J Bangladesh Agril Univ 18(S1): 805–810, 2020 https://doi.org/10.5455/JBAU.9739

ISSN 1810-3030 (Print) 2408-8684 (Online)

Journal of Bangladesh Agricultural University

Journal home page: http://baures.bau.edu.bd/jbau

Special issue: International Conference on Sustainable Agriculture (ICSA) 2019

Effectiveness of Botanical Insecticides for the Management of Legume Pod Borer (*Maruca vitrata* F.) in Yard Long Bean

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ARTICLE INFO

Article history
Received: 01 Jan 2020
Accepted: 21 Oct 2020
Published: 30 Nov 2020

Keywords
Yard long bean,
Legume pod borer,
Maruca vitrata,
Azadirachtin

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ABSTRACT

A research was conducted in the field of the Department of Entomology, Bangladesh Agricultural University (BAU), Mymensingh during rabi season 2016-17 to evaluate the efficacy of some botanicals viz. BioNeem plus, Mahogany oil, Karanja oil, Castor oil, Tobacco leaf extract, Urmoi fruit extract and Garlic clove extract and Nitro 505EC as positive control along with an untreated control for the management of legume pod borer, *Maruca vitrata* F. The experiment was designed as randomized complete block design with three replications of each treatment. The botanicals were evaluated based on the effectiveness on percentage reduction of flower and pod and increase of yield and pod yield. Among the botanical insecticides BioNeem plus (Azadirachtin) 1% @ 1.0 ml/L at 7 days intervals on the yard long bean showed the best performance in respect of reduction of flower and pod damage of 59.94 and 66.10 percent, respectively with significantly higher pod yield of 51.91 percent. Moderate efficacy was found from the Mahogany oil and Karanja oil @ 4 ml/L of water in case of flower (45.47 & 36.65%, respectively) and pod damage (50.36 & 41.27%, respectively) and yield increase (31.57 & 31.05%, respectively). It was also mentioned that BioNeem plus was better in different studied parameters than the chemical insecticides Nitro 505EC. The highest BCR was calculated from the BioNeem plus (1.39). Therefore, BioNeem plus might be used to successfully manage bean pod borer singly or in IPM packages.

Introduction

Legumes are important sources of low-fat dietary protein, fiber, and micronutrients in the human diet (Messina, 1999) and therefore, considered as the `meat of the poor' (Heiser, 1990). In the farming system, legumes are planted in crop rotations to improve soil fertility by fixing atmospheric nitrogen, breaking pest cycles, controlling soil erosion, and producing livestock fodder (Leikam *et al*., 2007). Amongst food legume, yard long bean (*Vigna unguiculata* subsp. *sesquipedalis*) is one of the most popular vegetables in Bangladesh. It has potentiality for export of both fresh and frozen and can be grown all year round (Rashid, 1999). It is extensively grown in kharif season when there is a shortage of vegetables supply in the market. In Bangladesh, vegetables are produced less than 30% in kharif season and more than 70% in rabi season (Hossain and Arangzeb, 1992). Flower and pod-feeding Lepidopterans cause serious yield losses to edible legumes particularly in tropical and sub-tropical zones (Rouf and Sardar, 2011).

M. vitrata F. (Lepdoptera: Crambidae), a genetically complex species (Margam *et al*., 2011; Periasamy *et al*., 2015), is recognized as one of the most serious legume pests (Abate and Ampofo, 1996; Jackai, 1995; Shanower *et al*., 1999; Sharma, 1998) due to an extensive host range, high damage potential and cosmopolitan distribution (Margam *et al*., 2011; Sharma *et al*., 1999; Taylor, 1967). Larvae of *M. vitrata* feed on flowers, stems, peduncle sand pods of food legumes, thus damage occurs at all developmental stages from seedling to podding stages (Singh and Taylor, 1978), however greatest damage occurs at flowering (Singh and Jackai, 1988). For example, typical yield losses on cowpea due to *M. vitrata* range from 20–88% (Singh *et al*., 1990). Thus, Yard-long bean growers face serious losses at pod harvest caused by *M. vitrata* infestation and consequently employ an array of agronomic

Cite This Article
Ahmed, R.N., Uddin, M.M., Haque, M.A., Ahmed, K.S. 2020. Effectiveness of Botanical Insecticides for the Management of Legume Pod Borer (*Maruca vitrata* F.) in Yard Long Bean. *Journal of Bangladesh Agricultural University*, 18(S1): 805–810. https://doi.org/10.5455/JBAU.9739

management regimes such as application of conventional insecticides which cause adverse effects to the environment and human health, but fail to achieve satisfactory level of control (Srinivasan *et al*., 2012; Yule and Srinivasan, 2013). The present study was undertaken to evaluate the efficacy of seven botanicals viz., Neem, *Azadirachta indica,* mahogany, *Swietenia mahogany,*karanja, *Pongamia pinnata,* castor, *Ricinus communis*, tobacco, *Nicotiana tabacum,* urmoi, *Sapium indicum*and garlic, *Allium sativum*, against legume pod borer in the yard long bean field.

Materials and Methods

The field trial of seven botanicals each having three doses along with a standard insecticide and untreated control was conducted against legume pod borer, *M. vitrata* F. at experimental field of Entomology Department of BAU, Mymensingh at rabi season 2016-17. The yard long bean seeds (Long Red Mollika) were sown on October 21, 2016 in 69 plots. Treatments were assigned in randomized complete block design with three replications.The distance of plot to plot and replicate to replicate was 1.0 m and 2.0m, respectively. Each plot measuring 2.65m x 1.2m had 20 plants. Intercultural operations were done as and when needed. Fertilizers were applied as per recommendation (Zaman, 1992). Treatments were as follows:

T_1 = Spray of Azadirachtin 1% (BioNeem plus) @ 0.5ml, 1.0ml and 1.5ml per litre of water. First spray at the time of flowering and was continued 7 days intervals up to harvesting.

T_2 = Spray of Mahogany oil @ 2.0ml, 3.0ml and 4.0ml per litre of water. First spray at the time of flowering and was continued 7 days intervals up to harvesting.

T_3 = Spray of Karanja oil @ 2.0ml, 3.0ml and 4.0ml per litre of water. First spray at the time of flowering and was continued 7 days intervals up to harvesting.

T_4 = Spray of Castor oil @ 2.0ml, 3.0ml and 4.0ml per litre of water. First spray at the time of flowering and was continued 7 days intervals up to harvesting.

T_5 = Spray of Tobacco leaf extract @ 10ml, 15ml and 20ml per litre of water. First spray at the time of flowering and was continued 7 days intervals up to harvesting.

T_6 = Spray of Urmoi fruit extract @ 4.0g, 6.0g and 8.0g per litre of water. First spray at the time of flowering and was continued 7 days intervals up to harvesting.

T_7 = Spray of Garlic clove extract @ 2.0ml, 3.0ml and 4.0ml per litre of water. First spray at the time of flowering and was continued 7 days intervals up to harvesting.

T_8 = Spray of standard insecticide (Nitro 505EC) @ 1.0 ml per litre of water. First spray at the time of flowering and was continued 7 days intervals up to harvesting.

T_9 = Control (Untreated)

All tested botanicals and insecticide were applied at the above mentioned doses by high volume knapsack sprayer. To ensure complete coverage of plants, spraying was done uniformly on the entire plant maintaining the distance around 25cm between the nozzle and inflorescence. Sprayer was washed and cleaned after each spraying. Only water was sprayed in untreated control plots. The spraying was applied in the afternoon to avoid bright sunlight, drift caused by wind and save honey bees. Data were collected on first, third and seventh day after spraying. Number of healthy and infested flowers were counted and recorded from randomly selected 10 inflorescences per plot and to calculate percentage of flower infestation at each observation. During each data collection, number of healthy and infested pods were recorded and weighed to calculate the percentage of pod infestation and percentage yield increased. The number of legume pod borer larvae were counted and recorded from randomly selected 10 infested pods before spray and after on 1^{st}, 3^{rd} and 7^{th} day after spraying to calculate percentage of surviving larvae. All data were analyzed statistically after appropriate transformations and the means were separated using DMRT by MSTAT computer software

Results and Discussion

Seven botanicals *viz*. Azadirachtin 1% (BioNeem plus), Mahogany oil, Karanja oil, Castor oil, Tobacco leaf extract, Urmoi fruit extract and Garlic clove extract were evaluated against *M. vitrata.* The efficacy of these botanicals was assessed as the percent flower and pod infestation, percent survival of larvae and pod yield (Tables 1). The tested botanical insecticides on the infestation of flowers and pods over untreated control indicated that these botanicals had some effect on *M. vitrata*, although none of the tested plant materials could completely stop *M. vitrata* infestation. In this experiment, flower and pod damage ranged from 8.72 to 21.78 and 10.40 to 30.79 percent respectively. Surviving of larvae was recorded from 40.24 to 94.98 percent. Yield and percentage of yield increased ranged from 7.15 to 14.91 ton per hectare and 5.40 to 52.02 percent, respectively.

Among the botanicals Azadirachtin 1% (BioNeem plus) @ 1.5 ml/L and 1.0 ml/L sprayed at 7 days intervals provided only 8.83 and 8.72 percent of flower infestation. The reduction of flower infestation over control was 59.43 to 59.94 percent (Table 1). The present results on the flower infestation are in agreement with Ramasubramanian and Babu (1991) who tested Neem seed kernel extract against *M. vitrata*on lablab bean. The present results are also supported by Singh *et al.* (1985); Hongo and Karel (1986); Kareem *et al.* (1988); Ganapathy (1996); Deka *et al.* (1998); Emosairue and Ubana (1998); Oparaeke *et al.* (2000); Tanzubil (2000); Akhauri and Yadav (2002); Prajapati *et al*. (2003); Chandrayudu *et al*. (2006) who used Neem seed extract, Neem oil and Neem cake and black pepper and garlic bulb extract with varied doses against the *M. vitrata* hosted on cowpea and pigeon pea.

Azadirachtin 1% (BioNeem plus) @ 1.5 ml/L and 1.0 ml/L sprayed at 7 days intervals provided only 10.40 and 10.44 percent of pod infestation. The reduction of pod infestation over control was 66.22 to 66.10 percent (Table 1). Ameh and Ogunwolu (2000) revealed that plant materials *Azadirecta indica* seeds reduced significantly the pod damage by *M. vitrata*on cowpea as much as 75.3-81.5 percent. Srinivasan *et al*., (2009) and Yule & Srinivasan (2014) had confirmed that both Thai Neem 111w and Biofree-I w significantly reduced pod damage by *M. vitrata* in vegetable legumes. Rahman *et al.*(2014) reported that the lowest fruit infestation, both by number (27.15%), and weight (22.29%), and the highest percent infestation reduction over control (30.08%) against *Helicoverpa armigera* in tomato were observed in Neem seed kernel extract treated plots.

Table 1. Percentage of infested flowers and pods of yard long bean caused by legume pod borer, *M. vitrata* sprayed with botanicals

Treatments	Dose	Flower		Pod	
		Infestation (%)	Reduction over control (%)	Infestation (%)	Reduction over control (%)
Azadirachtin 1% (BioNeem plus)	0.50 ml/L	10.30 (3.20) f-h	52.72	13.50 (21.50) fg	56.15
	1.00 ml/L	8.72 (2.95) h	59.94	10.44 (18.81) g	66.10
	1.50 ml/L	8.83 (2.97) gh	59.43	10.40 (18.78) g	66.22
Mahogany oil	2.00 ml/L	12.94 (3.59) b-f	40.59	19.40 (26.10) c-f	37.00
	3.00 ml/L	12.12 (3.48) d-g	44.34	16.51 (23.95) d-f	46.37
	4.00 ml/L	11.87 (3.44) e-h	45.47	15.29 (22.97) e-g	50.36
Karanja oil	2.00 ml/L	14.96 (3.86) b-e	31.31	17.88 (24.92) d-f	41.93
	3.00 ml/L	15.97 (3.99) b-d	26.69	18.10 (25.12) d-f	41.22
	4.00 ml/L	13.80 (3.71) b-f	36.65	18.08 (25.14) d-f	41.27
Castor oil	2.00 ml/L	16.48 (4.06) bc	24.32	19.77 (26.39) b-e	35.80
	3.00 ml/L	13.74 (3.71) b-f	36.92	20.05 (26.57) b-e	34.89
	4.00 ml/L	15.82 (3.97) b-e	27.35	18.70 (25.56) c-f	39.28
Tobacco leaf extract	10.00 ml/L	16.52 (4.06) bc	24.14	23.26 (28.83) b-d	24.47
	15.00 ml/L	15.16 (3.89) b-e	30.41	23.17 (28.76) b-d	24.74
	20.00 ml/L	14.05 (3.74) b-f	35.47	20.20 (26.71) b-e	34.41
Urmoi fruit extract	4.00 g/L	13.20 (3.63) b-f	39.41	22.49 (28.25) b-d	26.96
	6.00 g/L	14.00 (3.74) b-f	35.73	21.65 (27.72) b-e	29.68
	8.00 g/L	12.66 (3.55) b-f	41.87	20.82 (27.12) b-e	32.37
Garlic clove extract	2.00 ml/L	17.08 (4.13) b	21.59	26.84 (31.20) ab	12.82
	3.00 ml/L	15.68 (3.95) b-e	28.01	25.75 (30.46) a-c	16.36
	4.00 ml/L	16.16 (4.02) b-d	25.80	25.67 (30.43) a-c	16.61
Nitro 505EC	1.00 ml/L	10.46 (3.22) f-h	51.99	15.64 (23.26) e-g	49.22
Control (Untreated)	-	21.78 (4.66) a	-	30.79 (33.68) a	-
Level of significance	-	0.01	-	0.01	-
CV (%)	-	5.74	-	7.34	-

Figures in parentheses are the square root transformations; means in each column followed by the same letter(s) are not significantly different by DMRT.

The remarkable percentage of larvae of *M. vitrata* survived after treatment with botanicals except Azadirachtin 1% of all doses. Azadirachtin 1% @ 1.5 ml/L, 1.0 ml/L and 0.5 ml/L at 7 days intervals provided minimum percentage of larvae survived as 40.24, 42.02 and 48.01 percent respectively (Table 2). This might indicate that most of the botanicals had not much toxic action on the larvae. The botanical extracts protected the flower and pod damage mostly by the antifeedant and repellent effect (Isman, 2006; Singh and Saratchandra, 2005). Machuka *et al*. (1999) and Machuka *et al*. (2000) reported that the lectin synthesized from African yam bean seed had no effect on development of larvae of *M. vitrata*, when tested through topical artificial diet incorporation assays, except at extremely high dose of 35% dietary level. In contrast, the result of Azadirachtin 1% was in confirmity with (Srinivasan *et al*., 2015), who obtained thai Neem

111w exhibited excellent chronic and lethal effects on *M. vitrata* larvae when they were fed on a Neem-treated diet. This also concurred with an earlier study by Jackai and Oyediran (1991), who found that Neem oil emulsifiable concentrate exhibited a high degree of insecticidal activity to the third instar larvae of *M. vitrata* at 50,000–200,000 ppm. An another experiment in Thailand had also confirmed that different concentrations of Neembaan showed significant effects on the mortality of all the larval instars of *M. vitrata* and over 80% mortality rate was observed with a dose-rate of 3000 ppm (Kumar *et al*. 2014).

As already noticed Azadirachctin 1% resulted better protection of pod damage to *M. vitrata*. This botanical caused increase of pod yield in all doses. Azadirachtin 1% @ 1.5 ml/L, 1.0 ml/L and 0.5 ml/L at 7 days intervals provided maximum yield as 14.91, 14.88 and 12.94 metric ton per hectare (Table 2). Similar observations were made by Singh and Yadav (2006) who used Azadirachtin containing formulations against *Helicoverpa armigera* in pigeonpea and got effective higher yield. These observations are partially supported by Rouf and Sardar (2011) and Ramasubramanian and Babu (1991) who tested crude seed extract of Neem to be effective in increasing of pod yield of country bean and lablab bean against *M. vitrata*. These results are also in agreement with Singh *et al*. (1985), Cobbinah and Osei (1988), Kareem *et al*. (1988), Venkateswarlu *et al*. (1992) and Prajapati *et al*. (2003) who observed the Neem seed extract @ 3-10% and Neem oil @ 1% to be effective against *M. vitrata* on the yield of cowpea and green gram. It was found that standard insecticide Nitro 505 EC showed the 51.99 percent reduction in flower and 49.22 percent reduction in pod damage, 71.54 percent of surviving larvae of *M. vitrata* and only 34.38 percent yield increased over control. Rest of the botanicals of all doses along with standard insecticide Nitro 505 EC at 7 days intervals offered the minimum reduction of flower and pod infestation, maximum survival of larvae and minimum yield with marginal benefit cost ratio (Table 1-2). In this study, Azadirachtin 1% @ 1.50 ml/L and 1.0 ml/L exhibited better performance in respect of reduction of flower and pod damage, reducing larval population and yield increased in comparison to rest of the botanicals and standard insecticide Nitro 505 EC. These results revealed that both the doses (1.50 ml/L and 1.0 ml/L) of Azadirachtin 1% might be more toxic to *M. vitrata*. Azadirachtin 1% @ 1.50 ml/L and 1.0 ml/L performed benefit cost ratio of 1.39 and 1.41 respectively (Table 4). Although, Azadirachtin 1% @ 1.50 ml/L showed good result but in consideration of benefit cost ratio Azadirachtin 1% @ 1.0 ml/L exhibited better performance. So, finally Azadirachtin 1% @ 1.0 ml/L may be used for effective and economic control of legume pod borer.

Table 2. Percentage of larvae survival inside, and yield and benefit-cost ratio (BCR) of yard long bean caused by legume pod borer, *M. vitrata* sprayed with botanicals

Treatments	Dose	Larvae survival (%)	Yield (t/ha)	Yield ↑ over control (%)	BCR
Azadirachtin 1% (BioNeem plus)	0.50 ml/L	48.01 (6.92) c	12.94 ab	44.70	1.25
	1.00 ml/L	42.02 (6.48) c	14.88 a	51.91	1.41
	1.50 ml/L	40.24 (6.33) c	14.91 a	52.02	1.39
Mahogany oil	2.00 ml/L	78.64 (8.86) ab	9.85 b-d	27.40	0.96
	3.00 ml/L	73.99 (8.59) b	10.41 b-d	31.26	1.01
	4.00 ml/L	72.83 (8.52) b	10.46 b-d	31.57	1.00
Karanja oil	2.00 ml/L	81.97 (9.05) ab	9.58 c-d	25.30	0.93
	3.00 ml/L	78.85 (8.87) ab	10.02 b-d	28.59	0.97
	4.00 ml/L	75.21 (8.66) ab	10.37 b-d	31.05	1.00
Castor oil	2.00 ml/L	86.16 (9.28) ab	9.34 cd	23.38	0.92
	3.00 ml/L	84.47 (9.19) ab	9.94 b-d	28.02	0.97
	4.00 ml/L	81.14 (9.00) ab	10.28b-d	30.43	1.00
Tobacco leaf extract	10.00 ml/L	82.83 (9.10) ab	9.29 cd	22.95	0.91
	15.00 ml/L	85.30 (9.23) ab	9.34 cd	23.42	0.91
	20.00 ml/L	83.20 (9.12) ab	9.68 b-d	26.05	0.94
Urmoi fruit extract	4.00 g/L	84.75 (9.19) ab	9.21 cd	22.32	0.90
	6.00 g/L	87.80 (9.37) ab	9.81 b-d	27.04	0.95
	8.00 g/L	79.59 (8.92) ab	9.84 b-d	27.26	0.94
Garlic clove extract	2.00 ml/L	89.23 (9.44) ab	7.56 cd	5.40	0.75
	3.00 ml/L	86.13 (9.28) ab	8.35 cd	14.34	0.83
	4.00 ml/L	86.07 (9.27) ab	8.08 cd	11.49	0.80
Nitro 505EC	1.00 ml/L	71.54 (8.44) b	10.90 bc	34.38	1.05
Control (Untreated)	-	94.98 (9.74) a	7.15 d	-	0.71
Level of significance	-	0.01	0.01	-	-
CV (%)	-	4.84	12.82	-	-

Figures in parentheses are the square root transformations; means in each column followed by the same letter(s) are not significantly different by DMRT.

Conclusion

Among the botanicals Azadirachtin 1% at the doses of 1.50 ml/L and 1.0 ml/L was more toxic to *M. vitrata*. Azadirachtin 1% @ 1.50 ml/L and 1.0 ml/L performed benefit cost ratio of 1.39 and 1.41 respectively. Azadirachtin 1% @ 1.0 ml/L at 7 days intervals on the yard long bean showed better performance in respect of benefit cost ratio and in the reduction of flower and pod damage of 59.94 and 66.10 percent with significantly higher pod yield of 51.91 percent.

Conflict of Interests

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

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