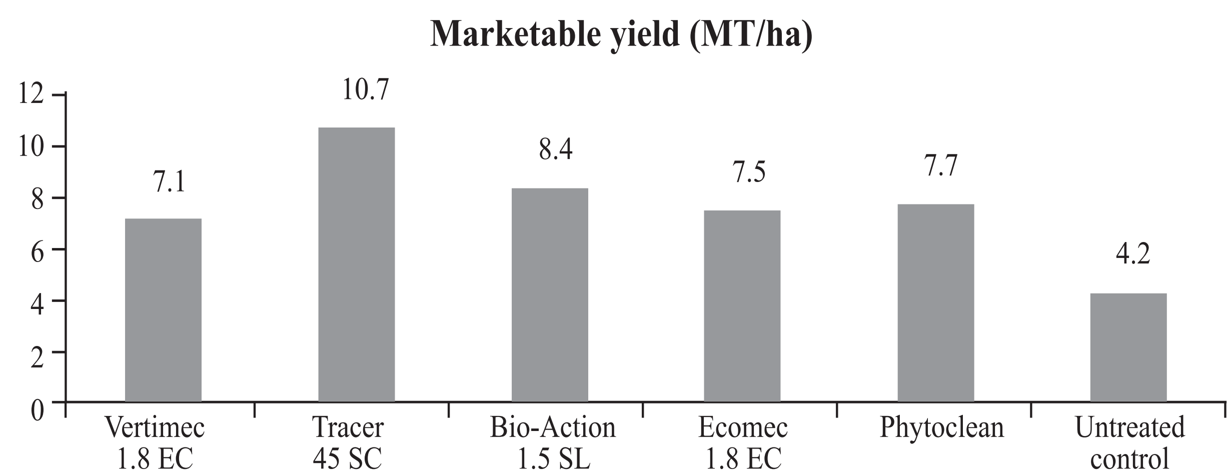

Fig. 1. Effects of different bio-rational management approaches against pod borer of yard long bean marketable yield (MT/ha).

Table 5. Marginal benefit cost ratio (MBCR) analysis of selected bio-rational management approaches against pod borer of yard long bean

Treatments	Management cost (Tk.)	Gross return (Tk.)	Net return (Tk.)	Adjusted net return (Tk.)	MBCR
Vertimec 1.8 EC	14880.0	212480.0	197600.0	44280.0	3.0
Tracer 45 SC	19368.0	322400.0	303032.0	149712.0	7.7
Bio-Action 1.5 SL	14460.0	253040.0	238580.0	85260.0	5.9
Ecomec 1.8 EC	14112.0	224800.0	210688.0	57368.0	4.1
Phytoclean	19155.0	232000.0	212845.0	59525.0	3.1
Untreated control	3480.0	156800.0	153320.0	0.0	

Market value of yard long bean = Tk. 30.0 per Kg.

to the minimum pest infestation to the other treatment components and the better yield of this treatment. According to Rahman (1989) spraying of Fenitrothion 0.1% at the flowering stage and the second spray either at an interval of 15 days or at podding offered the highest cost-benefit ratio.

Conclusion

Management approach comprising of 3 sprays of Tracer 45 SC (Spinosad) @ 0.4 g/L of water might be an effective, suitable and viable approach for suppressing pod borer of yard long bean.

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