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Research Article

Management of legume pod borer, *Maruca vitrata* (Lepidoptera: Crambidae) on yardlong bean using some new generation insecticides

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ABSTRACT

Yard-long bean (*Vigna unguiculata* subsp. *sesquipedalis*) is a protein-rich vegetable widely cultivated in Bangladesh; however, its production is severely hampered by the legume pod borer, *Maruca vitrata*. A field experiment was conducted from February to June 2024 at the Entomology Research Field of Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur, using a randomized complete block design (RCBD) to evaluate four selected new-generation insecticides against this pest. The treatments included Spinosad (Tracer 45 SC), Bio-chamak 1% EW (*Celastrus angulatus*), Spinetoram (Delegate 11.7 SC), Azadirachtin 1% EC, and an untreated control. Among the treatment, Spinetoram (Delegate 11.7 SC) @ 0.3 ml L^{-1} consistently resulted in the lowest pod infestation after three applications, reduced infestation by up to 80.56% compared to the control. It also produced the highest yield (9.15 t/ha), with a yield increase of 80.19% and the highest benefit-cost ratio (2.59). Therefore, Spinetoram proved to be an effective and economically viable option for sustainable management of pod borer in yard-long bean cultivation.

Introduction

Legumes are an excellent source of protein in the human diet and are often referred to as the “poor man’s meat” (Maphosa and Jideani, 2017). They also serve as valuable green manure crops, high-quality livestock feed, and contribute nitrogen to the soil through atmospheric nitrogen fixation (Cook et al., 2005). Among food legumes, yard long bean (*Vigna unguiculata* subsp. *sesquipedalis*) is widely consumed in Southeast Asia, West Africa, Europe, Oceania, and North America (Malacrino et al., 2019). In Bangladesh, it is extensively cultivated, especially during vegetable shortages, occupying 17,307 ha and producing 28,469 MT in 2018-2019 (BBS, 2024). A 100-g serving provides 50 calories, 9 g carbohydrates, 3 g protein, 0.2 g fat, and is rich in vitamins A, C, thiamin, and riboflavin (Jayasinghe et al., 2015).

Although a summer vegetable, the yard long bean is grown year-round in Bangladesh to meet strong market demand. The crop also has potential for export in both fresh and frozen forms (Mian et al., 2016). Despite this, overall production remains low, failing to meet both domestic demand and international standards. Its cultivation is threatened by multiple insect pests, causing significant economic losses (Oliveira et al., 2014). Among them, the legume pod borer, *Maruca vitrata* F. (Lepidoptera: Crambidae), is the most destructive, causing up to 80% yield losses due to its wide host range, high damage potential, and global distribution (Ali, 2019; Aktar et al., 2020; Margam et al., 2011). Farmers in Bangladesh frequently rely on indiscriminate chemical pesticide applications to rapidly knock down this pest (Ahmed et al., 2020; Aktar et al., 2020).

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However, conventional chemical control poses major problems, including ecological imbalance, pesticide resistance, pest resurgence, outbreaks, phytotoxicity, and environmental hazards (Ambethar, 2009; Mweke et al., 2020). Consequently, there is a global shift toward safer, newly formulated insecticides. These modern pesticides are highly selective, effective at low doses, biodegradable, less harmful to beneficial insects, and environmentally safer, making them suitable for sustainable agriculture (Kodandaram et al., 2014). However, research on the use of biorational insecticides for suppressing the yard-long bean pod borer in Bangladesh remains limited. Hence, considering the economic significance of pod borer, a field study was conducted to evaluate four newly formulated insecticides of Spinosad (Tracer 45 SC), Bio-Chamak 1% EW (*Celastrus angulatus*), Azadirachtin 1% EC, and Spinetoram (Delegate 11.7 EC) against *M. vitrata* on yardlong bean.

Materials and Methods

Experimental site and soil preparation

The experiment was conducted at the Research Field of the Department of Entomology, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur, Bangladesh, from February to June 2024. The experimental field was located on medium-high land in Agro-Ecological Zone AEZ-1 (Old Himalayan Piedmont Plain) and characterized by clay loam soil with a pH of 5.52, electrical conductivity (EC) of 2.0 mS m^{-1}, and medium organic matter content (Shil et al., 2016). Seeds of a dwarf yard-long bean variety were procured from the local market of Sadar Upazila, Dinajpur.

The land was ploughed and cross-ploughed several times using a power tiller to achieve a fine tilth, followed by laddering and spading. Before planting, the field was thoroughly leveled, and weeds and crop residues were eliminated. To provide sufficient soil moisture for germination, three seeds were planted in each pit and lightly irrigated. Thinning was done fifteen days after seeding, leaving one healthy plant per pit. A bamboo stick was used to support each plant to prevent lodging. Weeding, irrigation, and plant protection techniques were among the intercultural tasks carried out as needed. Fertilizers were applied according to the Fertilizer Recommendation Guide's suggested dosages (FRG, 2012). A randomized complete block design (RCBD) with three replications, five treatments, and an untreated control was used to set up the experiment. The field was divided into 15 plots. Each unit plot had a single pit measuring 1.0 m × 0.5 m. Plots were kept 0.35 m apart.

Treatments and data collection

The treatments evaluated were T_1 = Spinosad (Tracer 45 SC) @ 0.4 ml L^{-1} of water, T_2 = Bio-Chamak 1% EW (*Celastrus angulatus*) @ 1.5 ml L^{-1} of water, T_3 = Spinetoram (Delegate 11.7 SC) @ 0.3 ml L^{-1} of water, T_4 = Azadirachtin 1% EC @ 1.0 ml L^{-1} of water as well as an untreated control that received just water. A backpack sprayer was used to apply each treatment three times at 15 days intervals. Spraying was done in the late afternoon (about 4:00 pm) to assure pollinator safety. Ten days after flowering, the first spray was applied. During the podding stage, individual pods were harvested 5, 10, and 15 days after each spray. After each spray, data were recorded on the number of healthy pods, the weight of healthy pods, and the percent of pod protection relative to the untreated control.

Economic analysis and benefit-cost ratio

To evaluate the economic feasibility of the treatments, marketable yield data were collected from each pit at every harvest. Based on market-quality attributes, harvested pods were graded, including size, shape, and freedom from defects. Gross return was calculated by multiplying the marketable yield by the prevailing local market price. The benefit-cost ratio (BCR) was computed using the following formula:

BCR = Gross return / Total cost of production (treatment costs + common cost)

Statistical analysis

The LSD test ($p<0.05$) was used to separate the means after the data were statistically examined using Statistix 10 software to determine the significance of variation among the treatments.

Results and Discussion

Effect of treatments against *M. vitrata* on yard long bean after 1st spray

All tested biopesticides significantly reduced *Maruca vitrata* infestation on pods compared with the untreated control after the first spray (Table 1). Among the treatments, spinetoram 11.7% SC applied at 0.3 ml L^{-1} of water recorded the lowest number of infested pods at 1, 5, and 10 days after spraying (DAS), with mean values of 1.93, 1.70, and 1.57, respectively. Conversely, the untreated control showed the highest levels of infestation, with 5.03, 6.80, and 8.57 infested pods during the corresponding observation periods. Statistical analysis revealed highly significant differences among treatments at all intervals (1 DAS: $p < 0.01$, $F = 122.32$, $df = 4$; 5 DAS: $p < 0.01$, $F = 202.61$, $df = 4$; 10 DAS: $p < 0.01$, $F = 332.76$, $df = 4$). After the 1st spray, spinetoram 11.7% SC @ 0.3 ml L^{-1} produced the greatest overall reduction in pod infestation, with a 74.55% over the untreated control.

The current study's findings on spinetoram align with earlier scholars' findings. The best treatment for pod borer, according to Bhuva and Patel (2023), was spinetoram (0.010%), which reduced larval density to 0.33 larvae per plant, limited pod damage to 3.02%, and increased grain output by 46.78% above the control. Similarly, Akbar et al. (2018) reported that spinetoram caused the highest larval mortality (85.71%) of pod borers in chickpea, reducing larval populations to 0.33 per plant and pod damage to 4.62%. These findings confirm the rapid and effective action of Spinetoram against lepidopteran pod borers.

Table 1. Efficacy of tested bio-rational pesticides against *M. vitrata* after 1st spray on yardlong bean.

Treatments	Dose (ml L^{-1}) water	Number of infested pods plant^{-1} after 1st spray				Decrease (%) over control
		1 DAS	5 DAS	10 DAS	Mean	
T_1	0.4	2.46^{c}	2.23^{c}	2.40^{d}	2.37^{c}	65.15
T_2	1.5	3.10^{b}	2.83^{b}	3.13^{c}	3.02^{b}	55.44
T_3	0.3	1.93^{d}	1.70^{d}	1.57^{e}	1.73^{d}	74.55
T_4	1.0	3.30^{b}	2.73^{b}	3.70^{b}	3.24^{b}	52.35
Control	-	5.03^{a}	6.80^{a}	8.57^{a}	6.80^{a}	-
CV (%)	-	5.81	7.58	6.72	4.26	-

T_1 = Spinosad, T_2 = *Celastrus angulatus*, T_3 = Spinetoram, T_4 =Azadirachtin, DAS = Days after spray. Different superscripts indicate differences among the treatment.

Effect of treatments against *M. vitrata* on yardlong bean after the 2nd spray

Following the second spray, all tested biorational insecticides again significantly suppressed pod borer infestation compared with the untreated control (Table 2). Spinetoram 11.7% SC applied at 0.3 ml L^{-1} recorded the lowest number of infested pods at 1, 5, and 10 DAS, with mean values of 1.37, 1.16, and 1.03, respectively. Conversely, the untreated control exhibited the highest infestation levels (5.40, 6.37, and 6.47 pods). These differences were statistically highly significant (1 DAS: $p < 0.01$, $F = 50.64$, df = 4; 5 DAS: $p < 0.01$, $F = 147.08$, df = 4; 10 DAS: $p < 0.01$, $F = 209.49$, df = 4). After the second spray, spinetoram reduced overall pod infestation by 80.56% compared to the control, suggesting increased efficacy with repeated treatment.

These findings agree with those of Abbas et al. (2021), who reported that spinetoram reduced pod borer larval populations by 70.0% at 3 days, 59.67% at 7 days, and 49.10% at 14 days after application, demonstrating its sustained effectiveness. Likewise,Kumar and Muthukrishnan (2018) found that spinetoram 12 SC applied at 45 g a.i. ha^{-1} reduced pod borer infestation to 4.4%, corresponding to an 82.9% reduction over the untreated control. Nur et al. (2020) also reported similar results using Spinosad against *M. vitrata*. The present findings also align with Kumar and Pavviya (2018), who reported that Spinetoram 12 SC effectively reduced *M. vitrata* incidence on pigeon pea when applied three times at 36-45 g a.i. ha^{-1} intervals.

Effect of treatments against *M. vitrata* on yardlong bean after the 3rd spray

After the third spray, tested biorational insecticides continued to show promising efficacy in reducing *M. vitrata* infestation (Table 3). Spinetoram 11.7% SC @ 0.3 ml L^{-1} again recorded the lowest number of infested pods at 1, 5, and 10 DAS (1.50, 1.13, and 1.33 pods, respectively), whereas the untreated control showed the highest infestation levels. Overall, spinetoram achieved a 66.24% reduction in pod infestation compared with the untreated control after the third spray.

The consistent superiority of Spinetoram across all three sprays highlights its strong, reliable efficacy against *M. vitrata*. Similar results were reported by Srinivasan et al. (2025), who found that spinetoram 6% w/v + methoxyfenozide 30% w/v SC applied at 144 g a.i. ha^{-1} reduced *M. vitrata* and *Lampides boeticus* larval populations by 86.97% and 85.75%, respectively, and reduced pod damage by 73.78%. Patel et al. (2023a) also reported that spinetoram 11.7% SC significantly reduced pod borer larval populations in chickpea, ranking among the most effective insecticides tested. The present results are comparable to those of Hossain et al. (2025). They reported that the lowest number of infested pods (1.33, 1.11, and 1.22) $plant^{-1}$ was observed in Spinosad- treated plants. Additionally, Patel et al. (2023b) observed effective suppression of *M. vitrata* on cowpea, with only 1.53 larvae per plant and 14.24% pod damage.

Table 2. Efficacy of tested bio-rational pesticides against *M. vitrata* after the 2nd spray on yardlong bean.

Treatments	Dose (ml L^{-1}) water	Number of infested pods/plant				Decrease (%) over control
		2nd spray				
		1 DAS	5 DAS	10 DAS	Mean	
T_1	0.4	2.20^c	2.13^c	2.43^c	2.25^c	62.93
T_2	1.5	3.13^b	2.97^b	3.03^b	3.04^b	49.92
T_3	0.3	1.37^d	1.16^d	1.03^d	1.18^d	80.56
T_4	1.0	$2.87b^c$	2.73^b	$2.83b^c$	2.81^b	53.70
Control	-	5.40^a	6.37^a	6.47^a	6.07^a	-
CV (%)	-	12.27	9.15	7.60	6.37	-

T_1 = Spinosad, T_2 = *Celastrus angulatus*, T_3 = Spinetoram, T_4 =Azadirachtin, DAS= Days after spray. Different superscripts indicate differences among the treatment.

Table 3. Efficacy of tested bio-rational pesticides against *M. vitrata* after 3rd spray on yardlong bean.

Treatments	Dose (ml L^{-1}) water	Number of infested pods $plant^{-1}$ after 3rd spray				Decrease (%) over control
		1 DAS	5 DAS	10 DAS	Mean	
T_1	0.4	1.83^{cd}	1.90^{c}	2.27^{c}	2.00^{c}	48.85
T_2	1.5	2.16^{bc}	2.06^{c}	2.53^{bc}	2.25^{bc}	42.45
T_3	0.3	1.50^{d}	1.13^{d}	1.33^{d}	1.32^{d}	66.24
T_4	1.0	2.50^{b}	2.73^{b}	2.90^{b}	2.71^{b}	30.69
Control	-	3.77^{a}	3.83^{a}	4.13^{a}	3.91^{a}	-
CV (%)	-	12.77	12.32	11.31	10.41	-

T_1 = Spinosad, T_2 = *Celastrus angulatus*, T_3 = Spinetoram, T_4 =Azadirachtin, DAS= Days after spray. Different superscripts indicate differences among the treatment.

Effect of treatments on the yields of yardlong bean

Yield data further substantiated Spinetoram's effectiveness. All treatments resulted in significantly higher yields than the untreated control (Table 4). Spinetoram 11.7% SC @ 0.3 ml L^{-1} produced the highest yield per harvest and also the highest cumulative yield (9.15 ton/ ha), while the untreated control recorded the lowest cumulative yield (1.81 ton ha^{-1}). The Spinetoram treatment resulted in an 80.19% increase in yield over the control, clearly demonstrating its contribution to enhanced productivity. Similar yield improvements with spinetoram have been reported by Srinivasan et al. (2025), Patel et al. (2023b), Bhuva and Patel (2023), and Kumar and Muthukrishnan (2018). Novel research demonstrates that newly formulated insecticides have been successfully evaluated by multiple researchers against various pod borer species (Haripriya et al., 2019). The present findings are consistent with those of Dahal et al. (2020), who reported the lowest pod damage and higher cowpea yield in Spinosad-treated plots compared with pod-borer treatments.

Effect of tested bio-rational pesticides on Benefit Cost Ratio (BCR)

According to the economic analysis (Table 5), the most economical treatment was Spinetoram (Delegate 11.7% SC), which achieved the highest benefit-cost ratio (BCR) of 2.59, while the untreated control had the lowest BCR (0.54). Parallel results were also reported by Mrong et al. (2024), who observed that the lowest pod infestation, along with the highest marketable yield (10.7 ton/ha) and marginal benefit-cost ratio (7.7), was achieved using a management approach involving Tracer 45 SC (Spinosad) applied at 0.4 g L^{-1} of water for the effective suppression of pod borer in yardlong bean. These results are consistent with reports of positive economic returns for spinetoram-based management techniques by Khan et al. (2025), Bhuva and Patel (2023), and Patel et al. (2023a). Sharma et al. (2023) also reported that spinetoram, as a widely used insecticide for fall armyworm management, proved economically viable in Nepal.

Table 4. Effect of tested biorational insecticides on the yield of yardlong bean at different harvesting time.

Treatments/dose ($ml\ L^{-1}$) water		Yield ($g\ pit^{-1}$) at different harvesting						Yield (ton/ha)	Increase yield (%) over control
		1st	2nd	3rd	4th	5th	6th		
T_1	0.4	68.68^b	61.25^b	40.63^b	28.83^b	18.01^b	23.41^b	4.81^b	62.40
T_2	1.5	42.91^c	41.57^c	22.43^c	17.73^c	30.96^a	19.10^c	3.49^c	48.17
T_3	0.3	128.02^a	87.53^a	144.21^a	35.72^a	34.32^a	27.47^a	9.15^a	80.19
T_4	1.0	42.01^c	51.92^b	46.98^b	11.99^d	17.44^b	13.31^d	3.67^c	50.69
Control	-	17.60^d	30.80^d	13.16^b	10.42^d	10.73^c	7.84^e	1.81^d	-
CV (%)	-	5.55	10.00	7.66	10.89	8.22	10.99	5.03	-

T_1 = Spinosad, T_2 = *Celastrus angulatus*, T_3 = Spinetoram, T_4 =Azadirachtin. Different superscripts indicate differences among the treatment.

Table 5. Effectiveness of tested bio-pesticides on the economics and benefit cost ratio.

Treatments	Yield (ton/ha)	Gross return (Tk/ha)	Cost of production (Tk/ha)			Net return (Tk/ha)	BCR
			Common cost	Treatment cost	Total		
T_1	4.81	192664	135000	5020	140020	52644	1.37
T_2	3.49	139768	135000	2000	137000	2768	1.02
T_3	9.15	365800	135000	6165	141165	224635	2.59
T_4	3.67	146920	135000	4350	139350	7570	1.05
Control	1.81	72440	135000	-	135000	-62560	0.54

Here, T_1 = Spinosad, T_2 = *Celastrus angulatus*, T_3 = Spinetoram, T_4 = Azadirachtin. BCR: Benefit Cust Ratio.

Conclusion

The field experiment on yard long bean was evaluated against *M. vitrata* using four new-generation insecticides: Spinosad, Bio-chamak 1% EW, Spinetoram, and Azadirachtin. All evaluated biorational pesticides demonstrated promising efficacy compared to the untreated control. However, Spinetoram consistently resulted in reduced pod infestation (up to 80.56% over the control) and produced the highest yield (9.15 t/ha) and benefit-cost ratio (2.59). Spinetoram is a foliar spray containing the semisynthetic spinosyn, broad-spectrum, contact, stomach poison, and exhibits translaminar activity, which effective against borers and caterpillars. The insecticide acts on the insect's nervous system to cause rapid cessation of feeding, paralysis, and death. Owing to its high selectivity, lower environmental impact, and novel mode of action, spinetoram can be used as a reliable and effective option for managing *M. vitrata* and enhancing yard-long bean productivity.

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Authors contribution

MAH conceived and designed the experiment. MAH supervised the study, and MAA analyzed the data. SA performed the experiments, collected the data, and drafted the manuscript. MAH, MAA, and HFE revised both the initial and final versions of the manuscript. All authors read and approved the final manuscript.

Conflict of interest

The authors declare no conflicts of interest.

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