Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2019; 7(5): 199-203

Received: 07-07-2019
Accepted: 09-08-2019

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Potentiality of some insect growth regulators on the mortality of bean aphid, *Aphis craccivora* (Koch.)

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Abstract
In the present study, experiments were conducted in the laboratory of Department of Entomology, Bangladesh Agricultural University, Mymensingh-2202 to evaluate the potentiality of some promising insect growth regulators (IGRs) viz. Buprofezin (Award 40 SC), Lufenuron (Heron 5 EC) and Pyriproxyfen (Pyrifen 10.8 EC) on the mortality of bean aphid, *Aphis craccivora (*Koch). Each of the IGRs was tested in three different concentrations (0.5, 1.0 and 1.5 ml/L) following three application methods namely direct (topical), indirect (leaf-dip) and combined (topical+ leaf-dip). Data on mortality were collected at 1, 3 and 7 days after treatment (DAT) application. All selected IGRs were found very effective against bean aphid in the laboratory condition. Mortality of bean aphid was clearly dose, time and method dependent. No mortality was found at 1 DAT while mortality was reached to significant level at 3 DAT from all application methods but the highest mortality was found at 7 DAT. Highest mortality was recorded through combined application method @ 1.5 ml/L (85 to 93%) which was followed by 1.0 ml/L (~80%) and 0.50 ml/L (60-70%) respectively. It was also observed that combined application method along with highest concentration was found very effective than topical and leaf-dip method regarding mortality.

Keywords: Buprofezin, lufenuron, pyriproxyfen, *Aphis craccivora*, mortality

1. Introduction
Country bean, *Lablab purpureus* (L) is one of the major winter vegetable crops grown in all over Bangladesh [9]. In Bangladesh, bean is considered as cheap and readily available source of protein; therefore, it has a great demand to all people. Apart from proteins, it contains appreciable amount of vitamins, calcium, phosphate and sodium. In spite of being a prospective crop, high incidence of insect pests results in low yield and poor quality of country bean. Farmers of Bangladesh face significant yield loss of country bean in every year due to severe attack of various insect pests. The yield loss in country bean due to insect pests is reported to be about 12-30% [11]. Country bean is infested by nine different insect species and one species of mite. For example, the major insect pests of common bean are aphids, pod borer, epilachna beetle, stem maggot etc. Among these insects, bean aphid, *Aphis craccivora* (Koch.) and *Aphis medicaginis* are major constraints of country bean production which inflict a destructive damage throughout the country [2].
A. craccivora (Koch.) (Aphididae: Hemiptera) is a serious sucking pest of different legume vegetables which does approximately 40-50% of the damage [5]. Various control strategies such as biological, chemical, cultural methods have been evaluated against this pest. Conventionally, farmers are using various types of synthetic chemical insecticides to control bean aphid that creates several problems in agro-ecosystem and development of high level of resistance [1]. Therefore, there is a need of developing other strategies like biorational-based control methods which target the insect during the specific time of damage. It has been trying since last few years to overcome resistance problems using target based molecules than broad-spectrum insecticides. Insect growth regulators (IGRs) might be potential alternates of conventional insecticides to control bean aphids. Insect Growth Regulators (IGRs) are natural and synthetic analogs capable of interfering with the processes of growth, development, moulting and metamorphosis of the target pest. The mode of action of IGR is not central nervous system-oriented but kills insects potentially through cessation of moulting process [4]. Insect growth regulators (IGRs) viz. Buprofezin, Lufenuron and Pyriproxyfen are found as potential alternatives of broad-spectrum insecticides against lepidopteran and hemipteran insects [8, 14, 16].

2. Experimental methods

The effects of some insect growth regulators like Buprofezin (Award 40 SC), Lufenuron (Heron 5 EC) and Pyriproxyfen (Pyrifen 10.8 EC) were evaluated against bean aphid, *Aphis craccivora* (Koch.) in the Laboratory of the Department of Entomology, Bangladesh Agricultural University, Mymensingh from July, 2017 to March, 2018.

2.1 Collection of bean aphid

For laboratory bioassay, bean aphids were collected from the Entomology Field Laboratory, Bangladesh Agricultural University, Mymensingh. Country bean plants were raised in the field for mass-production of aphids and care was taken to keep these plants from any insecticidal contamination or drift residues. Severely attacked twigs of bean crop by *A. craccivora* were carefully cut from the plant and kept with small twigs in a large petridish cautiously. The petridish was then covered so that aphids could not escape from there and brought to the laboratory. Then bean aphids were kept in the laboratory at room temperature and used for IGR testing on that day. For every experiment, fresh and alive aphids were collected from the field laboratory for conducting experiments.

2.2 Specifications of selected insect growth regulators

Each of the selected IGRs had three concentrations *viz*. 0.50, 1.0 and 1.5 ml/L. Each of the concentration was considered as a treatment. Each treatment was replicated thrice and ten larvae were used for each replication.

2.3 Treatment application methods

Treatments were applied through three application methods *viz*. topical or direct, leaf-dip or indirect and combined (direct + indirect).

2.3.1 Direct/topical application method

In this method, bean aphids were directly treated (using micropipette) with different concentrations of selected IGRs. The treated insects were then transferred on untreated country bean leaves using fine camel hair brush and finally placed in petridishes.

2.3.2 Indirect/leaf-dip method

In this method, country bean leaves were dipped into different concentrations of selected IGRs for few seconds. Then dipped leaves were taken out from the solution and dried on tissues. Then untreated insects were transferred on treated country bean leaves using fine camel hair brush and finally placed in petridishes.

2.3.3 Combined (topical + leaf-dip) method

In this method, both aphids and country bean leaves were treated with different concentrations of selected IGRs. After that treated leaves were transferred in petridishes. Then, treated aphids were carefully transferred on treated country bean leaves.

2.4 Data collection

Percent mortality was recorded at 1, 3 and 7 DAT. The percentage of mortality of aphid compared to control was calculated using the following formula:

$$\% \text{ Mortality} = Po/Pr \times 100$$

Where,

Po = Number of died insects

Pr = Number of treated or untreated insects provided

2.5 Statistical Analysis

The recorded data were compiled and tabulated for statistical analysis. Analysis of variance (ANOVA) was done with the help of computer software WASP 2.0. The mean differences among treatments were adjudged with Duncan's Multiple Range Test (DMRT) and Least Significant Difference (LSD).

3. Results

3.1 Potentiality of Award 40 SC on the mortality of bean aphid through different application methods

3.1.1 Direct effect of Award 40 SC on mortality of bean aphid

The mean percent of mortality of bean aphid has been shown in the table 1A when bean aphids were treated with different concentrations of Award 40 SC. Almost no mortality was found at 1 DAT which clearly indicates that Award 40 SC is a slow acting molecule which fits the mode of action of an ideal IGR. But with increasing time (at 3 DAT) the mortality level increased significantly compared to control and reached to the peak level by 7 DAT. It was clear that the effect was dose and time dependent. At 3 DAT, 23.33% mortality was recorded when aphids were directly treated with 1.5 ml/L which was followed by 1.0 ml/L (20.0%) and 0.50 ml/L (13.33%) respectively. The highest mortality was found from 1.5 ml/L of Award 40 SC (83.33%) at 7 DAT which was followed by 1.0 ml/L (70.0%) and 0.50 ml/L (62.33%) respectively.

3.1.2 Indirect effect of Award 40 SC on mortality of bean aphid

The mean percent of mortality of bean aphid has been shown in the table 1B when country bean leaves were treated with different concentrations of Award 40 SC. No mortality was found at 1 DAT. But with increasing time (at 3 DAT) the mortality level increased significantly compared to control and reached to the peak level by 7 DAT. It was clear that the effect was dose and time dependent. At 3 DAT, 30.00% mortality was recorded when country bean leaves were treated with 1.5 ml/L which was followed by 1.0 ml/L (28.33%) and 0.50 ml/L (23.33%) respectively. The highest mortality was found from 1.5 ml/L of Award 40 SC (86.66%) at 7 DAT which was

followed by 1.0 ml/L (75.30%) and 0.50 ml/L (63.33%) respectively.

3.1.3 Combined effect of Award 40 SC on mortality of bean aphid

The mean percent of mortality of bean aphid has been shown in the table 1C when both aphids and country bean leaves were treated with different concentrations of Award 40 SC. Very low percentage of mortality was found at 1 DAT. But with increasing time (at 3 DAT) the mortality level increased significantly compared to control and reached to the peak level by 7 DAT. It was clear that the effect was dose and time dependent. At 3 DAT, 36.67% mortality was recorded when both aphids and country bean leaves were treated with 1.5 ml/L which was followed by 1.0

ml/L (26.67%) and 0.50 ml/L (23.33%) respectively. The highest mortality was found from 1.5 ml/L of Award 40 SC (92.66%) at 7 DAT which was followed by 1.0 ml/L (80.00%) and 0.50 ml/L (69.11%) respectively.

Table 1: Mean percent mortality of bean aphid at different time interval following treated with different concentrations of Award 40 SC through different application methods

[A] Direct application method

Treatments	Mean percent mortality of *A. craccivora* at different DAT		
	1	3	7
Award 40 SC @ 0.5 ml/L	0.00	13.33ab	62.33b
Award 40 SC @ 1.0 ml/L	0.00	20.00ab	70.00a
Award 40 SC @ 1.5 ml/L	3.33	23.33a	83.33a
Control	0.00	3.33b	9.00c
Level of significance	NS	*	**

[B] Indirect application method

Treatments	Mean percent mortality of *A. craccivora* at different DAT		
	1	3	7
Award 40 SC @ 0.5 ml/L	0.00	23.33 a	63.33 b
Award 40 SC @ 1.0 ml/L	0.00	28.33 a	75.30 ab
Award 40 SC @ 1.5 ml/L	0.00	30.00 a	86.66 a
Control	0.00	3.33 b	9.00 c
Level of significance	NS	*	**

[C] Combined application method

Treatments	Mean percent mortality of *A. craccivora* at different DAT		
	1	3	7
Award 40 SC @ 0.5 ml/L	0.00	23.33 ab	69.11 b
Award 40 SC @ 1.0 ml/L	0.00	26.67 a	80.00 a
Award 40 SC @ 1.5 ml/L	3.33	36.67 a	92.66 a
Control	0.00	3.33 b	9.00 c
Level of significance	NS	*	**

In a column, means followed by different letters are significantly different, DAT = Days After Treatment, *= Significant at 5% level of probability, ** = Significant at 1% level of probability, NS = Not significant.

3.2 Potentiality of Heron 5 EC on the mortality of bean aphid through different application methods

3.2.1 Direct effect of Heron 5 EC on mortality of bean aphid

Lufenuron is another important IGR which acts as chitin synthesis inhibitor. It inhibits the growth and development and becomes responsible for the mortality of insects. Mortality of bean aphid following treated with different concentrations of Heron 5 EC through topical application method has been shown in Table 2A. The result clearly revealed that Heron 5 EC was effective against bean aphid and the effect was clearly dose and time dependent. No mortality was found at 1 day after treatment (DAT) application, the significant (P<0.01) effect was found at 3 DAT which reached to the peak level by 7 DAT. At 3 DAT, all the treatments also significantly increased mortality compared to control but highest mortality was found from 1.5 ml/L of Heron 5 EC (81.00%) at 7 DAT which was followed by 1.0 ml/L (73.33%) and 0.50 ml/L (66.66%) respectively.

3.2.2 Indirect effect of Heron 5 EC on mortality of bean aphid

Table 2B clearly showed that Heron 5 EC had significant effect on the mortality of bean aphid (P<0.01). The effect was clearly dose and time dependent. At 3 DAT, 60.00% mortality was recorded when country bean leaves were treated with 1.5 ml/L which was followed by 1.0 ml/L (53.33%) and 0.50 ml/L (53.33%) respectively. The highest mortality was found from 1.5 ml/L of Heron 5 EC (80.67%) at 7 DAT which was followed by 1.0 ml/L (71.67%) and 0.50 ml/L (68.33%) respectively.

3.2.3 Combined effect of Heron 5 EC on mortality of bean aphid

The mortality of bean aphid due to combined application of Heron 5 EC has been shown in table 2C. There had significant effect of different concentrations of Heron 5 EC on the mortality of bean aphid (P<0.01). No mortality was found at 1 DAT. The mortality level increased significantly with the increase of time (at 3 DAT) compared to control and reached to the peak level by 7 DAT. It was clear that the effect was always dose and time dependent. At 3 DAT, 66.67% mortality was recorded when both bean aphids and country bean leaves were treated with 1.5 ml/L which was followed by 1.0 ml/L (63.33%) and 0.50 ml/L (61.67%) respectively. The highest mortality was found from 1.5 ml/L of Heron 5 EC (86.66%) at 7 DAT which was followed by 1.0 ml/L (81.67%) and 0.50 ml/L (73.33%) respectively.

Table 2: Mean percent mortality of bean aphid at different time interval following treated with different concentrations of Heron 5 EC through different application methods

[A] Direct application method

Treatments	Mean percent mortality of *A. craccivora* at different DAT		
	1	3	7
Heron 5 EC @ 0.5 ml/L	0.00	46.67 a	66.66 c
Heron 5 EC @ 1.0 ml/L	0.00	50.00 a	73.33 b
Heron 5 EC @ 1.5 ml/L	0.00	53.33 a	81.00 a
Control	1.67	2.83 b	8.00 d
Level of significance	NS	**	**

[B] Indirect application method

Treatments	Mean percent mortality of *A. craccivora* at different DAT		
	1	3	7
Heron 5 EC @ 0.5 ml/L	0.00	53.33 a	68.33 b
Heron 5 EC @ 1.0 ml/L	0.00	53.33 a	71.67 b
Heron 5 EC @ 1.5 ml/L	0.00	60.00 a	80.67 a
Control	0.00	2.83 b	8.00 c
Level of significance	NS	**	**

[C] Combined application method

Treatments	Mean percent mortality of *A. craccivora* at different DAT		
	1	3	7
Heron 5 EC @ 0.5 ml/L	0.00	61.67 a	73.33 b
Heron 5 EC @ 1.0 ml/L	0.00	63.33 a	81.67 ab
Heron 5 EC @ 1.5 ml/L	0.00	66.67 a	86.66 a
Control	0.00	2.83 b	8.00 c
Level of significance	NS	**	**

In a column, means followed by different letters are significantly different, DAT = Days After Treatment, ** = Significant at 1% level of probability, NS = Not significant.

3.3 Potentiality of Pyrifen 10.8 EC on the mortality of bean aphid through different application methods

3.3.1 Direct effect of Pyrifen 10.8 EC on mortality of bean aphid

Like as Award 40 SC and Heron 5 EC, Pyrifen 10.8 EC had

significant effect on the mortality of bean aphid (Table 3A, $P<0.01$). But the mortality was significantly affected by dose, time and application method. Similar with Award 40 SC and Heron 5 EC, no or very low (2-4%) mortality was found at 1 DAT which further confirms the slower action of IGR. In contrast, mortality level rapidly reached to 79% by 3 DAT when aphids were directly treated 1.5 ml/L of Pyrifen that was followed by 1.0 ml/L (71.67%) and 0.50 ml/L (48.33%) respectively. The highest mortality was found from 1.5 ml/L of Pyrifen 10.8 EC (90.33%) at 7 DAT which was followed by 1.0 ml/L (88.33%) and 0.50 ml/L (61.67%) respectively.

3.3.2 Indirect effect of Pyrifen 10.8 EC on mortality of bean aphid

The mean percent of mortality of bean aphid has been shown in the table 3B when country bean leaves were treated with different concentrations of Pyrifen 10.8 EC. Very low mortality was found at 1 DAT with all the concentrations tested. But with increasing time (at 3 DAT) the mortality level increased significantly compared to control and reached to the peak level by 7 DAT. It was clear that the effect was dose and time dependent. At 3 DAT, 48.33% mortality was recorded when country bean leaves were treated with 1.5 ml/L which was followed by 1.0 ml/L (38.33%) and 0.50 ml/L (33.50%) respectively. The highest mortality was found from 1.5 ml/L of Pyrifen 10.8 EC (62.67%) at 7 DAT which was followed by 1.0 ml/L (51.67%) and 0.50 ml/L (41.67%) respectively. It was notable that the% mortality was comparatively lower in indirect method than that of direct method.

3.3.3 Combined effect of Pyrifen 10.8 EC on mortality of bean aphid

Percent mortality of bean aphid in combined application method was further increased than that of direct or indirect application method (Table 3C, $P<0.01$). The highest mortality (93.33%) was found from 1.5 ml/L at 7 DAT which was followed by 1.0 ml/L (88.33%) and 0.50 ml/L (61.67%) respectively. Comparatively lower mortality was found from 3 DAT than 7 DAT. Very low mortality (2-6%) was found at 1 DAT.

Table 3: Mean percent mortality of bean aphid at different time interval following treated with different concentrations of Pyrifen 10.8 EC through different application methods

[A] Direct application method

Treatments	Mean percent mortality of *A. craccivora* at different DAT		
	1	3	7
Pyrifen 10.8 EC@ 0.5 ml/L	2.00	48.33 c	61.67 b
Pyrifen 10.8 EC@ 1.0 ml/L	2.00	71.67 b	80.33 a
Pyrifen 10.8 EC@ 1.5 ml/L	3.00	79.00 a	90.33 a
Control	0.00	3.50 d	5.80 c
Level of significance	NS	**	**

[B] Indirect application method

Treatments	Mean percent mortality of *A. craccivora* at different DAT		
	1	3	7
Pyrifen 10.8 EC @ 0.5 ml/L	3.33	33.50 c	41.67 c
Pyrifen 10.8 EC @ 1.0 ml/L	4.33	38.33 b	51.67 b
Pyrifen 10.8 EC@ 1.5 ml/L	4.00	48.33 a	62.67 a
Control	2.00	3.50 d	5.80 d
Level of significance	NS	**	**

[C] Combined application method

Treatments	Mean percent mortality of *A. craccivora* at different DAT		
	1	3	7
Pyrifen 10.8 EC @ 0.5 ml/L	1.67	53.33 c	64.63 b
Pyrifen 10.8 EC @ 1.0 ml/L	0.00	76.33 b	82.33 a
Pyrifen 10.8 EC @ 1.5 ml/L	0.00	84.10 a	93.33 a
Control	0.00	3.50 d	5.80 c
Level of significance	NS	**	**

In a column, means followed by different letters are significantly different, DAT = Days After Treatment, ** = Significant at 1% level of probability, NS: Not significant.

4. Discussion

In the present study it has been observed that Buprofezin (Award 40 SC), Lufenuron (Heron 5 EC) and Pyriproxyfen (Pyrifen 10.8 EC) worked as potent insect growth regulators (IGRs) against bean aphid. These findings cleared that all these three IGRs work more potently when come in contact through cuticle and enters endocrine system through foods. It was also observed that high concentrations of Buprofezin (Award 40 SC), Lufenuron (Heron 5 EC) and Pyriproxyfen (Pyrifen 10.8 EC) molecules are needed (1.5 ml/L) to disrupt moulting process and thereby attaining high mortality. Moderate mortality can be achieved by applying moderate concentrations (1.0 ml/L) while lower concentrations (0.5 ml/L) were found to be very ineffective regarding mortality of aphid. So, combined application method and 1.5 ml/L were found much better than individual methods (direct or indirect) to control bean aphid.

From previous findings it has been found that the effect of Buprofezin on the mortality is dose and method dependent. Vadja and Kalasariya reported that Buprofezin @ 0.05% caused 69.95% mortality of bean aphid which is higher than lower doses. Buprofezin was found to be highly effective against brown plant hopper, brinjal shoot and fruit borer and jassid populations. Buprofezin was found to be the most effective against aphid offering the lowest aphid population (1.56/top10cm central twig) at 7 days after treatment (DAT) [3, 6, 7, 17].

Similarly, it has been found that higher dose of Lufenuron is found to be more effective against different sucking and borer pests than lower doses and the combined method has been proved the best which was closely followed by indirect and topical method [9, 12].

And Pyriproxyfen is currently used for the control of sucking insects. Pyriproxyfen causes sterility in most aphids exposed to dosages exceeding 1ppm and reduced aphid longevity of reproductively mature aphids. A field study indicates that Pyriproxyfen affects aphid population structure and may have potentiality in managing aphid outbreaks. Modifying aphid population structure and growth through the use of juvenoids such as Pyriproxyfen may prove to be an effective proactive approach to pest control without adversely impacting beneficial organisms or causing pest resurgence. And mortality of mature aphid was increased by higher concentrations of Pyriproxyfen and following results were obtained: 25, 55, 72.5, and 85% loss for 22.5, 45.90 and 180 ppm of Pyriproxyfen [13, 15].

5. Conclusion

From experimental findings it can be concluded that all these three insect growth regulators can be applied @ 1.5 ml/L for

eco-friendly management of bean aphid as it provided more than 80% mortality of bean aphid over control. It was also observed that combined application method was found more effective than direct and indirect application which indicates that both insects and plants should be treated carefully using selected IGRs during field spray. Therefore, all tested IGRs with the concentration of 1.5 ml/L would be potential alternatives of conventional insecticides to control bean aphid successfully.

6. Acknowledgement

This study was supported by the research grant from NATP-2/PIU-BARC sub-project (Project ID: 400) to Dr. Gopal Das.

7. References

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