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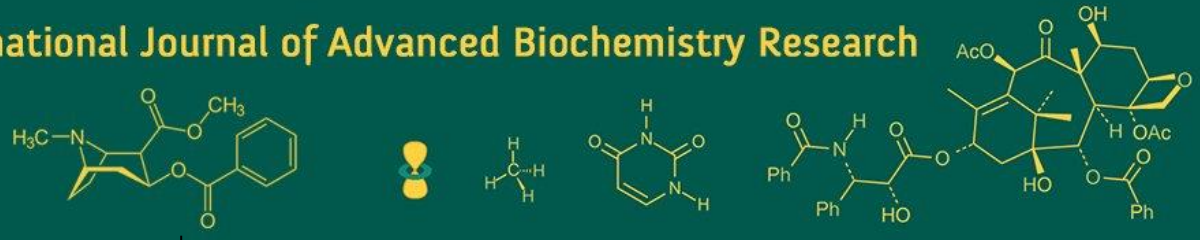

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Ecofriendly management of mustard aphid, (*Lipaphis erysimi* Kalt.) through Biorational

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Abstract
Study on bio rational management of mustard aphid was conducted S.I.F on Chandra Shekhar Azad University of Agriculture & Technology Kanpur, during Rabi 2023-24 on Indian mustard (*Brassica juncea*) variety "Varuna". Among the eight treatments including control plot Spinosad 45% SC found as the most effective treatment for reducing *Lipaphis erysimi* populations followed by NSKE 5%, *Beauveria bassiana*, Castor Leaf Extract 10%, Lantana leaf extract 10%, *Metarhizium anisopliae*, *Lecanicillium lecanii* and also the maximum yield was obtained with treatment Spinosad 45% SC giving 20.17 q/ha) followed by NSKE 5% (18.30), followed by *Beauveria bassiana* (17.52), castor leaf extract(17.42), lantana leaf extract(17.15) and *Lecanicillium lecanii*(16.17) The highest net profit (₹ 28320 per ha) was obtained from the Spinosad 45% SC while the lowest net profit (₹ 5274 per ha) was estimated from the treatment of *Lecanicillium lecanii.* The bio rational insecticides were effective enough in controlling the mustard aphid to a considerable level which are less harmful to the environment as well.

Keywords: Seed yield, management, mustard aphid, spinosad, *lecanicillium lecanii*

Introduction
Mustard plays a crucial role in India's agricultural economy, contributing significantly to the oilseed sector. In 2017-18, rapeseed-mustard covered an estimated 36.68 million hectares globally, producing 72.42 million tonnes with a yield of 1974 kg/ha (ICAR-DRMR, 2018). As the third most important oilseed crop worldwide, mustard accounts for about 28.6% of India's total oilseed production and ranks second in its oilseed economy, just after groundnut, with a 27.8% share (USDA, 2018). Key mustard-producing states in India include Rajasthan, Uttar Pradesh, and Madhya Pradesh, among others.

However, mustard crops are vulnerable to the mustard aphid, *Lipaphis erysimi*, a highly prolific pest that feeds on cruciferous plants. This aphid species causes significant yield losses, with reductions ranging from 35% to 90% depending on the season (Biswas and Das, 2000 [5]; Rohilla *et al*., 2004) [11]. In *Brassica campestris* L., aphid damage can lead to a 66% to 99% reduction in yield, while in *Brassica juncea* L., the losses range from 27% to 28% (Bakhetia, 1979) [4]. Additionally, the oil content of mustard crops may decrease by 15% due to aphid infestation (Verma and Singh, 1987) [17]. Given the severity of these losses, chemical control measures are recommended to mitigate yield reductions. Aphids remain one of the most destructive pests for Brassicaceae crops worldwide, often leading to substantial yield losses (Shylesha *et al*., 2006 [14]; Thakur *et al*., 2009) [16].The mustard aphid, *Lipaphis erysimi* (Hemiptera: Aphididae), is the predominant pest affecting rapeseed and mustard crops, with yield losses ranging from 35% to 73% and a reduction in oil content by 5% to 6% (Shylesha *et al*., 2006) [14]. Rapeseed-mustard crops are particularly vulnerable to insect pests and diseases, with aphid infestations potentially causing yield losses as high as 97**%** (Yadava and Singh, 1999) [18]. While traditional insecticides are effective in managing these pests, their use poses several drawbacks, including harm to beneficial predators and parasitoids, phytotoxicity, pest resistance, and disruptions to the agro-ecosystem. Moreover, these chemicals present risks to human health and contribute to environmental pollution (McIntyre *et al*., 1989) [9]. In response to growing environmental concerns, there has been a shift towards eco-friendly pest management approaches.

Research has shown that plant extracts with insecticidal and antifeedant properties can be effective against mustard aphids. Ethanol extracts of certain plant materials have demonstrated efficacy in both laboratory (Kushwaha, 2003) [8] and field conditions (Sharma, 2004) [13]**.** Notably, neem (*Azadirachta indica*), a subtropical tree native to Asia and Africa, contains several insecticidal alkaloids and is recognized for its pest management potential (Saha *et al*., 2006) [12]. In India, approximately 221 plant species with insecticidal properties have been identified (Ahmed, 1984) [1], highlighting the potential for natural, eco-friendly alternatives to chemical pesticides in mustard aphid control.

Materials and Methods

The experiment was conducted during Rabi season 2023-24 at S.I.F, Kanpur, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. The region is subtropical with semi-arid climate. The experiment was conducted by growing variety 'Varuna'. The details of the experiments are as follows: Design – RBD, Treatment -8, Replication-3, Plot size-4.5 m x 3 m.

The experiment will include eight treatments, including a control, each replicated three times. The plot size will be 4.5×3 meters, with row and plant spacing of 45×15 cm. Treatments will be applied at their recommended doses when pest populations reach the Economic Threshold Level (ETL).

To assess the effectiveness of the treatments, the population of *Lipaphis erysimi* Kalt. and the extent of pod damage was monitored. Aphid populations will be recorded from the top 10 cm of apical twigs on 10 randomly selected plants from each plot. Observations will be made one day before spraying, and 3, 5, and 8 days after the first, second, and third sprays. The pre-treatment count recorded one day before the first spray will serve as the baseline for subsequent measurements. All three sprays were applied at eight days intervals. Pod infestation will be calculated using Abbott's formula (1925).

$$\text{Pod infestation (\%)} = \frac{\text{Number of infested pods}}{\textit{Total number of Pods}} X100$$

Table 1: Effect of different Bio-rational pesticide against *Lipaphis erysimi* in mustard 2023-24.

Treatment	First Spray				Second Spray			Third Spray			Overall Mean
	1 DBS	3DAS	5DAS	8DAS	3DAS	5DAS	8DAS	3DAS	5DAS	8DAS	
NSKE 5%	29.79 (5.54)	17.52 (4.303)	15.31 (4.03)	13.4 (3.79)	10.56 (3.4)	9.59 (3.25)	9.55 (3.24)	9.13 (3.18)	7.81 (2.96)	6.24 (2.69)	12.89
Castor Leaf Extract 10%	29 (5.47)	21.95 (4.79)	17.91 (4.34)	16.88 (4.22)	14.68 (3.95)	12.31 (3.64)	10.58 (3.40)	10.56 (3.4)	9.25 (3.20)	7.04 (2.83)	15.02
Lantana Leaf Extract 10%	29.96 (5.56)	22.24 (4.82)	18.31 (4.39)	17.33 (4.28)	15.09 (4.01)	12.77 (3.71)	10.77 (3.43)	10.9 (3.45)	9.46 (3.234)	7.66 (2.94)	15.45
Beauveria bassiana	29.97 (5.57)	18.42 (4.40)	17.01 (4.24)	15.82 (4.10)	14.03 (3.87)	11.56 (3.54)	9.98 (3.31)	9.75 (3.27)	8.05 (3.00)	6.93 (2.81)	14.15
Metarhizium anisopliae	29.82 (5.55)	23.38 (4.93)	20.71 (4.65)	18.46 (4.41)	15.59 (4.07)	13.18 (3.76)	11.24 (3.49)	10.96 (3.45)	10.09 (3.33)	7.74 (2.95)	16.12
Lecanicillium lecanii	29.72 (5.54)	23.47 (4.94)	20.91 (4.68)	18.92 (4.46)	16.03 (4.12)	13.62 (3.82)	11.64 (3.55)	11.79 (3.57)	10.92 (3.45)	9.05 (3.17)	16.61
Spinosad 45% SC	29.99 (5.56)	10.84 (3.44)	9.64 (3.26)	8.72 (3.11)	7.84 (2.97)	6.77 (2.78)	6.14 (2.67)	5.53 (2.55)	4.66 (2.37)	3.72 (2.17)	9.39
Control	28.93 (5.47)	34.48 (5.95)	39.31 (6.34)	40.52 (6.44)	53.76 (7.4)	57.45 (7.64)	60.05 (7.81)	69.63 (8.40)	71.62 (8.52)	74.11 (8.66)	52.99
CD at 5%	N/A	0.09	0.08	0.09	0.09	0.12	0.07	2.40	3.21	2.59	
SE.m.±	0,03	0.03	0.02	0.03	0.03	0.04	0.02	0.78	1.05	0.84	

Table 2: Effectiveness of treatments based on reduction (%) in the population of mustard aphid after second spray during 2023-24.

Treatment	First Spray			Second Spray			Third Spray			Overall Mean
	3DAS	5DAS	8DAS	3DAS	5DAS	8DAS	3DAS	5DAS	8DAS	
NSKE 5%	86.89 (68.83)	89.10 (70.89)	91.58 (73.13)	86.89 (68.83)	89.10 (70.89)	91.58 (73.13)	86.89 (68.83)	89.10 (70.89)	91.58 (73.13)	89.19
Castor Leaf Extract 10%	84.83 (67.05)	87.08 (68.99)	90.50 (72.26)	84.83 (67.05)	87.08 (68.99)	90.50 (72.26)	84.83 (67.05)	87.08 (68.99)	90.50 (72.26)	87.47
Lantana Leaf Extract 10%	84.35 (66.67)	86.79 (68.72)	89.66 (71.22)	84.35 (66.67)	86.79 (68.72)	89.66 (71.22)	84.35 (66.67)	86.79 (68.72)	89.66 (71.22)	86.93
Beauveria bassiana	86.00 (68.00)	88.76 (70.50)	90.65 (72.36)	86.00 (68.00)	88.76 (70.50)	90.65 (72.36)	86.00 (68.00)	88.76 (70.50)	90.65 (72.36)	88.47
Metarhizium anisopliae	84.26 (66.59)	85.91 (67.92)	89.56 (71.13)	84.26 (66.59)	85.91 (67.92)	89.56 (71.13)	84.26 (66.59)	85.91 (67.92)	89.56 (71.13)	86.58
Lecanicillium lecanii	83.07 (65.71)	84.75 (66.98)	87.79 (69.52)	83.07 (65.71)	84.75 (66.98)	87.79 (69.52)	83.07 (65.71)	84.75 (66.98)	87.79 (69.52)	85.20
Spinosad 45% SC	92.06 (73.64)	93.49 (75.38)	94.98 (77.09)	92.06 (73.64)	93.49 (75.38)	94.98 (77.09)	92.06 (73.64)	93.49 (75.38)	94.98 (77.09)	93.51
Control	0	0	0	0	0	0	0	0	0	89.19
CD at 5%	0.08	1.92	1.77	2.48	3.27	2.48	2.07	4.29	3.34	
SE.m.±	0.263	0.62	0.57	0.81	1.07	0.81	0.67	1.40	1.09	

Table 3: Effect of treatments on Seed yield (q/ha) during *Rabi* 2023-24

Treatment	Seed Yield(q/ha)	Gross income	Cost of Treatment	Net income	Net income over control	ICBR
NSKE 5%	18.3	100650	3200	97450	16985	5.30
Castor leaf extract 10%	17.42	95810	6800	89010	8545	1.25
Lantana leaf extract 10%	17.15	94325	6000	88325	7860	1.31
Beauveria bassiana	17.52	96360	3285	93075	12610	3.83
Metarhizium anisopliae	17.12	94160	3185	90975	10510	3.29
Lecanicillium lecanii	16.17	88935	3196	85739	5274	1.65
Spinosad 45% SC	20.17	110935	2150	108785	28320	13.17
Control	14.63	80465	0	80465	0	0
CD at 5%	0.8					
SE.m.±	0.26					

Results and Discussion

Effect of different biorational insecticides against mustard aphid during 2023-24 at First spray

One day before treatment application (pre-treatment) during Rabi 2022-23, the mustard aphid population ranged from 29 to 29.99 aphids per 10 cm central twig per plant, showing no significant differences between plants. After the first spray, the aphid population decreased in all treated plots, while it increased in the control, indicating that all treatments were effective in controlling the mustard aphid. Spinosad 45% SC was the most effective treatment, showing superior results up to 8 days after spraying. At 3 days after spraying (DAS), Spinosad 45% SC recorded the highest aphid reduction at 68.56%, followed by NSKE 5%, *Beauveria bassiana*, castor leaf extract 10%, lantana leaf extract 10%, *Metarhizium anisopliae*, and *Lecanicillium lecanii*. By 5 DAS, all treatments showed a significant reduction in aphid populations compared to the control, with Spinosad 45% SC again leading with a 75.48% reduction, followed by similar treatments in the same order. The lowest reduction was seen with *Lecanicillium lecanii* at 46.81%. At 8 DAS, the trend continued, with Spinosad 45% SC showing the highest reduction in aphid population (78.48%), followed by the other treatments, all of which were superior to the control in reducing mustard aphid populations.

Effect of different biorational insecticides against mustard aphid during 2023-24 at second spray

The application of the first spray of treatments effectively reduced the mustard aphid population, while the aphid population increased in the control, confirming that all treatments were successful in controlling the pest. Among the treatments, Spinosad 45% SC (T7) proved to be the most effective, maintaining its superiority up to 8 days after spraying. At 3 days after spraying (DAS), the treatments showed significant differences in their effectiveness. Spinosad 45% SC recorded the highest aphid reduction at 85.42%, followed by NSKE 5%, *Beauveria bassiana*, castor leaf extract 10%, lantana leaf extract 10%, *Metarhizium anisopliae*, and *Lecanicillium lecanii*. The lowest reduction over the control was observed in *Lecanicillium lecanii* at 70.18%. At 5 DAS, all treatments continued to show superior aphid control compared to the control group. Spinosad 45% SC achieved the highest reduction at 88.22%, followed by NSKE 5%, *Beauveria bassiana*, castor leaf extract 10%, lantana leaf extract 10%, *Metarhizium anisopliae*, and *Lecanicillium lecanii*. By 8 DAS, Spinosad 45% SC continued to lead with a 89.78% reduction in the aphid population, followed by the same treatments in the same order, with all treatments proving more effective than the control in managing mustard aphid populations.

Effect of different biorational insecticides against mustard aphid during 2023-24 at Third spray

The application of the first spray of treatments effectively reduced the population of mustard aphids, while the control group saw an increase in aphid numbers, indicating that all treatments were successful in managing this pest. Spinosad 45% SC (T7) emerged as the most effective treatment, demonstrating superior results up to 8 days after application. At 3 days after spraying (DAS), Spinosad achieved the highest reduction percentage of 92.06%, followed by NSKE 5%, *Beauveria bassiana*, castor leaf extract 10%, lantana leaf extract 10%, *Metarhizium anisopliae*, and *Lecanicillium lecanii*, with *Lecanicillium lecanii* showing the least reduction at 83.07%. By 5 DAS, all treatments continued to outperform the control, with Spinosad 45% SC again leading with a 93.49% reduction. At 8 DAS, the trend persisted, with Spinosad 45% SC achieving a 94.48% reduction in aphid populations, followed closely by NSKE 5%, *Beauveria bassiana*, castor leaf extract 10%, lantana leaf extract 10%, *Metarhizium anisopliae*, and *Lecanicillium lecanii*, confirming the effectiveness of these treatments in controlling mustard aphids.

The data indicated that Spinosad 45% SC was the most effective treatment for controlling mustard aphid populations when sprayed on standing crops, achieving a notable 74.17% reduction compared to the control group. Following closely was NSKE 5%, which resulted in a 59.06% reduction in aphid numbers. In contrast, *Lecanicillium lecanii*, applied in a splitting form on standing crops, was the least effective treatment, achieving only a 44.02% reduction, though it still demonstrated statistical superiority over the untreated control.

During the second spray, Spinosad 45% SC maintained its effectiveness, reducing aphid populations by 87.80% compared to the control. NSKE 5% was again the second most effective, yielding an 82.59% reduction. *Lecanicillium lecanii* while still the least effective, showed a 75.70% reduction but remained statistically superior to the control.

In the third spray, Spinosad 45% SC continued to lead with a remarkable 93.51% reduction in aphid populations, while NSKE 5% achieved an 89.19% reduction. *Lecanicillium lecanii* was again the least effective, with an 85.20% reduction, yet still statistically better than the control. These results corroborate previous studies by Akter *et al*. (2021) [21], Khanal *et al*. (2020) [6], Sreeja and Kumar (2022) [15], which identified Spinosad 45% SC as the most effective treatment for reducing *Lipaphis erysimi* populations, followed by NSKE 5%, without causing phytotoxic effects. Additionally, recent research by Aswitha and Yadav (2023) [3] and Mishra *et al*. (2023) [10] further confirmed the

effectiveness of NSKE 5% in reducing aphid populations, while highlighting the lesser effectiveness of *Lecanicillium lecanii* and *Metarhizium anisopliae*, consistent with findings by Kumar and Kumar (2016) [7]. The results presented in revealed that all the treatments regarding the yield were proved significantly superior over control and ranged from 14.63 to 20.17 q/ha during Rabi, 2023-24. The maximum grain yield of 20.17 q/ha was obtained from the field which was treated with Spinosad 45% SC. The second-best treatment was NSKE 5%. with the grain yield to the tune of 18.3 q/ha, followed *Beauveria bassiana*, castor leaf extract, lantana leaf extract and *Metarhizium anisopliae* with the grain yield of 17.52, 17.42, 17.15 and 17.12 q/ha, respectively. Among the different treatments *Lecanicillium lecanii* the lowest grain yield of 16.17 q/ha was recorded in control field which differed significantly and inferior among all treatments.

Conclusion

The findings of management of mustard aphid through different bio-rational approaches revealed that chemical control the results revealed that most superior over the other treatments was found to be Spinosad 45% SC followed%, *Beauveria bassiana*, Castor Leaf Extract 10%, Lantana leaf extract 10%, *Metarhizium anisopliae*, *Lecanicillium lecanii*. Among the treatments studied, the maximum grain yield of 20.17 q/ha was obtained from the field which was treated with Spinosad 45% SC. The second-best treatment was NSKE 5%. with the grain yield 18.24 q/ha, followed by *Beauveria bassiana*, castor leaf extract, lantana leaf extract and *Lecanicillium lecanii* with the grain yield of 17.92, 17.35, 17.17 and 17.1 q/ha, respectively. Among the different treatments *Lecanicillium lecanii*, the lowest grain yield of 16.4 q/ha was recorded in control field which differed significantly and inferior among all treatments. 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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