Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2021; 9(4): 48-53

Received: 19-05-2021
Accepted: 21-06-2021

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Efficacy of plant derived and synthetic insecticides against mustard aphid for quality seed production

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Abstract
The study was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the 2017-2018 using BARI Sarisha-15 to evaluate the effectiveness of some promising bio-pesticides on aphid population abundance in field condition. Among the treatments, Spinosad 45EC performed as the most effective insecticide in reducing the highest percent of aphid population on leaves (60.00%) whereas Detergent showed the least performance (39.54%). In inflorescence, Spinosad 45EC performed as the most effective bio-insecticide in reducing the highest percent of aphid population (68.06%) whereas detergent showed the least performance (53.57%). The maximum quality seed of BARI Sarisha-15 obtained from treatment Spinosad 45EC (1.62 mt ha^{-1}) due to lower aphid abundance. On the other hand, lower quality yield performance obtained from the T_7 treatment due to an untreated control (1.29 mt ha^{-1}). After harvesting of seed, height germination (95.33%) was found in T_4 (Spinosad 45EC), on the other hand lowest germination (77.67%) was found in T_7 (Control plot).

Keywords: bio-pesticide, ecofriendly, quality seed, mustard aphid

Introduction
Mustard locally known as sharisha is a popular and most common oil seed crop in Bangladesh and in other tropical and sub-tropical parts of the world. It is also known as rapeseed and belongs to the family Cruciferae. Though mustard is produced mainly in the rabi season. It occupies an area of 91188 acre with an annual production of 66060 metric ton (BBS, 2017) [4]. Mustard is a popular nutritious oil seed crop. Mustard aphid is the major constraint responsible for low yield as well as low quality seed, which is considered as key factor in reducing mustard production and sometime it is so severe that may cause yield loss up to 90% (Gupta *et al*., 2003) [7]. Mustard plant is attacked by a number of insect pests (Bakhetia, 1983) [3]. Found more than three dozens of insect pests, associated with various phonological stages of these crops. Among them *Lipaphis erysimi*, commonly known as mustard aphid is most destructive in Bangladesh (Ahmed *et al.* 1977) [1]. It belongs to the family Aphididae of the order Homoptera. The insect is distributed to many other countries of the world. The attack is severe in those regions where the numbers of cloudy days are more during the pest activity period. Farmers used to apply different type of chemicals with repeated frequency in high dose and sometimes even banned chemicals. The use of chemicals for pest control leads to such problems as environmental pollution, development of resistance to insecticides, harmful effects on non-target organisms including pollinators, pest resurgence, upsetting the balance of nature and threat to the health of man. Twenty aphid species have gained resistance to insecticides (Minks and Harrewijn, 1988) [10]. Realization of negative consequences of chemical pesticides and the growing consensuses in regard of health and environment, viable and sustainable alternatives other than chemical method of pest control is in search. In this search, microbial approaches with antagonistic entomopathogenic fungi and botanicals pesticides (NORP, 1989/90) [12] have been included as the best alternatives. Neem based insecticides are non-phytotoxic, have good shelf life and also are used against many insects. Information on the seasonal prevalence of insect pests, particularly mustard aphid in relation to weather factors is scanty (Bishoni *et al*., 1992) [5]. Good seed good crop. As mustard aphid is major constraints for quality seed production as a result it is reduced the yield of mustard. We can manage the mustard aphid by using different types of bio-pesticide and limited no of

insecticides and by taking some mechanical control measure in eco-friendly manner.

Materials and Methods

The experiment was conducted in the central farm of Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from November 2017 to February 2018 to explore the efficiency of bio insecticides on the reduction of infestation level of mustard aphids for quality seed production. The mustard variety BARI-15 was cultivated in the designed field.

Design of the experiment and layout

The experiment was laid out in a Randomized Complete Block Design with four replications. The total numbers of plots were 28 for 7 treatments, each measuring 2 m3 m (6 m^2). The adjacent block and neighboring plots were separated by 1.0 m and 0.5 m, respectively.

Treatments

Five bio insecticides, field sanitation and control were evaluated in this study against mustard aphid. The group wise insecticides with their specific dose applied as treatment are given below.

The group wise insecticides with their specific dose applied as treatment are given below.

Treatments	Insecticides	Dose	Application interval
T_1	Spraying Neem Oil	3.0 ml/L of water	7 days interval.
T_2	Bioneemplus 1EC	1.0 ml/L of water	10 days interval
T_3	Neem seed kernel extract	50 g/L of water	7 days interval
T_4	Spinosad 45EC	0.4 ml/L of water	10 days interval.
T_5	Detergent	10 g/L of water	7 days interval
T_6	Field sanitation	Regular cleaning of the plot	
T_7	Control		

Statistical analysis

All the collected data were analyzed following the analysis of variance (ANOVA) technique using MSTAT-C package and the mean difference were adjusted by LSD technique.

Results and Discussion

The results on different parameters of the study have been interpreted and discussed under the following sub-headings:

Plant height (cm)

Plant height is an important character of a plant, which is closely related proper growth and development of a plant and finally produced higher yield. Plant height of mustard varied significantly at 40, 55 and 70 days after sowing (DAS) due to different treatment. At 70 DAS, the longest (92.33 cm) plant was produced from T_4 (Spinosad 45EC @ 0.4 ml/L) treatment and the shortest (80 cm) was found from T_7 (control) treatment (Table 1). The increase in height may be due to the influence of Spinosad 45EC. The present result also agrees well with (Mondal and Wahab, 2009) [11], who obtained the highest plant height (46.7 cm) with bio pesticides (Table 1).

Number of leaves plant^{-1}

Number of leaves per plant is an important parameter of crop plant because of its physiological role in photosynthetic activities. Number of leaves is directly related to the mustard yield. Number of leaves per plant of mustard varied significantly at 40, 55 and 70 days after sowing (DAS) due to different treatment. At 90 DAS, the highest number of leaves (25.83) per plant was obtained from T_4 (Spinosad 45EC @ 0.4 ml/L) treatment and the lowest (17.80) from (control) T_7treatment (Table 2).The result obtained from the present supported by Vekaria and Patel, (2005) [15] in respect of number of leaves per plant.

Table 1: Effect of treatments on plant height at different days after sowing of mustard.

Treatments	Plant height at(cm)		
	40 DAS	55 DAS	70 DAS
T_1	29.33 ab	56.33 bcd	85.67 ab
T_2	29.00 ab	61.00 ab	86.67 ab
T_3	28.70 ab	58.00 bc	85.33 ab
T_4	32.90 a	65.09 a	92.33 a
T_5	28.00 bc	50.33 de	84.67 b
T_6	24.00 c	54.00 cd	81.33 b
T_7	27.00 bc	45.33 e	80.00 b
LSD (0.05)	4.68	6.49	7.47
CV (%)	5.77	4.08	3.07

Table 2: Effect of treatments on number of leaves per plant at different days after sowing of mustard.

Treatments	No. of leaves per plant at		
	40 DAS	55 DAS	70 DAS
T_1	8.33 c	21.83 ab	23.50 ab
T_2	9.40 b	21.53 b	23.03 b
T_3	8.43 bc	19.77 bc	21.77 bc
T_4	10.47 a	23.83 a	25.83 a
T_5	8.03 c	18.57 cd	20.00 cd
T_6	8.20 c	19.80 bc	21.80 bc
T_7	6.57 d	16.83 d	17.80 d
LSD (0.05)	1.05	2.06	2.34
CV (%)	4.33	3.56	3.74

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability.
DBS =Day before spraying, DAS =Day after spraying

Number of branch plant^{-1}

Number of branches plant^{-1}in mustard showed significant difference where the number of branches (9.20) was found in T_4 (Spinosad 45EC @ 0.4 ml/L) followed by T_2 (8.13) and T_1 (8.07). Minimum number of branch plant^{-1}was recorded 6.00 in T_7 (Control) (Table 3) (Martin, 1983) [8] found highest 12.28 branches mustard. Alam *et al*., (1964) [2] reported that no. of branches increased with increasing rate of bio pesticide.

Number of silique plant^{-1}

Silique number plant^{-1}was observed maximum in T_4 (Spinosad 45EC @ 0.4 ml/L of water) i.e. 82.33 closely followed by T_2 (77.33) and minimum number of silique plant^{-1}was found 54.33 in T_7 (Control) (Table 3). The number of silique from this experiment was supported by Bakhetia (1983) [3] in respect of bio pesticide application.

Length of silique

Height length of silique was found 8.53 in T_4 (Spinosad 45EC @ 0.4 ml/L) which is closely followed by T_2 (7.73) and lowest number of silique per plant was found 5.60 in T_7 (Control) (Table 3). The length of silique from this experiment was supported by Dixon and Wellings (1982) [6] in respect of bio pesticide application.

Total number of seed silique^{-1}

Maximum number of seed silique^{-1}was found 22.67 in T_4 (Spinosad 45EC @ 0.4 ml/L) which is closely followed by T_2 (19.67) and minimum number of seed silique^{-1}was found 14.43 in T_7 (Control) (Table 3). The number of seedsilique^{-1}from this experiment was supported by [12] in respect of bio pesticide application.

Table 3: Effect of treatments on number of branches plant^{-1}, number of silique plant^{-1}, length of silique and total number of seed silique^{-1} of mustard

Treatment	Number of branches plant^{-1}	Number of silique plant^{-1}	Length of silique	Total number of seed silique^{-1}.
T_1	8.07 b	73.67 bc	7.40 b	18.40 b
T_2	8.13 b	77.33 ab	7.73 ab	19.67 ab
T_3	7.50 bc	71.10 bc	7.13 bc	18.67 b
T_4	9.20 a	82.33 a	8.53 a	22.67 a
T_5	7.20 c	70.67 bc	7.20 bc	18.00 bc
T_6	7.00 c	67.67 c	6.53 c	17.20 bc
T_7	6.00 d	54.33 d	5.60 d	14.43 c
LSD (0.05)	0.72	8.21	0.84	3.63
CV %	3.33	4.05	4.15	6.89

1000 seeds weight

There is no significant difference found in 1000 seed weight though higher 1000 seeds weight 3.52 found in T_6 (Field sanitation) and lower 1000 seeds weight 3.30 found in T_2 (Bioneemplus 1EC @ 1.0 ml/L) (Table 4).

Seed yield plot^{-1}

Yield is the ultimate economic product of the crop, which is determined mainly by seed weight, number of seeds, silique plant^{-1}. It was observed different levels of bio pesticide application significantly effect on the seed yield per plant of mustard (Table 4). Highest seed yield per plot was revealed 264.33 Kg in T_4 (Spinosad 45EC @ 0.4 ml/L) and lowest seed yield per plot was found 289.67 Kg in T_7 (Control) (Table 4). Saha *et al*., [14] reported that plant height, no. of branches per plant and seed yield increased due to application of different bio pesticide.

Table 4: Effect of treatment on 1000 seeds weight, seed yield plot^{-1}, seed yield ton ha^{-1} and germination of mustard.

Treatment	1000 seeds weight(gm)	Seed yield Plot^{-1} (kg)	Seed yield ton ha^{-1}	Germination %
T_1	3.50	324.33 c	1.44 c	85.67 bc
T_2	3.30	344.33 b	1.53 b	89.67 b
T_3	3.43	312.33 c	1.39 c	84.00 c
T_4	3.40	364.33 a	1.62 a	95.33 a
T_5	3.40	311.67 c	1.40 c	83.00 c
T_6	3.52	313.33 c	1.41 c	83.00 c
T_7	3.37	289.67 d	1.29 d	77.67 d
LSD (0.05)	0.08	15.67	0.06	5.06
CV %	3.15	1.70	1.66	2.07

Table 5: Effect of treatments on shoot length, root length and seedling length of mustard.

Treatment	Shoot length (cm)	Root length(cm)	Seedling length (cm)
T_1	6.03 b	6.87 ab	14.50 b
T_2	6.17 b	7.10 a	14.77 ab
T_3	5.90 b	6.43 bc	14.33 bc
T_4	6.77 a	7.33 a	15.50 a
T_5	5.80 bc	6.03 cd	13.53 cd
T_6	6.07 b	5.80 d	12.67 d
T_7	5.33 c	5.25 e	11.43 e
LSD (0.05)	0.49	0.53	0.96
CV %	2.91	2.93	2.43

Seed yield ton hectare^{-1}

Seed yield ton hectare $^{-1}$was showed statistically significant variation due to different treatment application (Table 4). The maximum seed yield ton per hectare (1.62) was found in T_4 (Spinosad 45EC @ 0.4 ml/L). On the other hand, the minimum seed yield ton hectare $^{-1}$(1.29) was found in T_7 (control) treatment. Rohilla *et al*., (2004) [13] found that high interval of bio pesticide application significantly reduced seed yield. Application of bio pesticide in low interval produced significantly higher seed yield.

Germination %

Different treatment application significantly influenced the germination of harvested mustard (Table 4). The highest (95.33%) germination was found from T_4 (Spinosad 45EC @ 0.4 ml/L) treatment. The lowest (77.67%) germination from was observed in T_7 (control) treatment. Rohilla *et al*., (2004) [13] also experienced the similar result due to application of bio-pesticide.

Shoot length (cm)

A significant variation was found in shoot length of mustard due to application of bio insectiside (Table 5). The highest (6.77 cm) shoot length of mustard was found from T_4 (Spinosad 45EC @ 0.4 ml/L) treatment. The lowest (5.33 cm) shoot length of mustard was observed in T_7(control) treatment. Mathur and Upadhyay (2000) [9] who reported that application of spinosad significantly increased the shoot and root length of mustard.

Root length (cm)

Different levels of treatment significantly influenced the root length of mustard (Table 5). The highest (7.33 cm) root length of mustard was found from T_4 (Spinosad 45EC @ 0.4 ml/L) treatment. The lowest (5.25 cm) root length of mustard was found from T_7 (control) treatment. Mathur and Upadhyay (2000) [9] who reported that application of spinosad significantly increased the shoot and root length of mustard.

Seedling length (cm)

A significant variation was found in seedling length (cm) of mustard due to application of different treatments (Table 5). The maximum (15.50 cm) seedling length of mustard was found from T_4 (Spinosad 45EC @ 0.4 ml/L) treatment. The minimum (11.43 cm) root length of mustard was found from T_7 (control) treatment. Mathur and Upadhyay (2000) [9] who reported that application of Spinosad significantly increased the shoot and root length of mustard.

Effect of bio-rational on the incidence of aphid population on leaves

The number of aphid population was observed before spraying insecticide. The highest population was recorded in T_7 (113.3 aphid leaves^{-1}) followed by T_1 (98.33 aphid leaves^{-1}) and the lowest aphid population was recorded in T_4 (71.67 aphid leaves^{-1}) preceding T_5 (78.33 aphid leaves^{-1}). Statistically significant variations were observed among the results of .The highest aphid population (178.33 aphid leaves^{-1}) was recorded in untreated control plot T_7, which was statistically different to that of T_3 (48.33 aphid leaves^{-1}) i.e., spraying of Neem seed kernel extract @ 50 g/L of water at 7 days interval and T_1 (43.33 aphid leaves^{-1}) treated plot (Table 6). On the other hand, the lowest aphid population (33.33 aphid leaves^{-1}) was recorded in T_2 i.e., spraying of Bio neemplus1EC @ 1.0 ml/L of water at 10 days interval followed by T_4 (43.33 aphid leaves^{-1}) i.e., spraying of Spinosad 45EC @ 0.4 ml/L of water at 10 days interval. followed by T_5 (38.33) comprising of Spraying of Detergent @ 10 g/L of water at 7 days interval. In case 4 days after spraying (DAS), the highest aphid population (225.00 aphid leaves^{-1}) was also recorded in control plot T_4 which was statistically different from all other treatments. It was followed by T_5 (60.00 aphid leaves^{-1}) and T_3& T_2 (48.33 aphid leaves^{-1}). On the other hand, the lowest aphid population (38.33 aphid leaves^{-1}) was also recorded in T_4 followed by T_6 (45.67 aphid leaves^{-1}) and T_1 (46.67 aphid leaves^{-1}) treated plots. In case of 7 days after spraying (DAS), the Highest aphid population of aphid leaves^{-1}) was recorded control plot followed by T_7 (380.00 aphid leaves^{-1}) and T5 (68.33 aphid leaves^{-1}) which is statistically different. On the other hand, the lowest aphid population (50.00 aphid leaves^{-1}) was recorded in T_4 followed by T_1 (52.00 aphid leaves^{-1}) and T_6 (56.00 aphid

Table 6: Effect of treatments on number of aphids on leaves plant^{-1} before and after spray

Treatments	Number of aphids				Aphid reduction over control (%)
	DBS	1 DAS	4 DAS	7 DAS	
T_1	71.67 c	33.33 c	38.33 c	50.00 b	32.76
T_2	93.33 bc	42.33 bc	48.33 bc	68.33 b	42.69
T_3	97.67ab	42.33 bc	45.67 bc	56.00 b	27.54
T_4	98.33 ab	43.33 bc	46.67 bc	52.00 b	47.11
T_5	88.33 bc	38.33 bc	60.00 b	68.33 b	27.08
T_6	80.00 bc	48.33 b	48.33 bc	58.33 b	26.78
T_7	113.3 a	178.3 a	225.0 a	380.0 a	----
LSD(0.05)	22.45	13.39	20.25	21.53	----
CV (%)	14.27	11.47	14.73	10.6	----

Effect of treatments on the abundance of aphid inflorescence plant^{-1}

Significant variations were observed among different bio-insecticidal treatments in terms of inflorescence infestation due to aphid infestation on mustard (Table 7). Statistically significant variation was observed among the results of different treatment application in terms of total infestation at different days after spraying during the management of mustard. In case of 1 days after spraying (DAS), the highest number of infestation (266.7 aphid inflorescence^{-1}) was recorded in T_7 composed which was statistically different from all other treatment followed by T_5 (48.33 aphid inflorescence^{-1}) spraying of Detergent @ 10 g/L of water at 7 days interval and T6 (43.33 aphid inflorescence^{-1}) treated plot (Table 7). On the other hand, the lowest number of infestation (38.33 aphid inflorescence^{-1}) was recorded in T_4 comprised of spraying of Spinosad 45EC @ 0.4 ml/L of water at 10 days interval followed by T_2 (40.33 aphid inflorescence^{-1})

comprised of spraying of Bioneemplus 1EC @ 1.0 ml/L of water at 10 days interval. In case 4 days after spraying (DAS), the highest infestation (340.00 aphid inflorescence^{-1}) was recorded in T_7 which was statistically different from all other treatment. This was followed by T_1 (58.33 aphid inflorescence^{-1}) and T_5 (55.00 aphid inflorescence^{-1}) treated plot. On the other hand, the lowest number of infestation T_4 (43.33 aphid inflorescence^{-1}) was recorded in treated control plot followed by T_2 (44.33 aphid/inflorescence). In case of 7 days after spraying (DAS), more or less similar trends were observed among different treatment application in terms of number aphid inflorescence^{-1} (Table 7). The highest number of infestation (400.0) was recorded in T_7 which was statistically different from all other treatment followed by T1 (70.00) and T_5 (65.00). On the other hand, the lowest aphid population (58.33) was recorded T_4 in control plot followed by T_2 (58.33) and T_3 (60.00).

Table 7: Effect of treatments on number of aphids on inflorescence plant^{-1} before and after spray

Treatments	Number of aphids				Aphid reduction over control (%)
	DBS	1 DAS	4 DAS	7 DAS	
T_1	105.0 b	43.33 b	58.33 b	70.00 b	41.91
T_2	118.0 b	40.33 b	44.33 b	58.33 b	50.56
T_3	103.3 b	43.33 b	45.00 b	60.00 b	41.80
T_4	120.0 b	43.33 b	48.33 b	58.33 b	51.39
T_5	111.7 b	48.33 b	55.00 b	65.00 b	37.5
T_6	93.33 b	38.33 b	43.33 b	58.33 b	33.33
T_7	206.7 a	266.7 a	340.0 a	400.0 a	---
LSD(0.05)	46.56	22.38	25.35	12.5	---
CV (%)	20.74	15.27	14.17	5.79	---

Table 8: Effect of treatments on number of aphids on stem plant^{-1} before and after spray

Treatments	Number of aphids				Aphid reduction over control (%)
	DBS	1 DAS	4 DAS	7 DAS	
T_1	98.33 bc	40.00 b	52.00 b	68.67 ab	33.79
T_2	100.7 b	42.67 b	51.67 b	66.67 a	33.79
T_3	103.3 c	43.33 b	58.33 b	65 bc	31.38
T_4	93.33 a	36.67 b	45.33 b	65 a	39.35
T_5	118.3 c	50.00 b	70.00 b	71.67 cd	30.42
T_6	111.7 c	41.67 b	65.00 b	76.67 d	30.16
T_7	121.7 d	216.70 a	325.0 a	405 e	----
LSD(0.05)	18.17	22.99	19.63	11.39	----
CV (%)	9.27	17.7	10.38	5.01	----

Effect of treatments on the number of aphid population per stem plant^{-1}

Statistically significant variation was observed among the results of different management practices in terms of total infestation at different days after spraying (DAS) during the management of mustard. In case of 1 days after spraying (DAS), the highest number of infestation (216.7 aphid stem^{-1}) was recorded in T_7 which was statistically different from all other treatment followed by T_5 (50.00 aphid stem^{-1}) spraying of Detergent @ 10 g/L of water at 7 days interval and T_3 (43.33 aphid stem^{-1}) treated plot (Table 2). On the other hand, the lowest number of infestation (36.67 aphid stem^{-1}) was recorded in T_4 comprised of spraying of Spinosad 45EC @ 0.4 ml/L of water at 10 days interval which is similar with T_1 (40.00 aphid stem^{-1}) comprised of spraying of Neem oil @ 3.0 ml/L of water with at 7 days interval, which similar with T_6 (41.67 aphid stem^{-1}) comprised of sanitation. In case 4 days after spraying (DAS), the highest infestation (325.0 aphid stem^{-1}) was recorded in T_7 which was statistically different from all other treatment. This was followed by T_5 (70.00 aphid/stem) and T_6 (65.00 aphid stem^{-1}) treated plot. On the other hand, the lowest number of infestation T_4 (45.67 aphid stem^{-1}) was recorded in treated control plot followed by T_2 (51.67 aphid stem^{-1}) treated plot followed by T_1 (52.00 aphid stem^{-1}) treated plot (Table 8). In case of 7 days after spraying (DAS), more or less similar trends were observed among different management practice in terms of number aphid/inflorescence (Table 8). Considering the highest number of infestation (405.0) was recorded in T_7 followed by T_6 (76.67) and T_5 (71.67). On the other hand, the lowest aphid population (65.00) was recorded T_4 in control plot followed by T_3 (65.00) and followed by T_2 (66.67).

Conclusion

In case of percent leaves aphid population reduction over control, the highest percent of aphid population reduction (47.11%) was observed in T_4. while the lowest percent of aphid population reduction over control was observed in T_6 (26.78%). The percent of inflorescence infestation reduction over control indicate that the highest percent of inflorescence infestation reduction (51.39%) was recorded in T_4. while, the lowest percent of reduction over control (33.33%) was recorded in T_6. The percent reduction of stem infestation over control indicate that the highest percent of infestation reduction (39.35%) was recorded in T_4. while, the lowest percent of stem aphid reduction over control (30.16%) was recorded in T_7.The maximum yield found in the treatment T_4 (1.62 mt ha^{-1}) because of low aphid infestation followed by T_2 (1.53 mt ha^{-1}) and T_3 (1.44 mt ha^{-1}). While low yield performance found in the T_7 treatment was untreated control (1.29 mt ha^{-1}).

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