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BIO-EFFICACY OF INSECT GROWTH REGULATORS AGAINST BEAN POD BORER, *MARUCA VITRATA* F. INFESTING COUNTRY BEAN

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Abstract

The Bean pod borer, *Maruca vitrata* F. (Lepidoptera: Crambidae) is a key pest of country bean causing severe yield loss. The present study was conducted to evaluate the efficacy of four insect growth regulators (IGRs) for managing the bean pod borer, on country bean. Four IGRs as T_1 = Lufenuron (Hayron 5 EC), T_2 = Emamectin Benzoate (Noclaim 5 SG), T_3 = Emamectin Benzoate + Lufenuron (Himam 50 WDG) and T_4 = Buprofezin (Award 40 SC) were used with three doses against *M. vitrata*. All the treatments were found significantly effective against the pod borer over untreated control. The highest efficacy was found in the Emamectin benzoate @ 1.0 g L^{-1} water treated plots followed by Buprofezin @ 0.50 ml L^{-1} water at 1st, 3rd and 7th days after treatments (DATs). The highest number of healthy flowers per ten inflorescences (126.56) were recorded in Emamectin benzoate at 1.0 g L^{-1} water treated plots but the lowest in the untreated control (68.11). The highest number of healthy pods were also observed in Emamectin Benzoate @ 1.0 g L^{-1} water treated plots. The highest pods $plant^{-1}$ (760.33 g) were found from Emamectin benzoate at 1.0 g L^{-1} water treated plots followed by Buprofezin at 0.50 ml L^{-1}. Conversely, the lowest weight of healthy pods per plant (478.33g) was recorded in the untreated control. So, based on bio-efficacy, among the IGRs studied, Emamectin benzoate may be used for better management of bean pod borer *M. vitrata*.

Keywords: Efficacy, IGRs, Damage, Bean pod borer, Country bean.

Introduction

Country bean, *Lablab purpureus* L. (Papilionaceae) is a self-pollinated winter legume vegetable in Bangladesh (Salim *et al*., 2013). Recently, farmers are cultivating this crop year round in large scale due to high demand, high profit and tremendous nutritional value (Khan *et al*., 2020). However, this crop is threatened by many insect pests during cultivation, resulting huge economic losses (Oliveira *et al.*, 2014). Among them, the legume pod borer, *Maruca vitrata* F. (Lepdoptera: Crambidae) is a key pest of bean causing up to 80% yield loss (Aktar *et al*., 2020). It is a genetically complex species (Margam *et al*., 2010 and Periasamy *et al*., 2015) due to an extensive host range, high damage potential and cosmopolitan distribution (Margam *et al*., 2010).

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This destructive pest is controlled by synthetic insecticides for quick knockdown (Pavela *et al*., 2009). But chemical protection measures suffer so many serious drawbacks (Lee *et al*., 2001 and Ambethar, 2009). The indiscriminate use of chemicals causes the natural enemies destruction, adverse effects on the environment, creates phytotoxicity, residues in foods and feeds, triggers pest resistance and resurgence and is hazardous to producers and consumers as well (Azad *et al*., 2010 and Hossain *et al*., 2013; Yule and Srinivasan, 2013; Srinivasan *et al*., 2015). Hence, globally researchers are trying to adopt alternatives to protect crop from insect pest infestation (Ahmed *et al*., 2020).

The new generation insecticides such as insect growth regulators (IGRs) offer several advantages over conventional pesticides like high selectivity, excellent efficacy at low dosage, least harmful to beneficial insects, biodegradable and safe (Kodandaram *et al*., 2010). Besides, IGRs are bio-rational compound, disrupts the normal growth, development, moulting and metamorphosis of insects eventually causing the death. IGRs as pesticide are relatively safe, available and fit well for sustainable agriculture. Again, reports on the IGRs against the bean pod borer are scanty in Bangladesh (Ahmed *et al*., 2020). Therefore, the present study was undertaken to evaluate the efficacy of four IGRs viz., Lufenuron, Emamectin benzoate, Lufenuron + Emamectin benzoate and Buprofezin against the bean pod borer, *M. vitrata* infesting country bean.

Materials and Methods

The experiment was conducted in the research field of the Department of Entomology, Hajee Mohammad Danesh Science and Technology University, Dinajpur. The experimental site was a medium high land belonging the AEZ-1 of Old Himalayan Piedmont Plain soil (p^H 5.52, EC 2.0 mS m^{-1}, contains medium organic matter).

Seeds of BARI Sheem-2 variety was collected from the BADC of Sadar Upazila in Dinajpur. The land was ploughed and cross-ploughed several times with a power tiller to obtain a good tilth followed by laddering and spading. The stubbles of the crops and uprooted weeds were removed from the field and the land was then leveled prior to seed sowing. Five seeds were sown in each prepared pit followed by a light irrigation to ensure soil moisture for germination. After 15 days of sowing, one healthy plants in each pit were kept by thinning. Each plant was stacking with bamboo stick to save the plant from lodging. Irrigation, weeding and other intercultural operations were done as and when needed. Fertilizers were applied according to the recommended doses (FRG, 2012). The whole field was divided into 39 plots.

The study was arranged in randomized complete block design (RCBD) with 3 replications. The unit plot size was 3.0 m × 2.0 m accommodating with a single pit. Plot to plot distance was maintained 1.0 m.

Treatments: The treatments were T_1 = Lufenuron (Hayron 5 EC) @ 0.50, 0.75 and 1 ml/L of water, T_2 = Emamectin Benzoate (Noclaim 5 SG) @ 0.50, 0.75 and 1.0 g/L of water, T_3 = Emamectin Benzoate + Lufenuron (Himam 50 WDG) @ 0.50, 0.75 and 1 g/L of water, T_4 = Buprofezin (Award 40 SC) @ 0.30, 0.40 and 0.50 ml/L of water. Besides, an untreated control was also maintained by applying water only. Treatments were applied 3 times with the help of knapsack sprayer at 15 days intervals at 4 pm for safety of pollinators. Data were recorded on number of healthy and infested flowers, number of healthy and infested pods and pod yield at 1st, 3rd and 7th days after treatment.

Statistical analyses: All the collected data of different parameters were compiled and arranged for statistical analysis. Then the data were statistically analyzed using Statistix 10 software to test the significance of variance among the treatments and means were separated using Tukey's HSD test ($p<0.05$).

Results

Effect of IGRs on the number of healthy and infested flowers: The tested IGRs had profound effects on the number of healthy and infested flowers of country bean after 1st, 2nd and 3rd spray as compared to untreated control (Tables 1-2). Significantly (1st: $P < 0.05$, $df = 12$, $F = 4.41$; 2nd: $P < 0.05$, $df = 12$, $F = 5.96$; 3rd: $P < 0.05$, $df = 12$, $F = 5.37$) the highest number of healthy flowers were recorded as 119.67, 125.33 and 134.67 in Emamectin Benzoate treated plants @ 1.0 g L^{-1} of water followed by Buprofezin (as 96.67, 114.67and 125.33) @ 0.50 ml L^{-1} of water at 1st, 3rd and 7th days after treatments, respectively (Table 1). Conversely, the lowest number of healthy flower was recorded in the untreated control at 1st, 3rd and 7th days after treatments. The pooled mean highest number of healthy flowers were counted as 126.56 in Emamectin Benzoate treated plots @ 1.0 g/L but the lowest (68.11) in the untreated control. Similarly, among the treatments significantly (1st: $P < 0.05$, $df = 12$, $F = 16.05$; 2nd: $P < 0.05$, $df = 12$, $F = 17.58$; 3rd: $P < 0.05$, $df = 12$, $F = 31.31$) the lowest number of infested flowers (13.0, 8.67 and 6.33) were observed at 1st, 3rd and 7th DATs, respectively in Emamectin Benzoate treated plot @ 1.0 g/L of water (Table 2). Conversely, the highest number of infested flowers was recorded as 36.67, 36.67 and 36.33 in the untreated control treatments at 1st, 3rd and 7th DATs, respectively. The lowest (9.33) pooled mean number of infested flowers were counted in Emamectin benzoate treated plots @ 1.0 g/L while the highest (34.78) from the untreated control.

Table 1. Effect of IGRs on the number of healthy flowers of country bean against by *M. vitrata*

Treatments	Doses (g/ml) L^{-1} water	Mean number of healthy flowers per ten inflorescences			Cumulative mean
		1st DATs	3rd DATs	7th DATs	
T_1	0.50	75.67 bc	87.33 bc	97.67 bc	86.89
	0.75	78.33 bc	88.67 bc	104.00 a-c	90.33
	1.00	83.67 bc	94.33 a-c	103.33 a-c	93.78
T_2	0.50	89.00 a-c	100.67 ab	113.33 bc	101.00
	0.75	92.33 a-c	112.67 ab	130.67 ab	111.89
	1.00	119.67 a	125.33 a	134.67 a	126.56
T_3	0.50	81.67 bc	95.00 a-c	104.00 a-c	93.56
	0.75	85.00 bc	98.00 a-c	112.00 ab	98.33
	1.00	92.67 a-c	113.67 ab	121.67 ab	109.34
T_4	0.30	82.33 bc	96.67 a-c	105.33 a-c	94.78
	0.40	88.00 a-c	98.67 a-c	113.33 ab	100.00
	0.50	96.67 ab	114.67 ab	125.33 ab	112.22
Untreated control	-	61.33 c	68.00 c	75.00 c	68.11
CV (%)		12.75	10.47	10.56	-

Within column values followed by different letter(s) are significantly different at 5% level of probability by Tukey's HSD test. T_1 = Lufenuron (Hayron 5 EC), T_2 = Emamectin Benzoate (Noclaim 5 SG), T_3 = Emamectin Benzoate + Lufenuron (Himam 50 WDG), T_4 = Buprofezin (Award 40 SC).

Table 2: Effect of IGRs on the number of infested flowers of country bean against *M. vitrata*

Treatments	Doses (g/ml) L^{-1} water	Mean number of infested flowers per ten inflorescences			Cumulative mean
		1st DATs	3rd DATs	7th DATs	
T_1	0.50	35.67 a	26.33 b	23.67 b	28.56
	0.75	35.33 a	23.33 bc	17.33 b-d	25.33
	1.00	20.00 b-d	17.33 b-f	11.00 d-g	16.11
T_2	0.50	26.00 a-d	15.00 c-f	12.00 d-g	17.67
	0.75	18.33 cd	13.67 d-f	10.33 d-g	14.11
	1.00	13.00 d	8.67 f	6.33 g	9.33
T_3	0.50	33.67 a	24.00 bc	20.67 bc	26.11
	0.75	28.33 a-c	21.67 b-d	16.33 c-e	22.11
	1.00	19.33 b-d	13.00 d-f	9.00 fg	13.78
T_4	0.30	29.33 ab	20.00 b-d	16.00 c-f	21.78
	0.40	26.67 a-c	18.33 b-e	15.33 c-f	20.11
	0.50	13.67 d	10.67 ef	10.00 e-g	11.44
Untreated control	-	36.67 a	36.67 a	36.33 a	34.78
CV (%)		13.91	16.23	15.54	-

Within column values followed by different letter(s) are significantly different at 5% level of probability by Tukey's HSD test. T_1 = Lufenuron (Hayron 5 EC), T_2 = Emamectin Benzoate (Noclaim 5 SG), T_3 = Emamectin Benzoate + Lufenuron (Himam 50 WDG), T_4 = Buprofezin (Award 40 SC).

Effect of IGRs on the number of healthy and infested pods: The treated different IGRs had potential effects on number of healthy and infested pods of country bean (Tables 3-4). Significantly (1st: $P < 0.05$, $df = 12$, $F = 4.76$; 2nd: $P < 0.05$, $df = 12$, $F = 8.91$; 3rd: $P < 0.05$, $df = 12$, $F = 6.41$) the highest number of healthy pods were recorded as 81.67, 92.33 and 106.67 when the plots were treated with Emamectin Benzoate @ 1.0 g L^{-1} followed by Buprofezin (80.67, 90.00 and 103.00) @ 0.50 ml L^{-1} water at 1st, 3rd and 7th DATs, respectively (Table 3). Conversely, the highest numbers of infested pods were observed in the untreated control (39.67, 49.67 and 55.00) at 1st, 3rd and 7th DATs, respectively. The polled mean highest number healthy pods were counted as 93.56 in Emamectin Benzoate treated plots @ 1.0 g L^{-1} while the highest (48.11) from the untreated control. Likewise, significantly (1st: $P < 0.05$, $df = 12$, $F = 25.95$; 2nd: $P < 0.05$, $df = 12$, $F = 22.48$; 3rd: $P < 0.05$, $df = 12$, $F = 25.38$) the lowest number of infested pods were found as 6.67, 6.67 and 8.33 in Emamectin Benzoate treated plot @ 1.0 g L^{-1} water followed by Buprofezin @ 0.50 ml L^{-1} water (10.0, 8.67 and 8.67) at 1st, 3rd and 7th DATs, respectively (Table 4). But the highest numbers of infested pods were counted in the untreated control as 29.67, 31.00 and 27.00 at 1st, 3rd and 7th DATs, respectively. The cumulative lowest infested pods were recorded as 7.22 in Emamectin Benzoate treated plots @ 1.0 g L^{-1} water followed by Buprofezin @ 0.50 ml L^{-1} water treated plots as 9.11. However, the highest (29.22) infested pods were detected in the untreated control.

Table 3. Effect of IGRs on the number of healthy pods of country bean against *M. vitrata*

Treatments	Doses (g/ml) L^{-1} water	Mean number of healthy pods per ten inflorescences			Polled mean healthy pods
		1st DATs	3rd DATs	7th DATs	
T_1	0.50	51.00 ab	58.33 cd	71.67 bc	60.33
	0.75	56.33 ab	69.33 a-d	79.67 abc	68.44
	1.00	77.33 a	88.33 ab	94.33 ab	86.66
T_2	0.50	58.67 ab	91.00 a	98.67 ab	82.78
	0.75	75.00 a	85.00 ab	102.67 a	87.56
	1.00	81.67 a	92.33 a	106.67 a	93.56
T_3	0.50	56.00 ab	64.67 bcd	80.67 abc	67.11
	0.75	64.67 ab	70.33 a-d	86.00 ab	73.67
	1.00	79.00 a	89.67 a	99.00 ab	89.22
T_4	0.30	58.33 ab	70.67 a-d	89.00 ab	72.67
	0.40	66.00 ab	77.00 abc	101.33 ab	81.44
	0.50	80.67 a	90.00 a	103.00 a	91.22
Untreated control	-	39.67 b	49.67 d	55.00 c	48.11
CV (%)		15.98	10.58	11.39	-

Within column values followed by different letter(s) are significantly different at 5% level of probability by Tukey's HSD test. T_1 = Lufenuron (Hayron 5 EC), T_2 = Emamectin Benzoate (Noclaim 5 SG), T_3 = Emamectin Benzoate + Lufenuron (Himam 50 WDG), T_4 = Buprofezin (Award 40 SC).

Table 4: Effect of IGRs on the number of infested pods of country bean caused by *M. vitrata*

Treatments	Doses (g/ml) L^{-1} water	Mean number of infested pods per ten inflorescences			Polled mean infested pods
		1st DATs	3rd DATs	7th DATs	
T_1	0.50	21.67 b	19.33 b	18.33 b	19.78
	0.75	21.00 bc	18.00 b	15.67 bc	18.22
	1.00	17.33 bcd	14.33 bcd	13.33 b-e	15.00
T_2	0.50	18.33 bcd	15.00 bcd	12.00 cde	15.11
	0.75	13.00 def	10.67 cde	10.33 def	11.33
	1.00	8.33 f	6.67 e	6.67 f	7.22
T_3	0.50	21.33 b	18.67 b	17.67 b	19.22
	0.75	18.33 bcd	15.67 bc	14.33 bcd	16.00
	1.00	13.00 def	10.00 cde	10.00 def	11.00
T_4	0.30	21.00 bc	16.00 bc	15.00 bcd	17.33
	0.40	15.33 cde	14.67 bcd	14.00 bcd	14.78
	0.50	10.00 ef	8.67 de	8.67 ef	9.11
Untreated control	-	29.67 a	31.00 a	27.00 a	29.22
CV (%)		11.06	14.66	12.57	-

Within column values followed by different letter(s) are significantly different at 5% level of probability by Tukey's HSD test. T_1 = Lufenuron (Hayron 5 EC), T_2 = Emamectin Benzoate (Noclaim 5 SG), T_3 = Emamectin Benzoate + Lufenuron (Himam 50 WDG), T_4 = Buprofezin (Award 40 SC).

Table 5. Effect of IGRs on pod yield of country bean against *M. vitrata*

Treatments	Doses (g/ml) L^{-1} water	Yield (g) in weight of pods/plant
T_1	0.50	552.00 bc
	0.75	581.33 abc
	1.00	641.33 abc
T_2	0.50	655.00 abc
	0.75	714.67 ab
	1.00	760.33 a
T_3	0.50	602.67 abc
	0.75	651.33 abc
	1.00	672.67 abc
T_4	0.30	639.00 abc
	0.40	678.33 ab
	0.50	716.33 ab
Untreated control	-	478.33 c
CV (%)		10.17

Within column values followed by different letter(s) are significantly different at 5% level of probability by Tukey's HSD test. T_1 = Lufenuron (Haron 5 EC), T_2 = Emamectin Benzoate (Noclaim 5 SG), T_3 = Emamectin Benzoate + Lufenuron (Himam 50 WDG), T_4 = Buprofezin (Award 40 SC).

Effect of IGRs on the yield: The yield of healthy pods of treated country bean varied with different IGRs in the assigned plots (Table 5). The effects of various IGRs and their doses and varied significantly ($P < 0.05$, $df = 12$, $F = 3.96$) among the treatments. The highest (760.33 g) of healthy pods were recorded in Emamectin Benzoate @ 0.10 g L^{-1} of water treated plants followed by Buprofezin @ 0.50 ml L^{-1} (716.33 g) which is statistically different. Conversely, the lowest (478.33 g) weight of healthy pods was found in the untreated control.

Discussions

In this study, four insect growth regulators (IGRs) were evaluated against the pod borer infestation in country bean with three doses. The outcome revealed that all treatments were found potential in reducing the pod borer infestation as compared to the untreated control. In the first, second, and third sprayings, all the IGRs reduced the flower and pod damages against the *M. vitrata*.

Results revealed that the tested IGRs had profound effects on healthy and infested flowers against the bean pod borer. Efficacy of the tested IGRs was observed as doses and time exposure dependent (Table 1-2). The highest number of healthy flowers were observed in Emamectin benzoate treated plots @ 1.0 g L^{-1} water at 1st, 3rd and 7th DATs as compared to the untreated control (Tables 1-2). Present findings are similar with the result of Patel *et al*. (2012). They observed that Emamectin benzoate 5% SG @ 0.3 g L^{-1} were found to be the most effective insecticides against the *M. vitrata* in Nepal, which provided lowering flower damage with the highest benefit cost ratio. The present results also could be supported by the Ahmed *et al*. (2020) where they claimed that Emamectin benzoate @ 1.0 g L^{-1} water showed a superior performance in comparison to spinosad- a widely used insecticide in respect of benefit cost ratio. Aryal *et al.* (2021) also experienced similar results with the same insecticides at equal doses.

The applied IGRs had promising effects on healthy pods and consequently offered lowest infested pods against the bean pod borer (Tables 3-4). Novel innovative research illustrated that the diverse IGRs have been tried by several researchers with a good degree of success against the pod borer, *M. vitrata* (Haritha, 2008; Ahmed *et al*., 2020). Tested IGRs provided the highest number of healthy pods from Emamectin benzoate treated plots @ 1.0 g L^{-1} water followed by Buprofezin @ 0.50 ml/L at 1st, 3rd and 7th DATs while the lowest in the untreated control (Table 3). Our findings are also comparable with the observations as stated by Kolarath *et al*. (2015) and Aktar *et al*. (2020). They found the highest healthy bean pods in Emamectin benzoate treated plots. This results are also similar with the report of Regmi *et al.* (2014) where they found the highest weight of healthy yardlong bean pods $plot^{-1}$ from the Emamectin treated plants.

IGRs as the novel insecticides showed their significant effect in reducing the infested pods as compared to the control (Table 5). This findings are in close proximity with Aktar *et al*. (2020) where they found that the lowest number of

infested pod plot^{-1} (2.88) from Emamectin benzoate treated plots. Parallel findings were also obtained by Patel *et al*. (2012) who observed that Emamectin benzoate 5% SG @ 0.3 g/L was the most effective insecticide in lowering cowpea pod damage with highest benefit cost ratio. Similarly, Haripriya *et al.* (2019) reported that due to sequential application of Emamectin benzoate only 8.87% pod was infested by *M. vitrata* on lablab bean. Aktar *et al.* (2020) also reported the highest increase of healthy pod (63.29%) over control from Emamectin benzoate treated plots against the *M. vitrata* infesting country bean.

The results revealed that all treatments significantly could increase marketable pod yield of country bean as compared to control (Table 5). However, the highest yield was obtained from Emamectin benzoate @ 1.0 g L^{-1} water treated plot while the lowest in untreated control plots. Aktar *et al.* (2020) also found the highest yield (7.1 t ha^{-1}) and yield increase 32.58% over control from Emamectin benzoate 5 SG (1g L^{-1} water) treated plots against country bean pod borer.

The used IGRs in the present study had direct effect against *M. vitrata* which reduced the infestation on flowers and pods. Use of these IGRs have a great economic and environmental importance in comparison to detrimental chemical pesticides. Hence, farmers can use IGRs especially Emamectin benzoate @ 1.0 g L^{-1} for effective management of *M. vitrata* in country bean.

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