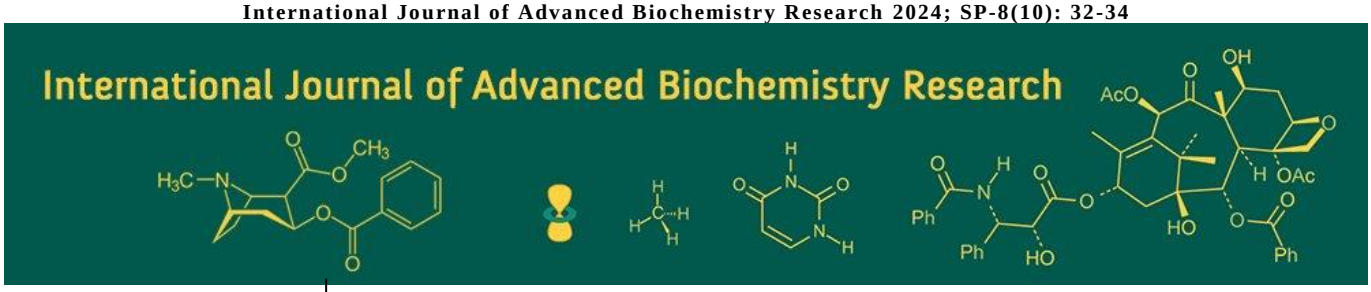

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Pinkesh Meena
M.Sc Student Department of Entomology, Bundelkhand University, Jhansi, Uttar Pradesh, India

Pradeep Kumar
Department of Entomology, Bundelkhand University, Jhansi, Uttar Pradesh, India

AK Chaudhary
Department of Entomology, Bundelkhand University, Jhansi, Uttar Pradesh, India

B Gangwar
Professor, Institute of Agricultural Sciences, Bundelkhand University, Jhansi, Uttar Pradesh, India

Corresponding Author:
Pinkesh Meena
M.Sc Student Department of Entomology, Bundelkhand University, Jhansi, Uttar Pradesh, India

Management of diamondback moth (DBM) *Plutella xylostella* (L.) by bio-pesticides and botanicals

Pinkesh Meena, Pradeep Kumar, AK Chaudhary and B Gangwar

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Abstract
The experiment was conducted in *Rabi* 2023 at Organic Research Farm, under Department of Entomology, Institute of Agricultural Sciences, Bundelkhand University, Jhansi to evaluate the efficacy of bio-pesticides and botanicals against the infestation of diamondback moth (*Plutella xylostella* L.) in cauliflower. Nine treatments included control (Untreted) were used in 9 plots with 3 replications, all the treatments were sprayed in three times and data collected at 3 days, 7 days and 14 days after applications. The investigation resulted all the treatments were found significantly effective over control. The minimum larval population of DBM was recorded under *Bacillus thuringiensis* @ 1.5 kg/hac as per with *Beauveria bassiana* @ 1.5 kg/hac and Neem oil 2% and *Metarhizium anisopliae*@ 1.5 kg/hac also give similar result as neem oil. The highest crop yield and C:B ratio was obtained under *Bacillus thuringiensis* @ 1.5 kg/hac (210.89 and 1:3.94) as per with *Beauveria bassiana* @ 1.5 kg/hac (190.65 and 1:3.48).

Keywords: Bio-pesticides, diamondback moth (DBM), *Bacillus thuringiensis*, neem oil, and *Beauveria bassiana*

1. Introduction
Cauliflower is one of the most preferable, traditionally grown winter vegetable, requires cold and moist climate and is less hardy than cabbage. Cauliflower has a small thick stem, bearing whorl of leaves and branched tap root system. It is a rich source of nutrient including vitamin A, vitamin-C, calcium, phosphorus, potassium, moisture, carbohydrates, protein, fat, fiber, and iron (Fageria M.S., 2012) [4]. It is consumed as cooked and also as salad.
The yield of cauliflower is adversely affected by many bottlenecks including insect pest, diseases, environmental stresses, nutritional imbalance etc. The cabbage crop is attacked by a number of different insect pests and among them cabbage caterpillar, diamondback moth, cabbage semi-looper, and tobacco caterpillar, cabbage leaf webber, cabbage borer, and cabbage flea beetles, are the pests of major importance (Atwal and Dhaliwal, 2002) [1]. Among all, diamondback moth (DBM), which was long considered a relatively insignificant pest, is now becoming a major pest. Diamondback moth can caused 100 percent yield loss of cauliflower crop (lingappa *et al.,* 2006) [10] and according to Krishnamurthy 2004, Ayalew 2006, the diamondback moth can damage 52-100 percent crop and caused heavy economic loss to farmers.

2. Methods and Materials
The experiment was conducted in Organic Research Farm Karguan ji, Department of Entomology, Institute of Agricultural Sciences, Bundelkhand University, Jhansi and it arranged in randomized block design with three replications of treatments. There was nine treatments including control (untreated) *viz.* T_1- *Beauveria bassiana,* T_2- *Verticillium lecanii* T_3- *Bacillus thuringiensis var. kurstaki* T_4- *Metarhizium anisopliae* T_5- Garlic extract T_6- NSKE T_7- Karanj oil T_8- Neem oil T_9- Control, were used in experiment and seedlings of cauliflower variety- Poosi were transplanted in plots with 60*45 cm row to row and plant to plant spacing in month of November. And all agronomical practices were followed at experimental side that required for crop cultivation. In the crop experiment nine treatments and three replications were applied hence total 27 plot were worked out. And total three sprays of the treatments were done in whole crop period in all plots.

3. Observations

To take the data for targeted pest five plants were randomly select and tagged in every plot of experimental field and these tagged plants lead to data of whole plot. The observations were taken at before and after every application of the treatments, where the larval population of diamondback moth were recorded at three days, seven days and fourteen days after spraying. The data collected after the application compare with data collected before spray then calculate how much population of the larvae of the diamondback moth were reduced in different treatments. And treated plot and untreated plot also compare for how much efficiently different treatments were control the damage of diamondback moth in cauliflower crop.

4. Result and discussion

4.1 Efficacy of treatment to management of the DBM

After the first spray of treatments resulted that among all the treatments, minimum population of the diamondback moth 4.10 larvae/plant were recorded in neem oil treated plot which was 6.56 at before spray of treatments and as per with *Bacillus thuringiensis* that recorded 4.32 larvae per plant. All treatments were found significantly effective to minimized the larval population of diamondback moth, after first spray among all treated plots garlic bulb extract was recorded highest population mean it was least effective treatment all microbial bio pesticides were found effective but *Bacillus thuringiensis* and *Beauveria bassiana* was give better result than other where untreated plot showed 5.81 larvae per plant population of diamondback moth.

After the second application minimum larval population and damage caused by diamondback moth recorded under *Bacillus thuringiensis* (3.05 larvae/plant) and next best treatment was *Beauveria bassiana* that recorded 3.29 larvae per plant as per with Neem oil (3.44 larvae/plant) and NSKE (4.17 larvae/plant), among all the treated plot garlic bulb extract (6.32 larvae/plant) was least effective treatment, where the untreated plot showed 6.42 mean larval population of diamondback moth.

Observation taken after the third spray resulted, among all treatments the best result was recorded under *Bacillus thuringiensis treated* plot that showed 1.69 mean larval population of the diamondback moth per plant and next was *Beauveria bassiana* recorded 2.25 larvae/plant as per with neem oil and *Metarhizium anisopliae* recorded 2.75 larvae/plant and 3.00 larvae/plant population respectively, among all treatments neem oil and microbial bio pesticides were found effective to control the larval population of diamondback moth where Garlic extract was found lest effective treatment and untreated plot 7.32 larvae per plant population of DBM in cauliflower crop.

4.2 Economics of cultivation

The and cost among all treatments were found significant but maximum yield and maximum cost benefit ratio was obtained from the T_3 *Bacillus thuringiensis* treated plot that recoded with 210.89 qt/ hac yield and 1:3.94 C:B ratio as per with *Beauveria bassiana* recorded 190.65qt/hac and 1:3.48 where neem oil treated plot give similar result as *Beauveria bassiana* but *Metarhizium anisopliae* treated plot gives higher C:B ratio than neem oil. *Moreover* Garlic bulb extract recorded minimum yield among all treated plot where untreated plot resulted 97.73 qt/hac yield and 1:1.43 C: B ratio among all plots.

Table 1: Effect of treatments against (DBM) *Plutella xylostella* (L.) in cauliflower after first spray

T.no	Treatments	Doses	Mean shoot damage percent				Mean
			Before	3DAS	7DAS	14DAS	
T_1	*Beauveria bassiana*	1.5 kg./ha	6.82	5.56	4.83	4.23	4.87
T_2	*Verticillium lecanii*	1.5 kg./ha	7.05	6.49	5.51	5.04	5.68
T_3	*Bacillus thuringiensis var. kurstaki*	1.5kg./ha	5.66	5.14	4.3	3.51	4.32
T_4	*Metarhizium anisopliae*	1.5 kg./ha	6.94	6.1	5.06	4.63	5.26
T_5	Garlic extract	10%	7.19	7.09	6.81	6.64	6.85
T_6	NSKE	5%	7.14	4.92	4.86	4.53	4.77
T_7	Karanj oil	2%	6.89	6.63	6.19	6.09	6.30
T_8	Neem oil	2%	6.56	4.63	4.26	3.4	4.10
T_9	Control	-	5.34	5.55	5.83	6.06	5.81
C.D.				0.472	0.541	0.586	0.931
SE(m)			0.647	0.156	0.179	0.194	0.308

Table 2: Effect of treatments against (DBM) *Plutella xylostella* (L.) in cauliflower after second spray

T.no	Treatments	Doses	Mean fruit damage percent				Mean
			Before	3DAS	7DAS	14DAS	
T_1	*Beauveria bassiana*	1.5 kg./ha	4.66	3.93	3.34	2.59	3.29
T_2	*Verticillium lecanii*	1.5 kg./ha	5.61	5.34	4.46	4.11	4.64
T_3	*Bacillus thuringiensis var. kurstaki*	1.5kg./ha	4.21	3.69	3.12	2.33	3.05
T_4	*Metarhizium anisopliae*	1.5 kg./ha	5.26	5.1	4.22	3.49	4.27
T_5	Garlic extract	10%	6.73	6.43	6.27	6.25	6.32
T_6	NSKE	5%	4.68	4.25	4.18	4.09	4.17
T_7	Karanj oil	2%	6.24	5.96	5.84	5.42	5.74
T_8	Neem oil	2%	4.12	3.81	3.46	3.06	3.44
T_9	Water contol	-	5.69	6.1	6.46	6.69	6.42
C.D.			0.720	0.548	0.658	0.573	0.575
SE(m)			0.238	0.181	0.218	0.189	0.190

Table 3: Effect of treatments against (DBM) *Plutella xylostella* (L.) in cauliflower after third spray

T.no	Treatments	Doses	Mean fruit damage percent				Mean
			Before	3DAS	7DAS	14DAS	
T_1	*Beauveria bassiana*	1.5 kg./ha	3.25	2.76	2.16	1.84	2.25
T_2	*Verticillium lecanii*	1.5 kg./ha	4.33	4.09	3.67	3.43	3.73
T_3	*Bacillus thuringiensis var. kurstaki*	1.5kg./ha	3.11	2.14	1.81	1.13	1.69
T_4	*Metarhizium anisopliae*	1.5 kg./ha	4.19	3.41	2.99	2.61	3.00
T_5	Garlic extract	10%	6.22	6.01	5.46	5.29	5.59
T_6	NSKE	5%	4.13	3.63	3.12	2.73	3.16
T_7	Karanj oil	2%	5.74	5.23	4.83	4.35	4.80
T_8	Neem oil	2%	3.46	3.1	2.81	2.35	2.75
T_9	Water contol	-	6.70	7.1	7.31	7.56	7.32
C.D.			0.679	0.446	0.435	0.324	0.633
SE(m)			0.224	0.147	0.144	0.107	0.209

Table 4: Economic of cultivation of cauliflower

T. No.	Treatments	Yield Qt/h	Cost of yield (Rs)	Common cost (Rs)	Treatment cost (Rs)	Total cost (Rs)	Net Income (Rs)	C:B ratio
T_1	*Beauveria bassiana*	190.65	381300	80400	4750	85150	296150	1:3.48
T_2	*Verticillium lecanii*	164.29	328580	80400	4275	84675	243905	1:2.88
T_3	*Bacillus thuringiensis var. kurstaki*	210.89	421780	80400	4950	85350	336430	1:3.94
T_4	*Metarhizium anisopliae*	180.24	360480	80400	4750	85150	275330	1:3.23
T_5	Garlic extract	129.28	258560	80400	3370	83770	174790	1:2.09
T_6	NSKE	176.38	352760	80400	19440	99840	252920	1:2.53
T_7	Karanj oil	135.51	271020	80400	18000	98400	172620	1:1.75
T_8	Neem oil	189.46	378920	80400	13860	94260	284660	1:3.02
T_9	Water contol	97.73	195460	80400		80400	115060	1:1.43

5. Conclusion

The above discussed experiment concluded with the bio-pesticides and botanicals also effective to control infestation of (DBM) *Plutella xylostella* (L.) as insecticides, as we know chemicals are not safe for ecology and environment then the bio-pesticides are good alternate that manage damage with sustainable manner it can incorporate with in organic farming or in integrated pest management.

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