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Effectiveness of insect growth regulators for management of legume pod borer, *Maruca vitrata* F. in yard long bean

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ABSTRACT

The legume pod borer, *Maruca vitrata* (Lepidoptera: Crambidae) is considered the most serious pest of yard long bean. An experiment was conducted in the field laboratory of the Department of Entomology, Bangladesh Agricultural University, Mymensingh during kharif season 2016 to evaluate the effectiveness of two commonly used insect growth regulators (IGR), burofezin and lufenuron with different doses and a widely used chemical insecticide nitro 505 EC as recommended dose for the management of legume pod borer. The treatments were arranged in Randomized Complete Block Design along with an untreated control with three replications of each treatment. The efficacy of the treatments was evaluated based on the percentage flower and pod infestation, percentage larval survivability and marketable pod yield. It was found that all the treatments were significantly effective against pod borer than the untreated control. The highest efficacy was found from the buprofezin among the treatments. Buprofezin @ 0.75 mL L^{-1} exhibited the best performance resulting 64.16 and 70.60% reduction of flower and pod infestation, respectively consequently providing 43.95% surviving larvae and 40.35% increase of pod yield with the benefit cost ratio1.47. This result was followed by buprofezin @ 0.5 mL L^{-1} and provided the results as 61.96%, 67.46%, 44.06%, 40.11%, and 1.48 flower infestation, pod infestation, surviving larvae, yield increase and benefit cost ration, respectively. Therefore, buprofezin @ 0.5mL L^{-1} might be recommended for the effective and economic management of legume pod borer in the yard long bean field.

Keywords: Efficacy, IGR, buprofezin, lufenuron, nitro 505EC, pod borer

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1 Introduction

Food legumes provide low-fat protein in the human diet and hence are considered as 'meat for the poor' (Heiser, 1990; Maphosa and Jideani, 2017). They also act as an important source of high quality livestock fodder and residual nitrogen suppliers in soil, fixing atmospheric nitrogen (Leikam et al., 2007). Amongst food legume, yard long bean (*Vigna unguiculata* subsp. *sesquipedalis*) is the most popular legume in Southeast Asia (Malacrinò et al., 2019), accounting for 7% of the total vegetable production area. Yard long bean is also one of the most popular vegetables in Bangladesh. The tender green pods of yard long bean are a good source of protein, iron, calcium, phosphorus, vitamin A, vitamin C and dietary fiber (Singh et al., 2001). Farmers in Bangladesh grow yard long bean throughout the year to meet high market demand, but it is extensively grown in kharif season when there is a shortage of vegetables supply in the market. This vegetable has potentiality for export of both fresh and frozen and can be grown all year round (Rashid, 1999; Mian et al., 2016).

In tropical and sub-tropical regions flower and pod-feeding Lepidopteran insects cause serious yield losses to edible legumes (Rouf and Sardar, 1970). The legume pod borer (LPB), *Maruca vitrata* F. (Lepdoptera: Crambidae), a genetically complex species (Margam et al., 2010; 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., 2010; Sharma et al., 1999; Taylor, 1967). It is also considered the most serious pest of yard long bean, mungbean, and soybean in Southeast Asia (Sharma, 1998; Soeun, 2001; Ulrichs et al., 2001). The pod borer larvae damage flower buds, flowers, green pods and seeds of yard long bean thereby reduce 54.4% production (Singh and Jackai, 1988) and cause 20-88% yield losses in cowpea (Jayasinghe et al., 2015; Singh et al., 1990).

In Bangladesh, pod borer damage has been estimated to be 54.4% in yard long bean (Ohno and Alam, 1989). But in country bean in some places of Bangladesh the yield loss is recorded upto 100% (Rouf and Sardar, 1970). Thus, Yard-long bean growers face serious losses at pod harvest caused by *M. vitrata* infestation. A recent study confirmed that more than 90% of growers rely on chemical pesticides as a curative measure to manage *M. vitrata*. Intensive and indiscriminate insecticide use is detrimental to the natural enemies in yard long bean production systems, and can have adverse effects on the environment and health of producers and consumers, and result in pest resistance and resurgence (Azad et al., 2010; Hossain et al., 2013; Nas, 2004; Srinivasan et al., 2012; Yule and Srinivasan, 2013). Concern about the impact of chemical insecticides on both health and environment and on the pest resistance/resurgence has resulted in the search for alternative control measures for insect pest. Amongst such 'alternatives' are insect growth regulators (IGRs), a class of biorational compounds that control the insect pests by disrupting the normal growth and development of insects eventually causing the death of the insects.

Considering the above points the present study was undertaken to evaluate the efficacy of two insect growth regulators *viz*., buprofezin and lufenuron against legume pod borer in the yard long bean field.

2 Materials and Methods

2.1 Experimental site and soil

The experiment was conducted in the field laboratory of the Department Entomology, Bangladesh Agricultural University, Mymensingh in kharif season 2016. The soil of the experimental site was silty loam belonging to the Old Brahmaputra Floodplain Alluvial Tract under the Agro Ecological Zone 9 having pH 6.8 (UNDP/FAO, 1988).

2.2 Development of plants

The experimental field was prepared thoroughly by ploughing with a power tiller following laddering to render a good tilth. All the stubbles were removed from the field before sowing the seeds. The chemical fertilizers and cow dung were applied as basal dose during final land preparation according to the recommendation of Zaman (1992). The yard long bean seeds (Long Red Mollika) were purchased from the seed store of Mymensingh town. Then the seeds were treated with seed treating agent (Vitavax 200) and three seeds were sown per pit in two rows on each plot. The plants were thinned to one per pit after 15 days of seed sowing keeping 20 plants per plot. Staking with bamboo sticks for each plant individually and for propping the plants trial net was prepared about 1.0m height from ground with the help of galvanized iron wire, bamboo stick and nylon thread from one end to other end of the plots as a means of propping, allowing easy creeping and preventing the plant from lodging. Irrigation, weeding and fertilizer application were done as and when necessary. The plants were sprayed by fungicide (Dithane M-45/Ridomil) to protect from wilting/damping off diseases.

2.3 Experimental design

The experiment was laid following the randomized complete block design with three replications of each treatment. The whole land was divided into three blocks and then into 24 plots. The unit plot size was 2.65 m $\times$ 1.2 m (Rashid and Singh, 2000). The distance between the plot was maintained 1.0 m.

2.4 Treatments and their application

Two insect growth regulators (IGRs) *viz*. T1 = Buprofezin (Award 40 SC) @ 0.25, 0.5 and 0.75 mL L^{-1} of water, T2 = Lufenuron (Heron 5 EC) @ 0.5, 1.0 and 1.5 mL L^{-1} of water and a widely used chemical insecticide, T3 = Nitro 505EC (Chlorpyrifos + Cypermethrin) @ 1.0 mL L^{-1} of water as positive control were evaluated to manage the bean pod borer. An untreated control (T4) treatment was also maintained. All treatments were sprayed on the yard long bean plants using a knapsack sprayer. First spraying was started after 10% of the flower infestation and was continued 7 days intervals up to final harvesting. To ensure complete coverage of plants, spraying was done uniformly on the entire plants. 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.

2.5 Collection of data

The efficacy of the tested insect growth regulators were assessed based on the percent flower and pod infestation, percent survival of larvae and marketable pod yield. Data were collected on 1st, 3rd and 7th 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 was recorded separately to calculate the percentage of pod infestation. The weight of healthy pod was done to estimate the yield of marketable pods and to calculate the percentage increase of pod yield over control. The number of legume pod borer larvae were counted and recorded from randomly selected 10 infested pods before spray and on 1st, 3rd and 7th day after spraying to calculate percentage of surviving larvae. Percentage reduction of flower or pod damage over control was calculated using the following formula:

$$\%D \downarrow = \frac{I_C - IT}{I_C} \times 100 \quad (1)$$

where, $\%D \downarrow$ = reduction of flower/pod damage over control; I_c and I_T designate percentage of flower/pod infested in control and treatment, respectively.

$$\%Y \uparrow = \frac{Y_T - Y_C}{Y_C} \times 100 \quad (2)$$

where, $\%Y \uparrow$ = yield increased over control ; Y_C and Y_T designate yields in the control and treated plots, respectively.

The benefit cost ration (BCR) was calculated for each treatment. BCR was calculated by dividing the total benefit by total cost for each treatment.

2.6 Analysis of data

All the data collected on different parameters were compiled and arranged for statistical analysis. Then the data were analyzed statistically after appropriate transformations using MSTAT-C package programme. The means were separated using DMRT test.

3 Results

3.1 Flower infestation

In the insect growth regulators and chemical insecticide treated plots, the flower infestation ranged from 10.20 to 28.47% and differed significantly (p<0.01) among the treatments (Table 1). The buprofezin sprayed @ 0.75 mL L^{-1} resulted the lowest (10.20%) flower infestation which was statistically identical to the plots treated with that of buprofezin @ 0.50 mL L^{-1} and 0.25 mL L^{-1} as well as lufenuron @ 1.5 mL L^{-1} and 1.0 mL L^{-1}. The highest flower infestation was recorded in the control plots (28.47%) (Table 1). The flower infestation by nitro 505EC treated plots was 16.14% followed by lufenuron @ 0.50 mL L^{-1}. The reduction of flower infestation over control incurred from 37.58 to 64.16% among the treatments (Table 1). The highest reduction of flower infestation (64.16%) over control was obtained from the plots applied with buprofezin @ 0.75 mL L^{-1} followed by that of buprofezin @ 0.50 mL L^{-1} (61.96%) and 0.25 mL L^{-1} (55.19%). While the lowest reduction of flower infestation was 37.58% observed in the plots treated with lufenuron @ 0.50 mL L^{-1} followed by nitro 505EC @ 1.0 mL L^{-1} (43.31%) and lufenuron @ 1.0 mL L^{-1} (47.53%) (Table 1).

3.2 Pod infestation

The pod damage caused by *Maruca vitrata* ranged from 11.22 to 38.19% and differed significantly (p<0.01) among the treatments (Table 2). The lowest pod infestation of 11.22% was recorded in the plots treated with buprofezin @ 0.75 mL L^{-1} followed by that of buprofezin @ 0.50 mL L^{-1} and 0.25 mL L^{-1} as well as lufenuron @ 1.50 mL L^{-1}. Intermediate pod infestation was recorded in the plots sprayed with nitro 505EC (19.40%) followed by lufenuron @ 1.0 mL L^{-1} and 0.50 mL L^{-1}. The highest pod infestation of 38.19% was obtained in the untreated control plots (Table 2). The reduction of pod damage over control due to spraying of insect growth regulators and chemical insecticide ranged from 39.80 to 70.60% (Table 2). The highest reduction of pod damage of 70.60% was obtained from the plots sprayed with buprofezin @ 0.75 mL L^{-1} followed by that of buprofezin @ 0.50 mL L^{-1} (67.46 percent) and 0.25 mL L^{-1} (63.05%). On the other hand, the lowest reduction of pod damage of 39.80% was found in the plots treated with lufenuron @ 0.50 mL L^{-1} followed by that of lufenuron @ 1.0 mL L^{-1} (47.91%) and nitro 505EC @ 1 mL L^{-1} (49.20%) (Table 2).

3.3 Survival of *Maruca vitrata* larvae

The tested insect growth regulators irrespective of doses offered significantly lower percentage of survival of larvae in comparison to untreated control. The percentage of larvae survived ranged from 43.95 to 94.03% and differed significantly (p<0.01) among the treatments (Table 3). The lowest of 43.95% surviving larvae was recorded in the plots treated with buprofezin @ 0.75 mL L^{-1} which was statistically identical to that of buprofezin @ 0.50 mL L^{-1} and 0.25 mL L^{-1}. Intermediate percentage of larvae survived (66.81%) was observed in the plots sprayed with nitro 505EC @ 1.0 mL L^{-1} which was statistically identical with all the tested doses of lufenuron. Significantly the highest of 94.03% larvae survived in the untreated control plots (Table 3).

Table 1. Effect of insect growth regulators on the percentage of infestation of flowers of yard long bean caused by *M. vitrata*

Treatments	Dose (mL L^{-1})	Infested flower (%) †	%D↓ of flower over control
Buprofezin (Award 45SC)	0.25	12.76 (3.57) bd	55.19
	0.50	10.83 (3.28) cd	61.96
	0.75	10.20 (3.19) d	64.16
Lufenuron (Haron 5EC)	0.50	17.77 (4.20) b	37.58
	1.00	14.94 (3.85) bd	47.53
	1.50	13.75 (3.70) bd	51.69
Nitro 505EC	1.00	16.14 (4.01) bc	43.31
Control (Untreated)	–	28.47 (5.32) a	–
Level of significance	–	0.01	–
CV (%)	–	7.62	–

† Figures in parentheses are the square root transformations; Means in each column followed by the same letter(s) are not significantly different by DMRT; *%D* ↓ = reduction of flower damage over control

Table 2. Effect of insect growth regulators on the percentage of infestation of pods of yard long bean caused by *M. vitrata*

Treatments	Dose (mL L^{-1})	Infested pod (%) †	%D↓ of pod over control
Buprofezin (Award 45SC)	0.25	12.76 (3.57) bd	55.19
	0.50	10.83 (3.28) cd	61.96
	0.75	10.20 (3.19) d	64.16
Lufenuron (Haron 5EC)	0.50	17.77 (4.20) b	37.58
	1.00	14.94 (3.85) bd	47.53
	1.50	13.75 (3.70) bd	51.69
Nitro 505EC	1.00	16.14 (4.01) bc	43.31
Control (Untreated)	–	28.47 (5.32) a	–
Level of significance	–	0.01	–
CV (%)	–	7.62	–

† Figures in parentheses are the square root transformations; Means in each column followed by the same letter(s) are not significantly different by DMRT; *%D* ↓ = reduction of pod damage over control

3.4 Yield and % yield increase of marketable pods

After spraying of different treatments the marketable pod yield of yard long bean differed significantly ($p<0.01$) among the treatments. The yield was recorded in the range of 9.03 to 15.14 t ha^{-1} (Table 4). The highest yield was 15.14 t ha^{-1} harvested from the plots applied with buprofezin @ 0.75 mL L^{-1} which was statistically similar to that of buprofezin @ 0.50 mL L^{-1} and 0.25 mL L^{-1}, lufenuron @ 1.50 mL L^{-1} and 1.0 mL L^{-1} as well as nitro 505EC @ 1.0 mL L^{-1}. The lowest pod yield of 9.03 t ha^{-1} was found in untreated control plots (Table 4). The pod yield increased in the treated plots ranging from 13.11 to 40.34% over control. The maximum pod yield increase of 40.34% was obtained from buprofezin applied plots @ 0.75 mL L^{-1} followed by that of buprofezin @ 0.50 mL L^{-1} (40.11%), lufenuron @ 1.50 mL L^{-1} (31.96%) and buprofezin @ 0.25 mL L^{-1} (31.29%). The lowest pod yield increase of 13.11% was recorded in the plots sprayed with lufenuron @ 0.50 mL L^{-1} followed by that of lufenuron @ 1.0 mL L^{-1} (24.78%) and nitro 505EC @ 1.0 mL L^{-1} (27.27%) (Table 4). The highest benefit cost ratio of 1.48 was recorded in the plots treated with buprofezin @ 0.50 mL L^{-1} followed by that of buprofezin @ 0.75 mL L^{-1} (1.47). The lowest benefit cost ratio of 0.89 was recorded in the untreated control plots followed by the plots treated with lufenuron @ 0.50 mL L^{-1} (1.01), 1.0 mL L^{-1} (1.14) and nitro 505EC (1.20) (Table 4).

4 Discussion

It was found that widely used the synthetic insecticide nitro 505 EC showed only 43.31 and 49.20% reduction of flower and pod infestation, respectively. In this case, buprofezin @ 0.75 mL L^{-1} and 0.5 mL L^{-1} exhibited better performance in respect of reduction of flower (64.16 and 61.96 %, respectively) and pod (70.60 and 67.46%, respectively) infestation.

Table 3. Effect of insect growth regulators on the percentage of surviving larvae of legume pod borer, *M. vitrata* inside the pods of yard long bean

Treatments	Dose (mL L^{-1})	Survival rate of larvae (%)
Buprofezin (Award 45SC)	0.25	51.05 c
	0.50	44.06 c
	0.75	43.95 c
Lufenuron (Haron 5EC)	0.50	79.11 b
	1.00	71.88 b
	1.50	70.71 b
Nitro 505EC	1.00	66.81 b
Control (Untreated)	–	94.03 a
Level of significance	–	0.01
CV (%)	–	9.07

Means in each column followed by the same letter(s) are not significantly different by DMRT.

Table 4. Effect of insect growth regulators on the yield and (%) increase of marketable pods of yard long bean and benefit cost ration (BCR)

Treatments	Dose (mL L^{-1})	Yield (t ha^{-1})	Yield↑ (%)	BCR
Buprofezin (Award 45SC)	0.25	13.15 ab	31.29	1.29
	0.50	15.08 a	40.11	1.48
	0.75	15.14 a	40.34	1.47
Lufenuron (Haron 5EC)	0.50	10.40 bc	13.11	1.01
	1.00	12.01 ac	24.78	1.14
	1.50	13.28 ab	31.96	1.24
Nitro 505EC	1.00	12.42 ac	27.27	1.2
Control (Untreated)	–	9.03 c	0	0.89
Level of significance	–	0.01	–	–
CV (%)	–	11.96	–	–

↑ = Yield increase over control; Means in each column followed by the same letter(s) are not significantly different by DMRT.

This finding was similar with the report of Islam et al. (2016) where they explained that burpofezin alone could significantly reduce the shoot and fruit infestation of brinjal caused by brinjal shoot and fruit borer in the field. This finding supports the present results as pod borer is also an internal feeder similar to brinjal shoot and fruit borer. In case of surviving of larvae of pod borer inside the infested pods it was found that nitro 505EC provided the moderate percentage, 66.81% of surviving larvae of *Maruca vitrata*. Among the treatments buprofezin @ 0.75 mL L^{-1} and 0.5 mL L^{-1} caused the lowest percentages of surviving larvae as 43.95 and 44.06%, respectively. But lufenuron caused 70.71% of surviving larvae @ 1.50mL L^{-1}. Irrespective of dose buprofezin showed the highest efficacy on the reduction of percentage survivality of larvae inside the infested pod. Similar results were reported by Khatun et al. (2017) who observed that buprofezin has significant effect on the mortality (60 to 68%) as well as inhibition of growth and development of different instars of *Spodoptera litura* larvae. The present results were also supported by the findings of Das and Islam (2014) who concluded that buprofezin is a potent IGR (insect growth regulator) molecule to reduce Leucinodes orbonalis populations through inhibition of chitin biosynthesis. Ragaei and Sabry (2011) found buprofezin very effective against the fourth instar larvae of the cotton leafworm, *S. littoralis* (Boisduval) and causing significant mortality and growth reduction of the leafworm larvae. Nasr et al. (2010) also found that buprofezin caused reasonable mortality in *S. littoralis* larvae. These two reports are also in agreement of the present findings. Islam et al. (2015) conducted an experiment on the mortality of *S. litura* (Fabricius) under laboratory conditions and found that lufenuron (Haron) is very effective against *S. litura*. Yong-sheng et al. (2009) observed the bioactivity of lufenuron 5 EC in the field on *H. armigera* showing that @ 600 mL ha^{-1} lufenuron possessed high efficacy on newly hatched larvae of *H. armigera* in field trials, and their control effects was 90.2% at 7 days after application. These findings again support our results since the pod borer is also an internal feeder which belong to Lepidoptera.

Chandrakar and Shrivastava (2002) conducted an experiment and reported that application of lufenuron + 1000 mL profenofos ha^{-1} resulted in the lowest pod damage (10.0%), grain damage by pod borer (0.7%) and the highest yield (1618.3 kg ha^{-1}) in pigeon pea. This finding strongly supports the results of the present research. From the present result it was clear that buprofezin had a significant effect of the yield and percentage yield increase of yard long bean and this result is partially supported by the finding of Islam et al. (2016) where they reported that burpofezin with emamectin benzoate (@ 0.5 g L^{-1}) increased 85.45% marketable yield of brinjal. The present results revealed that both the doses (0.75 mL L^{-1} and 0.5 mL L^{-1}) of buprofezin might be more toxic to *Maruca vitrata* in comparison to lufenuron and chemical insecticide. Buprofezin @ 0.75 mL L^{-1} and 0.5 mL L^{-1} performed benefit cost ratio 1.47 and 1.48, respectively (Table 4). Therefore, buprofezin @ 0.5 mL L^{-1} might be recommended alone or as a component of IPM for effective and economic management of legume pod borer, *Maruca vitrata*.

5 Conclusions

Buprofezin at the doses of 0.75 mL L^{-1} and 0.5 mL L^{-1} found more toxic to *Maruca vitrata* in comparison to lufenuron and chemical insecticide nitro 505EC. The treatments of buprofezin @ 0.75 mL L^{-1} and 0.5 mL L^{-1} resulted benefit cost ratio 1.47 and 1.48, respectively. Considering the cost of benefit and the toxic effect against the pod borer buprofezin @ 0.5mL L^{-1} might be recommended for the eco-friendly and sustainable management of this pest by the farmers.

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Conflict of Interest

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

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