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Bio rational management of mustard aphid, (*Lipaphis erysimi* Kalt.)

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Abstract
Study on bio rational management of mustard aphid was conducted on the Oilseed Farm Kalyanpur, Kanpur during rabi, 2018-19. The research was carried out on mustard variety "Varuna".Chemical control with Dimethoate 30EC@ 1ml/L followed by its second spray after 15 days was the most effective treatment for reducing mustard aphid but Azadirachtin followed by *Verticillium leccani*@2g/L after 15 days also showed promising results preceded by Azadirachtin followed by *Beauveria bassiana*@2g/L after 15 days. The bio rational insecticides along with plant based insecticide Azadirachtin were effective enough in controlling the mustard aphid to a considerable level which are less harmful to the environment as well.

Keywords: Mustard aphid, bio rational**,** dimethoate 30 EC, azadirachtin, *Verticillium leccani*.

Introduction
Mustard is a very important crop for the agricultural economy of India. The estimated area, production and yield of rapeseed-mustard in the world was 36.68 million hectares (m ha), 72.42 million tonnes (mt) and 1974 kg / ha, respectively, during 2017-18(ICAR-DRMR 2018). Globally, rapeseed-mustard is the third important oilseed crop in the world. It contributes about 28.6% in the total oilseeds production in India, whereas it is the second most important edible oilseed after groundnut sharing 27.8% in India's oilseed economy (USDA 2018). Major mustard producing states are Rajasthan, Uttar Pradesh, Madhya Pradesh, Haryana, Gujarat, West Bengal, Assam, Bihar, Jharkhand, Punjab, Himachal Pradesh, Jammu and Kashmir.

Lipaphis erysimi is a species of aphid of the family Aphididae. It is found in most temperate and tropical areas of the world and feeds only on cruciferous plants. The insects are almost exclusively female and are very prolific, with wingless females producing around one hundred young during a lifespan of a few weeks. The wingless female is pale green or whitish green with two rows of dark bands on the thorax and abdomen which unite into a single band near the tip of the abdomen. The antennae are dark, the legs are pale with dark joints and cornicles are pale with dark tips. The body is faintly dusted with a white powder. It is between 1.4 and 2.4 mm (0.06 and 0.09 in) in length. The winged female is a similar size and has a black head and thorax and a pale green abdomen with black bands near the tip and black patches on the sides. The antennae and legs are dark, and the cornicles are black at the base and yellowish towards the tips. Wingless males have occasionally been seen; these are smaller than the females and olive-green to brownish in colour. The losses of mustard due to aphids varied from 35 to 90 per cent depending upon the seasons (Biswas and Das, 2000 and Rohilla *et al*., 2004) [3, 6]. Mustard aphid may cause 66 to 99 percent loss in *Brassica campestris* L. and 27-28 per cent in *Brassica juncea* L. (Bakhetia, 1979) [2] and oil content of 15 percent (Verma and Singh, 1987) [12]. Considering yield losses due to this pest, chemical control measures are suggested and in many cases seed yield loss have been minimized. Aphids are also the most common and destructive pests of brassicaceae crops across the world, and often cause heavy losses in yield (Shylesha *et al*., 2006; Thakur *et al*., 2009) [10, 11]. Among aphids, mustard aphid, *Lipaphis erysimi* (Hemiptera: Aphididae) is predominant and reported to be a key pest of rapeseed and mustard causing 35-73 percent reduction in yield and 5-6 percent reduction in oil content (Shylesha *et al*., 2006) [10]. Rapeseed- mustard, in general, is highly vulnerable to diseases and insect pests. The yield losses could be as high as 97 percent due to aphid (*Lipaphis erysimi*) (Yadava and Singh, 1999) [14].

The management of the pest with traditional insecticides is quite effective but it adversely affects the predators and parasitoids of the pest and also causes phytotoxicity, resistant of the pest and disruption of agro-ecosystem, human health hazard and environmental pollution (McIntyre *et al*., 1989) [5]. In recent years, due to awareness towards the environment, the work on eco- friendly management of insect pests has been initiated and the insecticidal and antifeedant properties of some plant extracts has been reported against mustard aphid, the ethanol extracts of some plant materials were found effective against the pest under the laboratory conditions (Kushwaha, 2003) [4] and field conditions (Sharma, 2004) [9]. Ahmed (1984) [1] listed about 221 plant species possessing insecticidal properties in this country. The neem tree, *Azadirachta indica*, a source of several insecticidal alkaloids is a sub tropical tree native to the arid areas of Asia and Africa (Saha *et al.*, 2006) [7].

Materials and methods

The experiment was conducted during *rabi* season 2018-19 at Oilseed Farm, Kalyanpur, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. Geographically it is situated between 26°21` east longitude at a height of 125.1 meter above mean sea level. The region is subtropical with semi-arid climate. The experiment was conducted by growing variety '*Urvashi*'. The details of the experiments are as follows: Design – RBD, Treatment -7, Replication – 3, Plot size - 4 m x 3.2 m, Date of sowing - 25th November, 2018

Table 1: Insecticides for testing their effectiveness against Mustard aphid

S. No.	Common name	Trade name	Formulation	Dose/Conc.
1	Azadirachtin	Achook	5 SL	5ml/L
2	*Beauveria bassiana*	Ecoria	1.15 WP	2g/L
3	*Verticillium lecanii*	Bioline	1.15 WP	2g/L
4	Dimethoate	Rogor	30 EC	1ml/L

Treatments for testing their effectiveness against Mustard aphid were

T_1: Azadirachtin@ 5ml/L followed by its second spray after 15 days

T_2: Azadirachtin followed by *Beauveria bassiana*@2g/L after 15 days

T_3: *Beauveria bassiana* followed by its second spray after 15 days

T_4: Azadirachtin followed by *Verticillium leccani*@2g/L after 15 days

T_5: *Verticillium leccani* followed by its second spray after 15 days

T_6: Dimethoate 30EC@ 1ml/L followed by its second spray after 15 days

T_7: Control

Evaluation of insecticides

The post treatments population of the insects were recorded regularly at ten randomly selected plants of each plot 3,7 and 10 days after treatment application.

$$\text{Pest Intensity} = \frac{\text{Toatal no.of days adult feed on plants observed}}{\text{No.of plants observed}}$$

$$\text{Pest Infestation} = \frac{\text{No.of plant infested}}{\text{Total no.of randomly selected plants}} \text{ x } 100$$

Total number of nymphs and adults feed on plants observed.

Results and discussion

Effect of Bio-rationals against mustard aphid after first spray

Efficacy of different Bio-rational treatments viz. T_1 : Azadirachtin@ 5ml/L followed by its second spray after 15 days, T_2 : Azadirachtin followed by *Beauveria bassiana*@2g/L after 15 days,T_3 : *Beauveria bassiana* followed by its second spray after 15 days, T_4 : Azadirachtin followed by *Verticillium leccani*@2g/L after 15 days, T_5 : *Verticillium leccani* followed by its second spray after 15 days T_6 : Dimethoate 30EC@ 1ml/L followed by its second spray after 15 days, T_7 : Control.

The data presented in Table-2 shows that T_6 :Dimethoate followed by its second spray after 15 days and T_4 :Azadirachtin followed by *Verticillium leccani* after 15 days were found significantly at par and most effective against mustard aphid providing 11.06 and 15.16 aphids per 10 cm central twig per plant (3 days after spray) with higher reduction % viz. 88.48 and 84.21 percent over control followed by T_4 : Azadirachtin followed by *Verticillium leccani* after 15 days and Azadirachtin followed by *Beauveria bassiana* after 15 days were also at par against mustard aphid giving 15.16 and 23.16 aphids per 10 cm central twig per plant (3 days after spray) with high reduction % viz. 84.21 and 75.88 percent over control followed by T_2 : Azadirachtin followed by *Beauveria bassiana* after 15 days and T_1 : Azadirachtin followed by its second spray after 15 days which were also at par having 23.16 and 28 aphids per 10 cm central twig per plant (3 days after spray) with reduction % viz. 75.88 and 70.84 percent over control followed by T_1 : Azadirachtin followed by its second spray after 15 days, T_5 : *Verticillium leccani* followed by its second spray after 15 days and T_3 : *Beauveria bassiana* followed by its second spray after 15 days which were also at par having 28, 32.96 & 34.70 aphids per 10 cm central twig per plant (3 days after spray) with reduction % viz. 70.84, 65.68 & 63.87 percent, respectively, over control.

The observations recorded 7 days after spray depicted that the spray of T_6 : Dimethoate followed by its second spray after 15 days and T_4 : Azadirachtin followed by *Verticillium leccani* after 15 days were found significantly at par and most effective against mustard aphid providing 9.73 and 13.23 aphids per 10 cm central twig per plant (7 days after spray) with highest reduction % viz. 92.01 and 89.14 percent over control followed by T_2 : Azadirachtin followed by *Beauveria bassiana* after 15 days and T_1 : Azadirachtin followed by its second spray after 15 days which were also at par having 18.86 and 21.53 aphids per 10 cm central twig per plant (7 days after spray) with reduction % viz. 84.56 and 82.32 percent over control followed by T_1 : Azadirachtin followed by its second spray after 15 days, T_5 : *Verticillium leccani* followed by its second spray after 15 days and T_3 : *Beauveria bassiana* followed by its second spray after 15 days which were also at par having 21.53, 26.26 & 27.83 per 10 cm central twig per plant (7 days after spray) with reduction % viz. 82.32, 78.44 & 77.15 percent, respectively, over control.

The observations recorded 10 days after spray showed good results as compared to 3 days and 7 days after spray as T_6 : Dimethoate followed by its second spray after 15 days and T_4 : Azadirachtin followed by *Verticillium leccani* after 15 days were found significantly at par and most effective against mustard aphid providing 6.40 and 11.13 aphids per 10 cm central twig per plant (10 days after spray) with highest reduction % viz. 95.66 and 92.48 percent over control followed by T_4 : Azadirachtin followed by *Verticillium*

leccani after 15 days and T_2 : Azadirachtin followed by *Beauveria bassiana* after 15 days were also at par against mustard aphid giving 11.13 and 13.33 per 10 cm central twig per plant (10 days after spray) with high reduction % viz. 92.48 and 90.95 percent over control followed by followed by T_2 : Azadirachtin followed by *Beauveria bassiana* after 15 days and T_1 : Azadirachtin followed by its second spray after 15 days which were also at par having 13.33 and 17.63 aphids per 10 cm central twig per plant (10 days after spray) with reduction % viz. 90.95 and 88.04 percent over control followed by T_1 : Azadirachtin followed by its second spray after 15 days, T_5 : *Verticillium leccani* followed by its second spray after 15 days and T_2 : *Beauveria bassiana* followed by its second spray after 15 days which were also at par having 17.63, 21.83 & 23.90 aphids per 10 cm central twig per plant (10 days after spray) with reduction % viz. 88.04, 85.19 & 83.78 percent, respectively, over control.

Effect of Bio-rationals against mustard aphid after second spray

The data presented in Table-3 depicts that T_6 : Dimethoate followed by its second spray after 15 days, T_4 : Azadirachtin followed by *Verticillium leccani* after 15 days and T_2 : Azadirachtin followed by *Beauveria bassiana* after 15 days were found significantly at par and most effective against mustard aphid providing 5.56, 10.00 and 11.93 aphids, respectively, per 10 cm central twig per plant (3 days after spray) with higher reduction % viz. 97.00, 94.60 and 90.73 percent, respectively, over control followed by T_4 : Azadirachtin followed by *Verticillium leccani* after 15 days, T_2 : Azadirachtin followed by *Beauveria bassiana* after 15 days, T_1 : Azadirachtin followed by its second spray after 15 days and T_3 : *Beauveria bassiana* followed by its second spray after 15 days were also at par against mustard aphid giving 10.00, 11.93, 17.16 and 18.76 aphids, respectively, per 10 cm central twig per plant (3 days after spray) with high reduction % viz. 94.60,93.56, 90.73 and 89.86 percent, respectively, over control followed by T_2: Azadirachtin followed by *Beauveria bassiana* after 15 days, T_1 : Azadirachtin followed by its second spray, T_3 : *Beauveria bassiana* followed by its second spray after 15 days and T_5 : *Verticillium leccani* followed by its second spray after 15 days which were also at par having 11.93,17.16,18.76 and 18.67 aphids, respectively, per 10 cm central twig per plant (3 days after spray) with reduction % viz. 93.56,90.73,89.86 and 89.91 percent, respectively, over control.

The observations recorded 7 days after spray depicted that the spray of T_6 : Dimethoate followed by its second spray after 15 days and T_4 : Azadirachtin followed by *Verticillium leccani* after 15 days were found significantly at par and most effective against mustard aphid providing 4.43 and 6.73 aphids per 10 cm central twig per plant (7 days after spray) with highest reduction % viz. 97.81 and 96.68 percent over control followed by T_4 : Azadirachtin followed by *Verticillium leccani* after 15 days and T_2 : Azadirachtin followed by *Beauveria bassiana* after 15 days which were also at par having 6.73 and 9.16 aphids per 10 cm central twig per plant (7 days after spray) with reduction % viz. 96.68 and 95.48 percent over control followed by T_2 : Azadirachtin followed by *Beauveria bassiana* after 15 days and T_1 : Azadirachtin followed by its second spray after 15 days which were also at par having 9.16 and 12.63 aphids per 10 cm central twig per plant (7 days after spray) with reduction % viz. 95.48 and 93.77 percent over control followed by T_1 : Azadirachtin followed by its second spray after 15 days, T_5 : *Verticillium leccani* followed by its second spray after 15 days and T_3 : *Beauveria bassiana* followed by its second spray after 15 days which were also at par having 12.63, 15.46 & 16.13 aphids, respectively, per 10 cm central twig per plant (7 days after spray) with reduction % viz. 93.77, 92.37 & 92.04 percent, respectively, over control.

The observations recorded 10 days after spray showed good results as compared to 3 days and 7 days after spray as T_6 : Dimethoate followed by its second spray after 15 days, T_5 : Azadirachtin followed by *Verticillium leccani* after 15 days and T_2 : Azadirachtin followed by *Beauveria bassiana* after 15 days were found significantly at par and most effective against mustard aphid providing 2.90,4.86 and 5.90 aphids per 10 cm central twig per plant (10 days after spray) with highest reduction % viz. 97.84,96.38 and 95.61 percent over control followed by T_4 : Azadirachtin followed by *Verticillium leccani* after 15 days, T_2 : Azadirachtin followed by *Beauveria bassiana* after 15 days and T_1 : Azadirachtin followed by its second spray after 15 days were also at par against mustard aphid giving 4.86, 5.90 and 8.93 aphids per 10 cm central twig per plant (10 days after spray) with high reduction % viz. 96.38, 95.61 and 93.35 percent over control followed by followed by T_2 : Azadirachtin followed by *Beauveria bassiana* after 15 day, T_1 : Azadirachtin followed by its second spray and T_5 : *Verticillium leccani* followed by its second spray after 15 days which were also at par having 5.90, 8.93 and 11.40 aphids per 10 cm central twig per plant (10 days after spray) with reduction % viz. 95.61, 93.35 and 91.52 percent over control followed by T_1 : Azadirachtin followed by its second spray, T_5 : *Verticillium leccani* followed by its second spray and T_3 : *Beauveria bassiana* followed by its second spray after 15 days which were also at par having 8.93, 11.40 and 12.56 aphids per 10 cm central twig per plant (10 days after spray) with reduction % viz. 93.35, 91.52 & 90.65 percent, respectively, over control.The spray of Dimethoate 30 EC @ 1 ml/l followed by *Verticillium lecanii* @ 108 CS/ml was proved to be the best treatment with pooled mean aphid population of 4.5, 3.25 and 1.65 aphids/plant as against 22.0, 24.0 and 26.0 aphids/plant in the control after 3, 7 and 10 days of treatment, respectively. Yadav and Singh (2015) [14]

Table 2: Effect of bio-rationals against mustard aphid *Lipaphis erysimi* Kalt. after first spray

Treatment	Mean population of Mustard aphid per 10 cm central twig per plant						
	1 DBS	3DAS	% Reduction over control	7DAS	% Reduction over control	10DAS	% Reduction over control
Azadirachtin @ 5ml/L followed by its second spray after 15 days	58.00 (7.65)	28.00 (5.31)	70.84	21.53 (4.69)	82.32	17.63 (4.25)	88.04
Azadirachtin followed by *Beauveria bassiana*@2g/L after 15 days	60.03 (7.78)	23.16 (4.84)	75.88	18.86 (4.40)	84.56	13.33 (3.70)	90.95
Beauveria bassiana followed by its second spray after 15 days	59.86 (7.77)	34.70 (5.89)	63.87	27.83 (5.32)	77.15	23.90 (4.94)	83.78
Azadirachtin followed by *Verticillium leccani*@2g/L after 15 days	60.56 (7.81)	15.16 (3.93)	84.21	13.23 (3.65)	89.14	11.13 (3.38)	92.48
Verticillium leccani followed by its	58.90 (7.71)	32.96 (5.78)	65.68	26.26 (5.17)	78.44	21.83 (4.72)	85.19

second spray after 15 days							
Dimethoate 30EC@ 1ml/L followed by its second spray after 15 days	62.30(7.92)	11.06 (3.40)	88.48	9.73 (3.20)	92.01	6.40 (2.62)	95.66
Control	60.50 (7.81)	96.03 (9.81)		121.80 (11.06)		147.36 (12.13)	
SE ±	0.63	0.43		0.29		0.39	
CD@ 5%	1.37	0.94		0.66		0.85	

* Figures within Parenthesis are $\sqrt{x+0.5}$ transformed value, DBS = Days Before Sowing, DAS = Days After Sowing

Table 3: Effect of bio-rationals against mustard aphid *Lipaphis erysimi* Kalt. after 15 days

Treatment	Mean population of Mustard aphid per 10 cm cental twig per plant						
	1 DBS	3DAS	%Reduction over control	7DAS	%Reduction over control	10DAS	%Reduction over control
Azadirachtin@ 5ml/L followed by its second spray after 15 days	24.86 (5.04)	17.16 (4.17)	90.73	12.63 (3.61)	93.77	8.93 (3.06)	93.35
Azadirachtin followed by *Beauveria bassiana*@2g/L after 15 days	20.83 (4.60)	11.93 (3.5)	93.56	9.16 (3.11)	95.48	5.90 (2.50)	95.61
Beauveria bassiana followed by its second spray after 15 days	31.56 (5.64)	18.76 (4.35)	89.86	16.13 (4.04)	92.04	12.56 (3.54)	90.65
Azadirachtin followed by *Verticillium leccani*@2g/L after 15 days	18.60 (4.37)	10.00 (3.22)	94.60	6.73 (2.69)	96.68	4.86 (2.31)	96.38
Verticillium leccani followed by its second spray after 15 days	27.53 (5.29)	18.67 (4.37)	89.91	15.46 (3.97)	92.37	11.40 (3.44)	91.52
Dimethoate 30EC@ 1ml/L followed by its second spray after 15 days	10.30 (3.28)	5.56 (2.45)	97.00	4.43 (2.21)	97.81	2.90 (1.84)	97.84
Control	173.7 (13.19)	185.16 (13.6)		202.7 (14.24)		134.36 (11.59)	
SE ±	0.36	0.52		0.38		0.44	
CD@ 5%	0.78	1.13		0.82		0.95	

* Figures within Parenthesis are $\sqrt{x+0.5}$ transformed value, DBS = Days Before Sowing, DAS = Days After Sowing

Conclusion

The findings of management of mustard aphid through different bio-rational approaches revealed that chemical control with Dimethoate 30EC@ 1ml/L followed by its second spray after 15 days was the most effective treatment for reducing Mustard aphid but Azadirachtin followed by *Verticillium leccani*@2g/L after 15 days also showed promising results. The following conclusions were drawn from the findings of the present study: For the development of appropriate pest management model monitoring of insect pests population is crucial. Bio-rational management of mustard aphid provides a considerable control on mustard aphid and is effective from ecological point of view.

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