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EFFICACY OF BIO-RATIONAL INSECTICIDE FOR ECO-FRIENDLY MANAGEMENT OF POD BORER OF MUNG BEAN

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Abstract

Pod borer species *Maruca vitrata* (Geyer) and *Euchrysops cnejus* (Fab.) are the major limiting constraints in mung bean. The present experiment was conducted in the experimental field of the Department of Entomology, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh during March to June 2021 to develop an ecofriendly management approach against pod borer attacking mung bean. Four eco-friendly biopesticides (Biomax 1.8 EC (Abamectin) @ 1.2 ml/L, Tracer 45 SC (Spinosad) @ 0.4 g/, Fytomax PM (0.1% Azadirachtin) @ 5.0 ml/L, Neem Seed kernel Extract (NSKE) @ 50.0 g/L) and clean cultivation were tested against pod borers of mung bean variety BU mug 4. An untreated control treatment was maintained for comparison. The marginal benefit-cost ratio of the treatments and the impact of the treatments on the abundance of beneficial arthropods in the experimental plots were recorded. The management approaches did not affect the abundance of beneficial arthropods in the bean field. The findings revealed that the lowest rate of pod infestation (1.9% by n/n and w/w) as well as the highest marketable yield (1.55 MT/ha) and marginal benefit-cost ratio (3.02) were obtained with the foliar spray with Tracer 45 SC (Spinosad) @ 0.4 g/L of water at 15 days interval. Tracer 45 SC (Spinosad) @ 0.4 g/L of water at 15 day intervals is an effective, suitable, and viable approach for suppressing pod borer complex without harm to beneficial arthropods in the mung bean field.

Keywords: Botanicals, abamectin, spinosad, *Euchrysops cnejus*, *Maruca vitrata.*

Introduction

Mung bean (*Vigna radiata* L. Wilczek) is one of the leading legume crops widely grown during Rabi season in Bangladesh as well as in many other tropical and subtropical countries of the world (Asante *et al*., 2002). Due to availability of short duration varieties (BARI Mung 6, BU mug 4, BU mug 5), farmers are becoming more interested to cultivate this valuable crop after harvesting of *Rabi* crops in *Kharif-I* season (Hossain, 2015). It is a good source of proteins, carbohydrates and vitamins for the human race all over the world. It contains 51% carbohydrate, 26% protein, 10% water, 4% minerals and 3% vitamins (Ghafoor *et al*., 2003).

In Bangladesh, the area under pulse crops is 0.372 million hectares with a production of 0.425 million MTs but 0.041 million hectares of land are under mung bean cultivation where

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its production is 0.044 million MTs (BBS, 2021). It is considered as a quality pulse in the country. However, production of the crop per unit area is very low (931 kg/ha) as compared to other countries of the world (BBS, 2021). It ranks fifth both in acreage and production and contributes 6.5% of the total pulse production in Bangladesh (Alam *et al*., 2021).

A number of insect pests affect the production of mung bean. According to the report of Rahman *et al.* (2000), more than twelve species of insect pests are found to infest mung bean in Bangladesh. Among these pests stemfly, flea beetles, flower thrips and pod borers cause serious damage. Tanzum *et al.* (2021) reported that pod borers consisting *Euchrysops cnejus* (Fab.), *Maruca vitrata* (Fab.), flea beetles, thrips, jassid and whitefly were major pests attacking mung bean. Umbarkar and Parsana (2014) reported that among the various insect pests, *Maruca vitrata* (Geyer) is the most formidable and potential pest of green gram. Due to severe infestation of pod borers, pods as well as seed maturation hampered greatly and the viability of the seeds were reduced (Kraft and Pfleger, 2001). The rate of infested plant by pod borer complex was 84.4% (Tanzum *et al*., 2021).

Farmers of Bangladesh are mostly depending on the toxic synthetic pesticides to combat those pests (Rahman *et al*., 2012). These insecticidal controls of the insect pests are not only expensive but also left over residues on the sprayed surface of the crops or in the soils; destroying natural enemies which become a matter of great concern of human health and environmental pollution (Rikabdar, 2000) and ultimately pest resurgence (Devi *et al*., 2017). Moreover, synthetic insecticides possess a serious threat to public health and the environment.

Bio-rational insecticide includes both eco-friendly insecticides and other nonchemical (i.e. mechanical, cultural, biological, botanical, etc.) management approaches. Spinosad, Abamectin, Emamectin Benzoate, Azadirachtin etc. are some example of eco-friendly new generation insecticides (Ahad *et al*., 2016). Bio-rational insecticide to combat insect pests is a more modern strategy that has caught the interest of entomologists all over the world. In programs to control insect pests, bio-rational strategies like plant extracts and oils are applied (Soares *et al*., 2019). Insect pests are poisoned by botanical extracts and oils, which prevents them from growing and reproducing (Mazumder *et al*., 2016). Presently, Bio-rational insecticide are encouraged to use for satisfactory management of insect pests and to avoid health hazards and environmental polution. Therefore, the present experiment was designed with four bio-rational insecticides and mechanical approach to manage the pod borer complex attacking BU mug 4.

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 June 2021. The experimental field was contained18 plots (3×2 m^2). Space between two plots was 1m and block to block distance was 2m. The experimental plots were laid out in Randomized Complete Block Design (RCBD) with three replications. The seeds of mung bean variety BU mug 4 were sown on 15 March 2021 in the well-prepared plots following 30 cm apart from row to row and 6 cm from plant to plant in a row. Application of manures and fertilizers was done according to the recommended fertilizer doses for mung bean production (FRG, 2018). Intercultural operations were done whenever necessary.

Treatments and methods of application: The experimental treatments were constituted with three biorational insecticides, neem seed kernel extract, mechanical method (Hand picking) and clean cultivation. A nontreated control was maintained for comparison of the treatments. Details of the bio-rational pesticides tested are shown in Table 1.

Data collection and analysis: The experimental plots were monitored weekly interval and the treatments were applied at the advent of the incidence of the borer and their infestation, and repeated twice at 15 days interval.

The number of healthy and infested pods and their weight per plot were recorded after harvest. The infestation of the borers was expressed in percentage based on total number of pods (n/n) and (w/w) checked. Just after threshing, the cumulative yield in kg per plot of healthy, infested as well as total seeds was computed from healthy and infested seeds and then it was converted to MT/ha. For economic analysis, Marginal Benefit Cost Ratio (MBCR) was calculated on the basis of total expenditure of the respective treatment with the total return from that particular treatment (Efad *et al*., 2021). The abundance of different beneficial arthropods like ladybird beetles, syrphid flies, black ants, spiders and bees were collected by sweep net and recorded six times after application of treatment at seven days interval. The captured beneficial arthropods were released again just after counting. The data were analyzed using MSTAT-C software for analysis of variance (ANOVA) and the mean values were separated by Duncan's Multiple Range Test (DMRT).

Results and Discussion

Effect of the treatments on pod infestation

The rate of pod infestation showed significant variation among the treatments (Table 2). The highest rate of pod infestation was found in untreated control plot (20.7%) and conversely significantly the lowest rate of pod infestation was found with Tracer 45 SC treated plot (1.9%). The rate of pod infestation in the plots treated with Biomax 1.2 EC, Fytomax PM, NSKE and mechanical control showed statistically similar and these were 5.9%, 7.1%, 7.3% and 8.7%, respectively.

Table 1. Details of the bio-rational insecticides tested against pod borer of mung bean

Treatment	Active ingredient	Recommended dose	Mode of action
Biomax 1.8 EC	Abamectin	1.2 ml/L	Contact and stomach action
Tracer 45 SC	Spinosad	0.4 g/L	Contact and stomach action
Fytomax PM 0.1%	Azadirachtin	5.0 ml/L	Antifeedant
Neem Seed kernel Extract (NSKE)	Azadirachtin	50.0 g/L	Antifeedant

Table 2. Effect of different management treatments on the infestation of bean pod borer

Treatment	Rate (%) of pod infestation (n/n)	Reduction (%) over untreated control (n/n)	Rate (%) of pod infestation (w/w)	Reduction (%) over untreated control (w/w)
Biomax 1.2 EC	5.9b	71.7	5.8b	72.0
Tracer 45 SC	1.9c	90.8	1.9c	90.8
Fytomax PM	7.1b	65.8	7.0b	66.2
NSKE	7.3b	64.8	7.2b	65.2
Hand picking	8.7b	58.0	8.6b	58.5
Untreated control	20.7a	-	20.7a	-
CV (%)	7.98	-	8.28	-

Means within a column followed by same letter(s) are not different significantly (P<0.05) according to Duncan's Multiple Range Test (DMRT)

Significantly the highest rate of pod infestation (w/w) was found in untreated control plot (20.7%) and conversely significantly the lowest rate of pod infestation was found with Tracer 45 SC treated plot (1.9%). The rate of pod infestation in plots treated with Biomax 1.2 EC, Fytomax PM, NSKE, mechanical control was statistically similar and these were 5.8%, 7.0%, 7.2% and 8.6%, respectively.

The highest percent of pod infestation reduction over untreated control was found in Tracer 45 SC (90.8% by n/n and w/w) treated plot followed by Biomax 1.2 EC (71.7% by n/n and 72.0% by w/w) treated plots. The lowest percent of pod infestation reduction over untreated control plot was found in mechanical control plot (58.0% by n/n and 58.5% by w/w) followed by NSKE (64.8% by n/n and 65.2% by w/w) and Fytomax PM (65.8% by n/n and 66.2% by w/w) treated plots.

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, *M. vitrata* 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%).

Effect of eco-friendly management approach on natural enemies

The effect of different bio-rational treatments on the abundance of beneficial arthropods in the experimental plots of mung bean are presented in Table 3. The beneficial arthropods namely ladybird beetles, syrphid flies, black ants, spiders and bees were present in the plots during entire season. The abundance of ladybird beetle was statistically similar in Tracer 45 SC and NSKE treated plots but significantly lower compared to other treatments. There was no statistical variation in the abundance of syrphid flies, black ants, spiders and bees among the treatments.

Efad *et al*. (2021) studied the effect of bio-rational insecticides namely Azadirachtin, Spinosad and Abamectin on the abundance of beneficial arthropods like ladybird beetles, syrphid flis, black ants, and spiders in the field of brinjal and reported their abundance entire the season. In their study, the abundance of ladybird beetle and black ant was statistically similar in Spinosad and Abamectin treated plots along with untreated control plot. There was no statistical variation in the abundance of syrphid fly and spiders' among the treatments.

Effect of different management approaches on yield of mung bean

The highest marketable yield (1.55 MT/ha) was obtained from Tracer 45 SC treated plot which was statistically similar to Biomax 1.2 EC treated plot (1.32 MT/ha). The lowest marketable yield (0.93 MT/ha) was recorded from untreated control plot which was statistically similar to mechanical control plot (1.08 MT/ha). The yield obtained from Fytomax PM (1.24 MT/ha) and NSKE treated plots (1.20 MT/ha) was statistically similar.

Significantly the lowest infested yield was obtained from Tracer 45 SC (0.03 MT/ha). The highest yield of infested pods per plot was recorded in untreated control plot (0.24 MT/ha). Mechanical control plot (0.10 MT/ha), Fytomax PM (0.09 MT/ha) and NSKE (0.09 MT/ha) and Biomax 1.2 EC (0.08 MT/ha) treated plots showed statistically similar yield of infested pods.

The highest total yield (1.58 MT/ha) was obtained from Tracer 45 SC treated plot which was statistically similar to Biomax 1.2 EC treated plot (1.40 MT/ha). The lowest total yield (1.17 MT/ha) was recorded in untreated control plot which was statistically similar to mechanical control plot (1.18 MT/ha), NSKE

Table 3. Effect of different management approaches on the abundance of beneficial arthropods in mung bean plots

Treatments	No. of ladybird beetle/plot	No. of syrphid fly/plot	No. of black ant/plot	No. of spiders/plot	No. of bees/plot
Biomax 1.2 EC	32.2a	2.3a	267.2a	6.0a	2.2a
Tracer 45 SC	22.5b	1.8a	236.1a	4.3a	1.5a
Fytomax PM	23.5a	2.4a	217.1a	5.6a	3.3a
NSKE	20.1b	1.7a	216.9a	4.6a	1.6a
Hand picking	30.7a	3.1a	207.6a	5.3a	2.1a
Untreated control	33.5a	2.9a	228.3a	6.3a	3.2a
CV (%)	9.68	8.07	9.16	7.43	8.80

Means within a column followed by same letter(s) are not significantly different (P<0.05) according to Duncan's Multiple Range Test (DMRT). Plot size 3 m × 2 m

(1.29 MT/ha) and Fytomax PM (1.33 MT/ha) treated plots.

The highest percent increase of marketable yield over untreated control (66.7%) was found in plot treated with Tracer 45 SC. The lowest percent increase of marketable yield over control was recorded from mechanical control (16.1%) followed by NSKE (29.0%), Fytomax PM (33.0%) and Biomax 1.2 EC (41.9%) treated plots (Table 3).

Mittal and Ujagir (2005) evaluated Spinosad (Tracer) 45% SC along with other insecticides. Among different treatments lower number of *Helicoverpa 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.

Yasmin *et al.* (2019) found that highest number of pod (23.80 per plant), seed (10.20 per pod), 1000 seed weight (48.40 g) and yield (1026.91 kg/ha) were also found in Stargate 48 SC treated plots followed by Confidor 70WG and Actara 25WG treatments.

Economic analysis of different bio-rational approaches

The management cost, gross return, net return, adjusted net return of different management approaches used against pod borer complex in mung bean was calculated and presented in Table 5. The highest MBCR of 3.02 was obtained from the plot treated with Tracer 45 SC followed by 2.37 with Biomax 1.2 EC, 1.99 with NSKE and 1.88 with Fytomax PM sprayed plots. The lowest marginal benefit cost ratio (1.60) was obtained from the mechanical control plot.

Alam *et al*. (2021) found that the highest benefit cost ratio (12.81) with Voliam Flexi (Thiamethoxam+Chlorantraniliprole) @ 0.25 ml/L of water at 10 days interval and the lowest (4.16) with Allion 2.5 EC (Lamda-Cyhalothrin) @ 2.0 ml/L of water at 10 days interval. The highest BCR found in the treatment Voliam Flexi, may be due to the minimum pest infestation to the other treatment components and the better yield of this treatment. According to Rahman

Table 4. Effect of different management approaches on yield of mung bean variety BU mug 4

Treatment	Yield (MT/ha)			Marketable yield increase over untreated control (%)
	Marketable	Infested	Total	
Biomax 1.2 EC	1.32ab	0.08b	1.40ab	41.9
Tracer 45 SC	1.55a	0.03c	1.58a	66.7
Fytomax PM	1.24b	0.09b	1.33b	33.0
NSKE	1.20b	0.09b	1.29b	29.0
Hand picking	1.08bc	0.10b	1.18b	16.1
Untreated control	0.93c	0.24a	1.17b	-
CV (%)	6.73	5.92	5.28	-

Means within a column followed by same letter(s) are not significantly different (P<0.05) according to Duncan's Multiple Range Test (DMRT)

Table 5. Marginal benefit cost ratio (MBCR) analysis of selected management approaches against bean pod borers

Treatments	Management cost (Tk)	Gross return (Tk)	Net return (Tk)	Adjusted net return (Tk)	MBCR
Biomax 1.2 EC	9920.0	105600.0	95680.0	23600.0	2.37
Tracer 45 SC	12910.0	124000.0	111090.0	39010.0	3.02
Fytomax PM	9408.0	99200.0	89792.0	17712.0	1.88
NSKE	8212.0	96000.0	87788.0	15708.0	1.91
Mechanical control	5500.0	86400.0	80900.0	8820.0	1.60
Untreated control	2320.0	74400.0	72080.0	0.0	-

Market value of mung bean= 80.0 Tk/kg, cost of Biomax 1.2 EC per spay= 3800.0 Tk/ha, Tracer 45 SC per spay= 5295.0 Tk/ha, Fytomax PM per spay= 3544.0 Tk/ha, Neem Seed Extract per spray = 2946.0 Tk/ha, Mechanical control per schedule= 5 labor/ha, Labor cost= 550 Tk/day, No. of spray=2, sprayer rent= 30 Tk/day

(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. This study showed that the neem seed kernel extract as a source of plant material revealed better performance in reducing the infestation of pod borer and did not interrupt the abundance of predator and pollinator arthropods. These findings are in agreement with Ahmed *et al*. (2019) who applied plant materials in country bean field and found that the materials reduced aphid abundance and flower infestation, ensuring a higher yield with larger and heavier pods. They also found that the neem oil treatment had the lowest abundance of aphid and consequently produced the highest marketable and gross yields.

Spinosad is both a nerve poison and a stomach poison, so that it kills pests whenever the pests come into contacts or they consume it. It has a novel mode of action which will help prevent cross-resistance with organophosphates and carbamates (which are acetylcholinesterase inhibitors). Feeding stops within minutes and death occurs within 48 hours (Anonymous, 1999). 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 higher than the present study.

Conclusion

Management approach comprising of two sprays of Tracer 45 SC (Spinosad) @ 0.4 g/L of water at 15 days interval might be an effective, suitable and viable approach for suppressing pod borer complex in mung bean field.

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