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# Damage Assessment of Bean Aphid, *Aphis craccivora* Koch and its Biorational Management

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**ABSTRACT**

An experiment was carried out at the field of Entomology, Bangladesh Agricultural University, Mymensingh to determine the extent of damage of bean plants by aphid, *Aphis craccivora* Koch. and its biorational management. Efficacy of biorationals *viz*. Neem oil (2ml/l), Mahogany oil (2ml/l), Karanja oil (2ml/l), Abamectin (1ml/l), Spinosad (1ml/l), Emamectin benzoate (1g/l) and Lufenuron(1ml/l) were evaluated against bean aphid, *A. craccivora* Koch. The experiment was laid out in randomized complete block design with three replications of each treatment. Three sprays of the treatments were made at 15 days interval. The highest mean percentage of infested twig (82.57), flower (71.38), and pod (79.51) were found in untreated plants at 100 days after seed sowing (DAS). But at 60 DAS the lowest average percent infestations were found 26.08, 34.28 and 33.33 in twig, flower and pod, respectively. The highest reduction of aphid on the twigs was found in Abamectin (70.14%) followed by Spinosad (64.14%) and Neem oil (59.16%). Similarly, the highest reduction of aphid was in Abamectin (79.02%) followed by Spinosad (73.95%) and Neem oil (69.22%) on the flowers. In both cases the lowest reduction of aphid was noticed in Karanja (39.24% & 48.70%) followed by Mahogany oil (40.72% & 54.00%). Reduction of aphid population on pods was the highest in Abamectin (86.97%), followed by Spinosad (81.97%) and Neem oil (75.1%) after 1st spray. The lowest reduction of aphid was found in Karanja oil (53.16%) followed by Mahogany oil (61.17%). After 2nd and 3rd sprays similar trend in percent reduction of aphid population was observed. Results also revealed that among the selected insecticides, Abamectin, Spinosad and Neem oil provided better protection of plants against bean aphid. The maximum increase of yield over control was found in Abamectin (9.37t/ha) followed by Spinosad (8.36 t/ha) and Neem oil (7.36 t/ha) after all sprays respectively.



## Introduction

Country bean, *Lablab purpureus* (L.) is a popular and widely grown vegetable in Bangladesh. It is a common and protein rich (20-30% proteins on a dry weight basis) leguminous vegetable. It also contains appreciable amount of thiamin, riboflavin, niacin, vitamin C and iron @ 0.1, 0.06, 0.7, 9.0, and 41.7 mg/100g, respectively (Rehana, 2006). Bean is commonly known as “seem” in Bangladesh. The fresh pods and green seeds are eaten after boiling or used in curries. Mature seeds are used as pulse, often as soup as well as are occasionally sun-dried and stored for use as vegetable. This bean is also grown for fodder and as a cover crop (Begum, 1993). In Bangladesh total land area under bean cultivation is 49192acres and the production is 122091 MT during 2014-2015 (BBS, 2015). The farmers of Bangladesh face significant yield loss of country bean 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% (Hossain, 1990). According to Das (1998), Islam (1999) insect pests attacking country bean are different species of aphid including *Aphis craccivora* Koch., *A. medicaginis* Koch., and bean pod borer, *Maruca testulalis.* Both nymphs and adults of aphid suck cell sap of infested plants and while feeding they inject a toxin along with the salivary secretion into host plants. They also secrete honeydew, which by enhancing the growth of sooty moulds, interferes with the photosynthetic ability of plants (El-Defrawi, 1987; El-Fatah, 1991; Rizkalla *et al*., 1994). In addition, the pest may transmit virus diseases to plants. According to Singh and Allen (1980), the pest causes up to 40% reduction of crop yields in Asia. Attle *et al*. (1987) reported as high as 100% yield reduction of different bean crops due to aphid infestation. As country bean is attacked by many pests and cause considerable damage, pest management is

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essential. Current management practices of insect pests are based almost entirely on chemical insecticides as they give quick result. As most of our people are illiterate, they use pesticides more than the standard requirement indiscriminately. For example, farmers of Bangladesh particularly of intensive country bean growing areas like Jessore apply insecticides 84 to 140 times in a growing season (Anonymous, 2006). This over-use, misuse and the way of using which cause drifting loss to the nearest crop and in the atmosphere which results in pest resurgence, stimulation of the reproductive rate in certain pests, secondary pest outbreaks, mortality of beneficial insects, resistance of pest species and finally environmental pollution (Alam *et al.,* 2005).Indiscriminate and haphazard use of these chemicals, particularly at fruiting stage, leads to its accumulation in the vegetables which consequently cause hazards to human beings through food chain (Nafees, 2009). This results in serious contamination of different component of environment (surface water, aquifers, soil, air etc.) including human, wildlife and other organisms. Further, *A. craccivora* has also developed resistance towards many synthetic insecticides. Therefore, it is urgently needed to develop an eco-friendly and appropriate management strategy. An alternative to conventional pest control is Integrated Pest Management (IPM), an approach that aims to reduce pest status to tolerable levels by using effective, ecologically-sound and economically-sustainable management methods (Van Lenteren and Woets, 1988). There have been a large number of plant-products, which possess pesticidal properties and have been used successfully for controlling various pests in field and laboratory conditions (Bajpai and Sehgal, 2000; Pedigo, 2002). Bioefficacy of some biorational insecticides for the control of aphid (*Aphis gossypii*) on greenhouse grown cucumber has been proved to be more promising than any other conventional insecticides (Emami, 2016). Biorational pesticides showed high efficacy against aphid (*Toxoptera aurantii*) and effectively control aphid population (Sohail *et al.,* 2012). Ghanim and Abdel Ghani (2014) who reported the use of plant extract to control the population of *A. gossypii* in an environmentally friendly way. In Bangladesh research work with biorational pesticides against bean aphid is scanty. Keeping this in mind, the present study has been carried out to determine the extent of damage of bean aphid and its management with different biorational insecticides.

## Materials and Methods

To compare the efficacy of different biorational insecticides in managing bean aphid, a field experiment was carried out during the period from October, 2016 to April, 2017 in the field at Entomology Department of Bangladesh Agricultural University, Mymensingh. To grow the bean plants the soil was well prepared and good tilth was ensured. The land of the experimental field was ploughed with drawn disc plough followed by laddering to make the soil suitable for seed sowing. After ploughing and laddering, all the stubbles and uprooted weeds were removed and then the land was ready. The field layout and design of the experiment were followed immediately after land preparation. Individual plots were prepared with basal dose of chemical fertilizers with the help of a spade. At the same time of pre sowing, final weeding was done to facilitate seed germination and minimize crop weed competition. The whole area of experimental field was divided into 4 blocks and each block was again divided into 6 unit plots. There were 24 plots in the experiment with single pit per plot. Pits were prepared in such a way that these pits remained at least 10 cm above the ground level to avoid water stagnation. After 7 days of pit preparation, seeds were sown followed by a light irrigation to ensure soil moisture for germination. Subsequent irrigation was applied at the interval of 10-15 days inspecting the soil moisture level in all the plots. Five seeds were sown in each pit. Recommended manures and fertilizers were applied as per recommendation of Mondal *et al*. (2011). Bean seeds of vairiety, Ipsha-2 were purchased from Notunbazar, Sadar Mymensingh and used for the development of experimental plants. After germination of seeds all the agronomic practices were performed to have healthy seedlings for experiment. Propping of plants by bamboo sticks was provided to facilitate climbing of the plants and to avoid their lodging. A platform was built by bamboo sticks horizontally and to allow normal creeping. Plants of each plot were allowed to creep in a single platform. The bamboo sticks were two meter high from ground level. The following treatments were used to manage the bean aphid in the field.

Table 1. Treatments specification

| Treatments | Chemicals/botanical name | Trade name | Dose (ml/L) |
|---|---|---|---|
| $T_1$ | *Azadirecta indica* | Neem oil | 2 ml |
| $T_2$ | *Switenia macrofylla* | Mahogany oil | 2 ml |
| $T_3$ | *Pongamia pinnata* | Karanja oil | 2 ml |
| $T_4$ | Abamectin | Ambush1.8EC | 1 ml |
| $T_5$ | Spinosad | Libsen 45SC | 1 ml |
| $T_6$ | Lufenuron | Heron 5EC | 1 ml |
| $T_7$ | Emamectine benzoate | Suspend 5SG | 1 g |
| $T_8$ | Control | - | - |

Different treatments for managing bean aphid such as botanical oils, microbial derivatives were prepared by taking insecticides into plastic bottle with addition of distilled water. In case of botanical oils 1 ml/L of liquid detergent was added to mix the oil with the water. Biorationals were measured by electric balance and micro pipette based on the nature of insecticides. Then

the biorationals were applied in the crops using a hand sprayer. The insecticides were applied against bean aphid from the flowering stages of plants. A total of 3 sprays of each treatment were given at 15 days of interval. First treatment was applied on the 1st week of January 2017. The bean pods were harvested at the maturity and weighed with the help of an electric balance. First of all, a single plant was tagged and then number of aphid twig$^{-1}$, flower$^{-1}$and pod$^{-1}$ was counted with naked eye. Data were collected at 3, 5 and 7 days intervals after each spraying of treatments. A pretreatment data was also collected. Percentage twig, flower and pod infestation and percentage reduction of aphid on twig, flower and pod over control was calculated using the following formulae.

% infestation (twig, flower, pod) = (I/N) x 100
Where, I = number of infested twig, flower or pod, and N = total number of twig, flower or pod

% reduction of aphid over control = $(M_C–M_t)/M_c$ x 100
Where, $M_C$ = mean number of aphid in control and $M_t$ = mean number of aphid in treatment.

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data were statistically analyzed using R statistic software and Duncan Multiple Range Test (DMRT) was used to determine the levels of significant differences among the treatments.

## Results

### *Damage assessment*

The mean percentage of infestation in twig, flower and pod at different days after seed sowing differed significantly (Fig. 1). In the control plants, the highest mean percentage of aphid infestation in twig (82.57), flower (71.38), pod (79.51) were found at 100 days after seed sowing and minimum mean percentage of aphid in twig (26.08), flower (34.28) and pod (33.33) was found at 60 days after sowing. The average percent infestations were found 56.50, 48.56 and 55.56 in twig, flower and pod, respectively at 85 days after seed sowing (Fig.1).

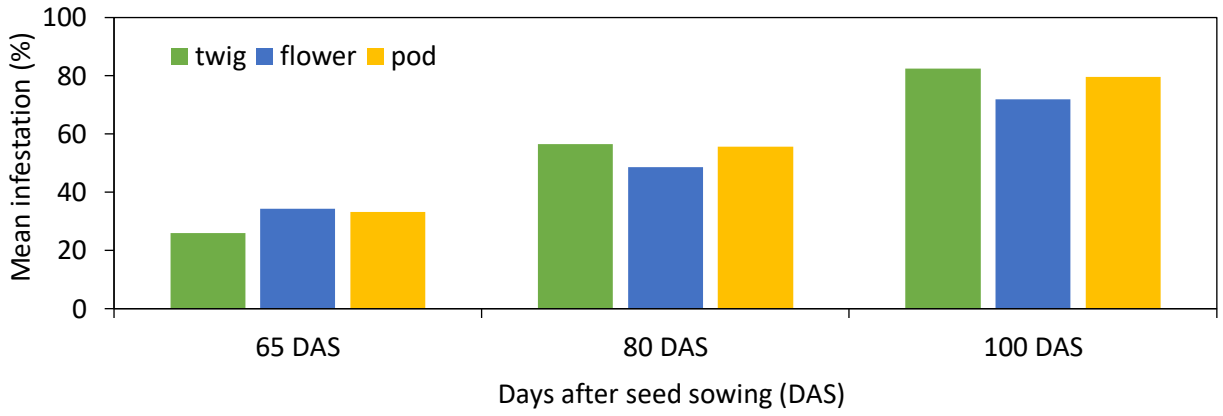


Figure 1. Damage estimation based on % infestation in twig, flower and pod at different days after sowing

### *Management using different biorational insecticides*

#### Aphid infestation in bean plants after 1st spray

Aphid population on twig, flower and pod varied significantly ($p \leq 0.05$) after 1st spray of biorational insecticides (Table 2). The lowest mean number of aphids/twig (34.00) was observed in Abamectin treated plants followed by Spinosad (40.00) and Neem oil (45.00) and the highest number of aphids/twig (116.33) was found on control plants at 3 DAS (Table 2). At 5 DAS, the lowest number of aphids/twig was observed in Abamectin (29.33) followed by Spinosad (34.00), Neem oil (40.00), Emamectin benzoate (40.00) and the highest mean number of aphids/twig (92.33) was noticed on control plants (Table 2). Similar trend of results was found at 7 DAS. After 1st spray, the lowest number of aphids/flower (25.33) was observed in Abamectin treated plants followed by Spinosad (30.00) and Neem oil (35.33) and the highest mean number of aphid flower-1 (116.33) was found on control plants at 3 DAS. The lowest number of aphids/flower was observed in Abamectin (20.67) followed by Spinosad (25.33), Neem oil (30.33), Emamectin benzoate (35.33) and the highest mean number of aphids/flower (95.67) was noticed on control plants at 5 DAS (Table 2). At 7 DAS, the result was similar to the trend of 5 DAS. The lowest number of aphids/pod (15.33) was observed in Abamectin treated plants followed by Spinosad (21.00) and Neem oil (25.33) and the highest mean number of aphids/pod (103.00) was found on control plants at 3 DAS (Table2). At 5 DAS, the lowest number of aphids/pod-1 was observed in

Abamectin (10.00) followed by Spinosad (15.33), Neem oil (20.33) and Emamectin benzoate (25.33) and the highest mean number of aphids/twig (82.33) was noticed on control plants (Table 2). Similar result was found at 7 DAS. The results revealed that Abamectin had the highest efficacy in managing bean aphid. Lufenuron, Karanja oil, and Mahogany oil showed moderate effect on aphid population. Similar trends were observed in case of cumulative mean number of aphids/twig, aphids /flower and pods/aphids (Table 2).

Percentage infestation reductions of aphid in twig, flower and pod over control after 1st spray is presented in Fig. 2. The highest reduction (70.14%) of aphid on twig was in Abamectin treated plants followed by Spinosad (64.14 %), Neem oil (59.16%), Emamectin benzoate (53.74%) and Lufenuron (48.76%) and the lowest percentage reduction was in Karanja oil (39.24%) followed by Mahogany oil (40.72 %) treated plants (Fig. 1). In case of percentage infestation reduction of aphid in flower over control it was found that the highest reduction (86.97%) was in Abamectin treated plants followed by Spinosad (81.16 %), Neem oil (75.10%), Emamectin benzoate (70.58%) and Lufenuron (65.03%), and the lowest percentage reduction was in Karanja oil (53.16 %) followed by Mahogany oil (61.17%) treated plants (Fig. 2). Similarly the percentage infestation reduction of aphid in pod over control was the highest (86.97%) in Abamectin treated plants followed by Spinosad (81.16%), Neem oil (75.10%), Emamectin benzoate (70.58%) and Lufenuron (65.03%), and the lowest percentage reduction was in Karanja oil (53.16%) followed by Mahogany oil (61.17%) treated plants (Fig.2).

Table 2. Efficacy of biorational insecticides on the incidence of bean aphid at 1st spray

| Treatments | Before spray | After spray | | | |
|---|---|---|---|---|---|
| | | 3 DAS | 5 DAS | 7 DAS | Cumulative mean |
| | | Number of aphids/twig | | | |
| Abamectin | 176.67 | 34.00 f | 29.33 h | 24.67 h | 29.33 |
| Spinosad | 178.33 | 40.33 ef | 34.33 g | 31.00 g | 35.22 |
| Neem oil | 178.00 | 45.00 de | 40.33 f | 35.00 f | 40.11 |
| Emamactin Benzoate | 178.33 | 51.00 d | 46.00e | 39.33 e | 45.44 |
| Lufeneuron | 178.00 | 55.33 cd | 50.33 d | 45.33 d | 50.33 |
| Mahogani oil | 179.67 | 69.67 b | 54.67 c | 50.33 c | 58.22 |
| Karanja oil | 179.00 | 65.00 bc | 59.33 b | 54.67 b | 59.67 |
| Control | 179.00 | 116.33 a | 92.33a | 86.00 a | 98.22 |
| P-Value | 0.92 | 0.00 | 0.00 | 0.00 | - |
| Level of significant | NS | * | * | * | - |
| CV (%) | 1.53 | 10.04 | 2.85 | 1.73 | - |
| | | Number of aphids/flower | | | |
| Abamectin | 173.67 | 25.33 h | 20.67 h | 16.00h | 20.67 |
| Spinosad | 175.33 | 30.67 g | 25.33 g | 21.00g | 25.67 |
| Neem oil | 175.00 | 35.33 f | 30.33 f | 25.33 f | 30.33 |
| Emamactin Benzoate | 175.33 | 41.00 e | 35.33 e | 31.00 e | 35.78 |
| Lufeneuron | 175.00 | 45.33 d | 40.33 d | 35.33d | 40.33 |
| Mahogani oil | 176.67 | 50.33 c | 45.33 c | 40.33 c | 45.33 |
| Karanja oil | 176.00 | 55.33 b | 51.00 b | 45.33 b | 50.55 |
| Control | 176.00 | 116.00 a | 95.67 a | 84.00 a | 98.56 |
| P-Value | 0.93 | 0.00 | 0.00 | 0.00 | - |
| Level of significant | NS | * | * | * | - |
| CV (%) | 1.53 | 1.41 | 2.74 | 2.10 | - |
| | | Number of aphids/pod | | | |
| Abamectin | 170.67 | 15.33 g | 10.00 h | 8.33 h | 11.22 |
| Spinosad | 172.33 | 21.00 f | 15.33 g | 12.33 g | 16.22 |
| Neem oil | 174.00 | 25.33 e | 20.33 f | 16.33 f | 20.67 |
| Emamactin Benzoate | 175.33 | 30.33 d | 25.33 e | 20.33 e | 25.33 |
| Lufeneuron | 175.00 | 34.67 c | 30.33 d | 25.33 d | 30.11 |
| Mahogani oil | 178.67 | 35.33 c | 34.67 c | 30.33 c | 33.44 |
| Karanja oil | 178.00 | 44.67 b | 41.00 b | 35.33 b | 40.33 |
| Control | 178.00 | 103.00 a | 82.33 a | 73.00 a | 86.11 |
| P-Value | 0.92 | 0.00 | 0.00 | 0.00 | - |
| Level of significant | NS | * | * | * | - |
| CV (%) | 1.53 | 2.90 | 3.02 | 3.39 | - |

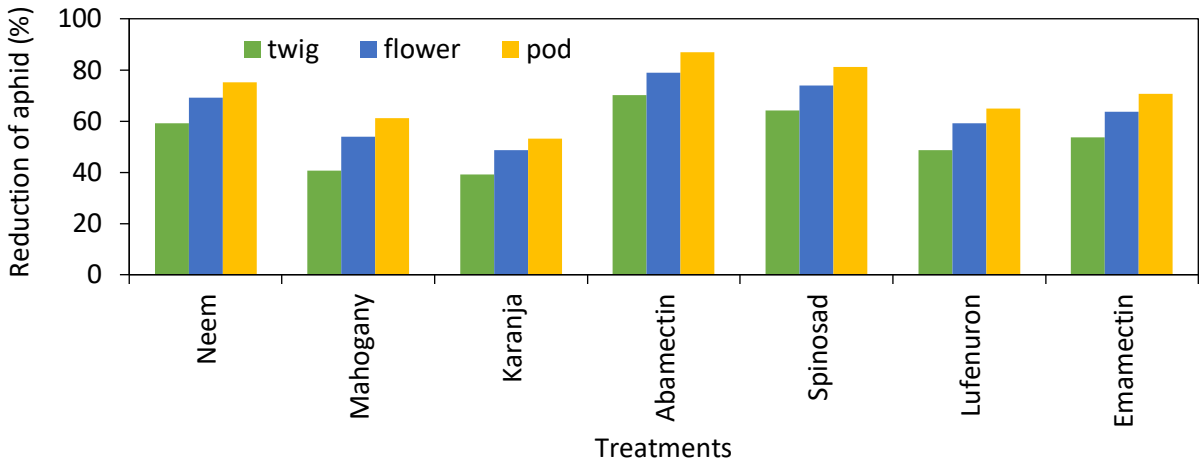


Figure 2. Reduction (%) of aphid infestation on twig, flower and pod over control after 1st spray

### Aphid infestation in bean plants after 2nd spray

The mean numbers of aphids/twig, aphids/flower and aphids/pod under treated biorational insecticides were counted at different time intervals and aphid population on twig, flower and pod varied significantly after 2ndspraying of biorational insecticides (Table 3). The lowest number of aphid twig-1 (24.00) was observed in Abamectin treated plants followed by Spinosad (29.33) and Neem oil (35.33). The highest mean number of aphids/twig (116.33) was found on control plants at 3 DAS (Table 3). At 5 DAS, the lowest number of aphids/twig was observed in Abamectin (18.33) followed by Spinosad (24.00), Neem oil (29.00) and Emamectin benzoate (34.67) and the highest mean number of aphids/twig (96.33) was noticed on control plants (Table 2).The lowest mean number of aphids/twig (14.00) was explored in Abamectin followed by Spinosad (19.67), Neem oil (25.00) and Emamectin benzoate (29.67) and the highest mean number of aphids/twig (85.00) was in control plants at 7 DAS. After 2nd spray, the lowest number of aphids/flower (19.00) was observed in Abamectin treated plants followed by Spinosad (25.33) and Neem oil (30.67). The highest mean number of aphids/flower (114.0) was found on control plants at 3 DAS (Table 3). At 5 DAS, the lowest number of aphids/flower was observed in Abamectin (14.33) followed by Spinosad (20.33), Neem (25.00) and Emamectin benzoate (30.33) and the highest mean number of aphids/flower (95.00) was noticed on control plants (Table 3). The same result was observed at 7 DAS that the lowest mean number of aphid flower-1 (9.00) was explored in Abamectin followed by Spinosad (15.33), Neem oil (20.67) and Emamectin benzoate (25.33) and the highest mean number of aphids/flower (84.67) was in control plants. After 2nd spray, the lowest number of aphids/pod (9.67) was observed in Abamectin treated plants followed by Spinosad (14.33) and Neem oil (18.33). The highest mean number of aphids/pod (120.00) was found on control plants at 3 DAS (Table 3). At 5 DAS, the lowest number of aphids/pod was observed in Abamectin (5.67) followed by Spinosad (10.33), Neem oil (14.33) and Emamectin benzoate (14.67) and the highest mean number of aphids/pod (95.00) was noticed on control plants (Table 3). Similarly, at 7 DAS, the lowest mean number of aphids/pod (3.67) was explored in Abamectin followed by Spinosad (8.33), Neem oil (12.33) and Emamectin benzoate (13.33) and the highest mean number of aphids/pod (83.00) was in control plants. The results revealed that Abamectin had the highest efficacy in managing bean aphid. Lufenuron, Karanja oil, and Mahogany oil had the moderate effect on aphid infestation (Table 3).

Percentage infestation reduction of aphid in twig, flower and pod over control was presented in Fig. 3. The highest reduction (81.9%) was in Abamectin treated plants followed by Spinosad (75.48%), Neem oil (69.99%), Emamectin benzoate (65.05%) and Lufenuron (59.01%), and the lowest percentage reduction was in Karanja oil (48.82 %) followed by Mahogany oil (53.97%) treated plants (Fig. 3). In case of percentage infestation reduction of aphid in flower over control it was presented in Fig.3. The highest reduction (85.59%) was in Abamectin treated plants followed by Spinosad (79.23%), Neem oil (74.00%), Emamectin benzoate (70.27%) and Lufenuron (64.02%), and the lowest percentage reduction was in Karanja oil (54.25 %) followed by Mahogany oil (60.06 %) treated plants (Fig. 3). Percentage infestation reduction of aphid in pod over control was presented in Fig. 3. The highest reduction (93.63%) was in Abamectin treated plants followed by Spinosad (89.83%), Neem oil (85.8%), Emamectin benzoate (83.56%) and Lufenuron (79.42%), and the lowest percentage reduction was in Karanja oil (66.67%) followed by Mahogany oil (74.72 %) treated plants (Fig. 3).

Table 3. Efficacy of biorational insecticides on the incidence of bean aphid at 2nd spray

| Treatments | Before spray | After spray | | | |
|---|---|---|---|---|---|
| | | 3 DAS | 5 DAS | 7 DAS | Cumulative mean |
| | | Number of aphids/twig | | | |
| Abamectin | 174.67 | 24.00 h | 18.33h | 14.00h | 18.78 |
| Spinosad | 174.33 | 29.33 g | 24.00g | 19.67g | 24.33 |
| Neem oil | 174.00 | 35.33 f | 29.00f | 25.00 f | 29.78 |
| Emamactin Benzoate | 174.33 | 39.67 e | 34.67e | 29.67e | 34.67 |
| Lufeneuron | 174.00 | 45.67 d | 41.00d | 35.33d | 40.67 |
| Mahogani oil | 175.67 | 51.00 c | 45.33c | 40.67c | 45.67 |
| Karanja oil | 175.00 | 55.67 b | 51.00b | 45.67b | 50.78 |
| Control | 174.00 | 116.33a | 96.33a | 85.00a | 99.22 |
| P-Value | 0.9091 | 0.00 | 0.00 | 0.00 | - |
| Level of significant | NS | * | * | * | - |
| CV (%) | 1.51 | 2.03 | 2.68 | 2.36 | - |
| | | Number of aphids/flower | | | |
| Abamectin | 177.67 | 19.00 h | 14.33h | 9.00 h | 14.11 |
| Spinosad | 178.33 | 25.33 g | 20.33g | 15.33g | 20.33 |
| Neem oil | 177.00 | 30.67 f | 25.00 f | 20.67 f | 25.45 |
| Emamactin Benzoate | 178.33 | 34.33ed | 30.33e | 25.33e | 29.10 |
| Lufeneuron | 178.00 | 39.67 d | 35.33d | 30.67d | 35.23 |
| Mahogani oil | 179.67 | 45.33 c | 40.00c | 34.67c | 39.99 |
| Karanja oil | 179.00 | 50.00 b | 44.67b | 39.67b | 44.78 |
| Control | 178.00 | 114.00a | 95.00a | 84.67a | 97.89 |
| P-Value | 0.91 | 0.00 | 0.00 | 0.00 | - |
| Level of significant | NS | * | * | * | - |
| CV (%) | 1.52 | 2.55 | 2.05 | 2.78 | - |
| | | Number of aphids/pod | | | |
| Abamectin | 175.67 | 9.67 h | 5.67 g | 3.67g | 6.34 |
| Spinosad | 174.33 | 14.33 g | 10.33 f | 8.33f | 10.10 |
| Neem oil | 175.33 | 18.33 f | 14.33 e | 12.33e | 14.10 |
| Emamactin Benzoate | 174.34 | 21.00 e | 14.67 e | 13.33e | 16.33 |
| Lufeneuron | 175.50 | 25.00d | 21.00 d | 15.33d | 20.44 |
| Mahogani oil | 175.37 | 30.00 c | 25.00 c | 20.33 c | 25.11 |
| Karanja oil | 174.00 | 45.00b | 29.00b | 25.33b | 33.11 |
| Control | 174.57 | 120.00a | 95.00a | 83.00a | 99.33 |
| P-Value | 0.91 | 0.00 | 0.00 | 0.00 | - |
| Level of significant | NS | * | * | * | - |
| CV (%) | 1.503 | 2.96 | 2.89 | 4.46 | - |

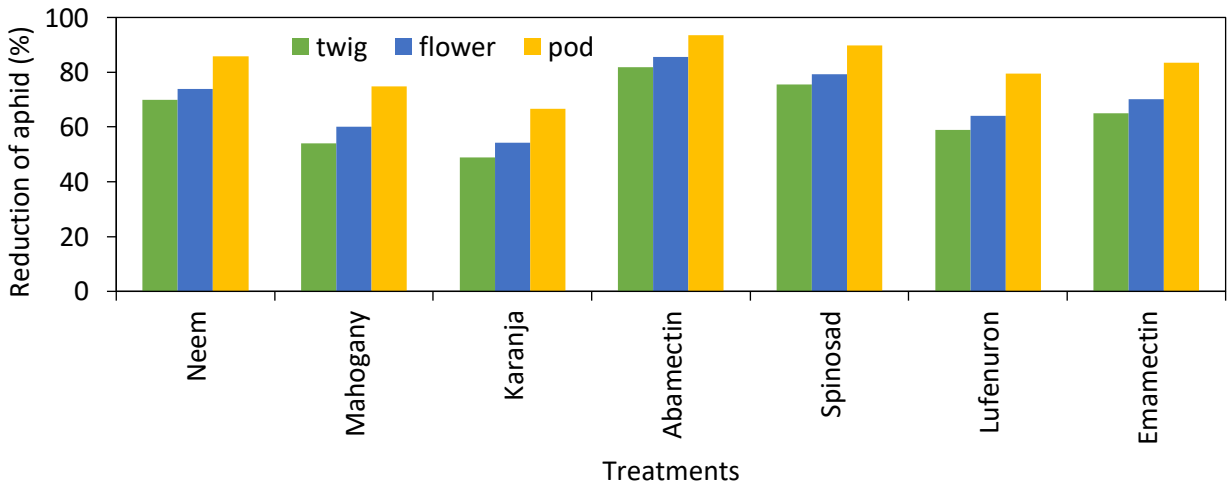


Figure 3. Reduction (%) of aphid infestation on twig, flower and pod over control after 2nd spray

### Aphid infestation in bean plants after 3rd spray

The number of aphids/twig, aphids/flower and aphids/pod under treated biorational insecticides were counted at different time intervals. From the results it was observed that aphid population on twig, flower and pod varied significantly ($p \leq 0.05$) after 3rdspraying of biorational insecticides. The lowest number of aphids/twig (5.00) was found in Abamectin treated plants followed by Spinosad (12.33) and Neem oil (18.33). The highest mean number of aphids/twig (114.00) was found on control plants at 3 DAS (Table 4). At 5 DAS, the lowest number of aphids/twig was observed in Abamectin (2.00) followed by Spinosad (8.00), Neem oil (12.00) and Emamectin benzoate (16.00) and the highest mean number of aphids/twig (96.00) was noticed on control plants (Table 4). Similarly, at 7 DAS, the lowest mean number of aphids/twig (00.67) was explored in Abamectin followed by Spinosad (5.00), Neem oil (8.33) and Emamectin benzoate (12.33) and the highest mean number of aphids/twig (82.66) was in control plants. After 3rd spray, the lowest number of aphids/flower (10.33) was observed in Abamectin treated plants followed by Spinosad (15.33) and Neem oil (20.33). The highest mean number of aphids/flower (111.00) was found on control plants at 3 DAS (Table 4). The lowest number of aphids/flower was observed in Abamectin (5.33) followed by Spinosad (11.00), Neem oil (15.33) and Emamectin benzoate (21.00) and the highest mean number of aphids/flower (83.00) was noticed on control plants at 5 DAS (Table 4). At 7 DAS, the lowest mean number of aphids/flower (3.33) was explored in Abamectin followed by Spinosad (5.67), Neem oil (11.00) and Emamectin benzoate (15.33) and the highest mean number of aphids/flower (74.00) was in control plants. The lowest mean number of aphids/pod (3.67) was observed in Abamectin treated plants followed by Spinosad (7.67) and Neem oil (10.33). The highest mean number of aphids/pod (102.00) was found on control plants at 3 DAS (Table 4). The lowest number of aphids/pod was observed in Abamectin (1.67) followed by Spinosad (5.00), Neem oil (8.33) and Emamectin benzoate (7.00) and the highest mean number of aphids/twig (82.00) was noticed on control plants at 5 DAS (Table 4). At 7 DAS, the lowest mean number of aphids/pod (0.67) was explored in Abamectin followed by Spinosad (3.33), Neem oil (5.33) and Emamectin benzoate (5.00) and the highest mean number of aphids/pod (71.00) was in control plants. The results revealed that Abamectin had the highest efficacy in managing bean aphid. Lufenuron, Karanja oil, and Mahogany oil had moderate effect on aphid (Table 4). Percentage infestation reduction of aphid on twig, flower and pod over control after third spray was presented in Fig. 4. The highest reduction (97.38%) was in Abamectin treated twigs followed by Spinosad (91.35%), Neem oil (86.79%), Emamectin benzoate (82.69%) and Lufenuron (80.42%), and the lowest percentage reduction was in Karanja oil (70.61 %) followed by Mahogany oil (75.51%) treated plants (Fig. 4). The highest reduction (92.91%) of aphid in flower over control was in Abamectin treated plants followed by Spinosad (88.05%), Neem oil (82.58%), Emamectin benzoate (76.98%) and Lufenuron (76.38%), and the lowest percentage reduction was in Karanja oil (66.54 %) followed by Mahogany oil (71.39 %) treated plants. In case of percentage infestation reduction of aphid in pod over control it was presented in Fig. 4. The highest reduction (97.66%) of aphid in pod over control was in Abamectin treated plants followed by Spinosad (93.75%), Neem oil (71.68%), Emamectin benzoate (91.07%) and Lufenuron (89.45%), and the lowest percentage reduction was in Karanja oil (85.15%) followed by Mahogany oil (87.23 %) treated plants (Fig. 4).

From the present findings of comparative efficacy of different biorational insecticides on the aphid infestation it was observed that aphid infestation changed significantly on the twig, flower and pod at different sprays and time intervals. The mean percentage of reduction of aphid population was also significantly different among the treatments after spraying on aphid infested plants compared to control plants. The highest percentage of reduction of aphid over control was found in Abamectin treated plants. In case of twig, a remarkable reduction 74.14%, 81.9%, 97.38% was observed on the plants treated with Abamectin from 1st, 2nd and 3rd spray, respectively. Similar results were found by Sun *et al.* (2013) who used 1.8% Abamectin, 25% Imidacloprid, 2.5% Lamda-cyhalothrin powder, 25% Pymetrozine, 5% Pyrethrin, 1% Matrina water and reported that from Abamectin about 98.90% protection was found against aphid. Saad *et al.* (2007) also revealed that Abamectin, Azadirachtin and the Detergent provided better performance against aphid, *A. craccivora,* whitefly and spider mite. Sujay *et al*. (2012) also observed the effectiveness of Abamectin in aphids, thrips and mites, by using Abamectin 1.8EC @ 0.5ml/l, Thiamethoxam 25WG @ 1g/l, Diafenthiuron 50WP @ 0.75g/l. In the present study the biorational insecticides Abamectin, Spinosad, Neem oil and Emamectin benzoate were found promising to reduce the aphid infestation in the field.

In case of percentage reduction of aphid in flowers over control was found 79.02%, 85.59%, 92.91% was in Abamectin treated plants after 1st, 2nd and 3rd spray, respectively. The highest reduction was always observed in Abamectin followed by Spinosad 73.95%, 79.23 %, 88.05 % after 1st, 2nd and 3rd spray, respectively.

Table 4. Efficacy of biorational insecticides on the incidence of bean aphid at 3rd spray

| Treatments | Before spray | After spray | | | |
|---|---|---|---|---|---|
| | | 3 DAS | 5 DAS | 7 DAS | Cumulative mean |
| | | | Number of aphids/twig | | |
| Abamectin | 180.67 | 5.00 h | 2.00 h | 0.667 h | 2.555 |
| Spinosad | 179.33 | 12.33 g | 8.00 g | 5.00 g | 8.44 |
| Neem oil | 179.33 | 18.33 f | 12.00f | 8.33 f | 12.89 |
| Emamactin Benzoate | 180.34 | 22.33 e | 16.00 e | 12.33 e | 16.89 |
| Lufeneuron | 179.50 | 24.33 d | 20.33d | 15.33d | 19.10 |
| Mahogani oil | 180.37 | 29.33 c | 24.33 c | 18.00 c | 23.89 |
| Karanja oil | 179.00 | 35.33 b | 28.33b | 22.33 b | 28.67 |
| Control | 179.57 | 114.00 a | 96.00 a | 82.67 a | 97.56 |
| P-Value | 0.93 | 0.00 | 0.003 | 0.00 | - |
| Level of significant | NS | * | * | * | - |
| CV (%) | 1.50 | 2.62 | 3.43 | 4.93 | - |
| | | | Number of aphids/flower | | |
| Abamectin | 176.67 | 10.33 h | 5.33 g | 3.33 g | 6.33 |
| Spinosad | 175.33 | 15.33 g | 11.00 f | 5.67f | 10.67 |
| Neem oil | 175.33 | 20.33 f | 15.33 e | 11.00e | 15.55 |
| Emamactin Benzoate | 174.34 | 25.33 e | 21.00d | 15.33d | 20.55 |
| Lufeneuron | 176.50 | 27.33 d | 22.00d | 16.67d | 21.10 |
| Mahogani oil | 175.37 | 30.33 c | 25.33 c | 21.00c | 25.56 |
| Karanja oil | 175.00 | 34.67 b | 30.33 b | 24.67b | 29.89 |
| Control | 176.57 | 111.00 a | 83.00a | 74.00a | 89.33 |
| P-Value | 0.92 | 0.00 | 0.00 | 0.00 | - |
| Level of significant | NS | * | * | * | - |
| CV (%) | 1.503 | 1.80 | 3.52 | 6.10 | - |
| | | | Number of aphids/pod | | |
| Abamectin | 174.67 | 3.67 e | 1.67 g | 0.67 f | 2.00 |
| Spinosad | 174.33 | 7.67 d | 5.00 f | 3.33 e | 5.33 |
| Neem oil | 175.33 | 10.33 c | 8 .33de | 5.33d | 7.10 |
| Emamactin Benzoate | 174.34 | 11.00 c | 7.00 e | 5.00 d | 7.67 |
| Lufeneuron | 175.50 | 12.00 c | 9.00 cd | 6.00 d | 9.00 |
| Mahogani oil | 175.37 | 14.33 b | 10.33 bc | 8.00 c | 10.89 |
| Karanja oil | 174.00 | 15.67 b | 12.00 b | 10.33 b | 12.67 |
| Control | 174.57 | 102.33 a | 82.00 a | 71.67 a | 85.33 |
| P-Value | 0.93 | 0.00 | 0.00 | 0.00 | - |
| Level of significant | NS | * | * | * | - |
| CV (%) | 1.503 | 5.27 | 6.00 | 6.05 | - |

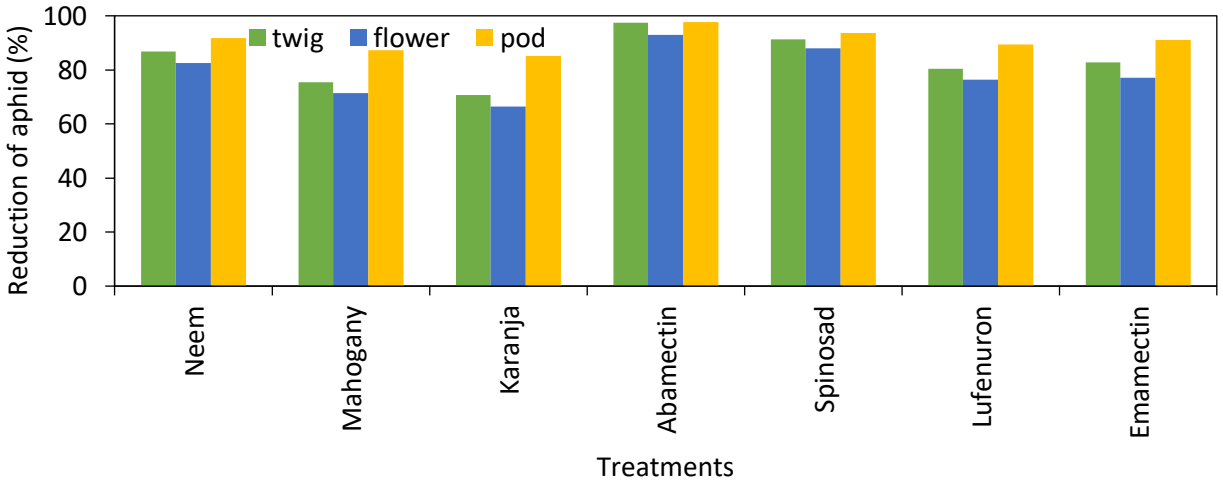


Figure 4. Reduction (%) of aphid infestation on twig, flower and pod over control after 3rd spray

This finding is similar to the findings of Wagh *et al.* (2017) who reported the treatment with Abamectin 1.9 EC @ 3 g a.i./ha and Spinosad 45SC @ 125 g a.i./ha, were found effective for controlling aphids, thrips, and whiteflies on tomato plants. Similar result of effectiveness of these insecticides against these pests was obtained earlier by Premachandra *et al.* (2005), Prabhatkumar and Poehling (2007) and Najir (2008). All these findings were similar

with the results of the present study where it was clearly observed that Abamectin had significant efficacy against bean aphid. In reduction of percent flower infestation, Neem oil had superiority. Indira Gandhi *et al*. (2006) tested the performance of Neem oil as seed treatment in comparison with Imidacloprid against aphid and jassid on okra crop and found excellent protection by Neem oil from both the sucking pests up to 45 days after treatment. This finding was also similar with present study where mean percentage reduction was 74.00%, 69.22%, and 82.58% after 1st, 2nd and 3rd spray, respectively in Neem oil treated plants.

Similar to the twig and flower the highest mean percentage reduction of aphid was detected from Abamectin and Spinosad, in case of pod infestation. The mean percent reduction of pod infestation was 86.97%, 93.63%, 97.66% after 1st, 2nd and 3rd spray, respectively in Abamectin treated plants. Royer and Edelson (1987) confirmed the activity of Abamectin on aphid in a cotton field. This study showed better suppression of aphid, *Aphis gossypii at* 7 days after treatment with Abamectin appliedat 0.01 and 0.02 Ib a.i./acre. The superiority of Abamectin 1.8 EC, Thiamethoxam 25WG, Diafenthiuron 50 WP and in management of sucking pest's *viz*., aphids, thrips and mites are in agreement with the findings of Nandini *et al.* (2012) and Mandal (2012). In the present study Emamectin benzoate also showed significant efficacy against bean aphid management. The mean percent reduction of pod infestation was 70.58 %, 85.80%, 91.68% after 1st, 2nd and 3rd spray, respectively in Emamectin benzoate treated plants. This finding was almost similar with the report made by Kalawate and Dethe (2012) where they found that Emamectin benzoate at 6.25 g a.i./ha was highly effective in controlling aphids on brinjal.

### *Effect of biorational insecticides on the yield of bean*

In this study the effects of biorational insecticides on the yield of bean plant was evaluated and shown in (Table 5). There were significant differences on the yield of bean among the treatments. The highest yield (1.41 kg/plot) was recorded in Abamectin treated plants and the lowest yield (0.3690 kg/plot) was recorded in control plants. Although yield of Mahogany (0.68 kg/plot) and Karanja (0.72 kg/plot) treated plants were not statistically significant, but higher yield was recorded from the plants treated with Neem, Spinosad, Emamectin benzoate and Lufenuron. The total yield of plant was 1.30 kg, 1.22 kg, 0.98 kg, 0.80 kg and 0.37 kg per plots in Spinosad, Neem oil, Emamectin benzoate, Lufenuron treated and untreated control plants, respectively. The amount of yield in all treated plants was increased over control plants (Table 5). Wagh *et al*. (2017) reported that Spinosad 45 SC @ 125 g a.i/ha emerged as most effective treatment to reduce the aphid (2.09-3.07), per three leaves/plant and it gave the highest marketable yield of tomato (45.47 t/ha), followed by Abamectin 1.9 EC @ 3 g a.i./ha and Chlorantraniliprole 18.5 SC @ 30 g a.i./ha. Spraying of Abamectin registered the highest yield (26.25 t/ha) and remained statistically at par with Spinosad (24.60 t/ha). However, Abamectin registered mean incremental cost benefit ratio (ICBR) of 1:0.78, which is the least among all the treatments because of its high cost. The highest ICBR of 1:23.71 was obtained in sole application of Endosulfan, followed by Cypermethrin (1:21.03) and NSKE (1:20.30) (Ramesh and Ukey, 2005). Previous studies are in accordance with the present findings, where Abamectin and Spinosad treated plants provided the higher podyield. Among the botanicals Neem oil showed a significant reduction of aphid population and consequently gave better yield (1.22 kg/plot) than those of two botanicals used. These findings are closely related with results of Das *et al.* (2008) where they showed aphidicidal activity of hot and cold water extracts of some indigenous plants, *Azadirachta indica* A. Juss (Neem), *Calotropis procera* (Aiton) W.T. Aiton (akanda), *Polygonum hydropiper* L. (Biskatali) and *Ipomoea sepiaria* J. Koenig ex Roxb (bankalmi), were tested against the bean aphid, *Aphis craccivora* Koch and the highest yield (3.25 kg/plant) was obtained.

Table 5. Yield of bean for application of biorational insecticides

| Treatments | Yield/plot (kg) | Yield (ton/ha) |
|---|---|---|
| Abamectin | 1.41 a | 12.68 a |
| Spinosad | 1.30 b | 11.66 b |
| Neem oil | 1.22 c | 10.94 c |
| Emamectin Benzoate | 0.98 d | 8.76 d |
| Lufeneuron | 0.80 e | 7.21 e |
| Mahogany oil | 0.68 f | 6.10 f |
| Karanja oil | 0.72 f | 6.46 f |
| Control | 0.37 g | 3.31 g |
| LSD0.05 | 0.0422 | 0.38 |
| P-Value | 0.00 | 0.00 |
| Level of Significant | * | * |
| CV (%) | 2.57 | 2.6 |

Means followed by different letters in a column are significantly ($p \leq 0.05$) different

## Conclusion

Damage of the plants started from early growing stage but at 100 DAS it reached to the peak. On the aphid population reduction Abamectin clearly showed the best performance which was followed by Spinosad. On the percentage reduction of crop damage and increase of pod yield Abamectin was found to be effective followed by Spinosad. Therefore, these two biorationals might be used for the successful management of bean aphid in the field.

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## Conflict of Interests

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

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