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BIO-EFFICACY OF DIFFERENT BIO-PESTICIDES AGAINST *Hyadaphis coriandari* DAS ON FENNEL

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ABSTRACT

The present investigation entitled "Bioefficacy of various biopesticides against *Hyadaphis coriandari* Das on fennel" was conducted under field and laboratory conditions at the Department of Entomology, College of Agriculture, SKRAU, Bikaner during the Rabi season of 2021–22. Biopesticides are considered environmentally safer alternatives because of their selective action against insect pests, lower mammalian toxicity, and their ability to interfere with insect growth and metabolism. The experiment comprised nine treatments including an untreated control, arranged in a Randomized Block Design with three replications. Fennel variety RF-143 was sown in plots measuring 3.0 × 2.4 m with spacing of 40 × 20 cm. Two spray applications were given for the management of aphid infestation. Among all tested treatments, *Verticillium lecanii* @ 5 g/litre proved to be the most effective in suppressing aphid population, followed by *Beauveria bassiana* @ 5 g/litre and Azadirachtin 3000 ppm @ 4 ml/litre. The highest seed yield (12.10 q/ha) was recorded from plots treated with *Verticillium lecanii*, while *Beauveria bassiana* and Azadirachtin produced 11.90 q/ha and 11.25 q/ha, respectively. Economic analysis also indicated maximum net return (Rs. 35,220/ha) and highest incremental cost benefit ratio (8.80) in the treatment receiving *Verticillium lecanii*. The next best treatment was *Beauveria bassiana* with a net return of Rs. 32,100/ha and benefit-cost ratio of 6.42.

Keywords **:** Fennel, *Hyadaphis coriandari*, bio pesticides, aphid management, seed yield.

Introduction

Fennel (*Foeniculum vulgare* Mill.), a member of the Apiaceae family, is native to Southern Europe, North America, and the coastal Mediterranean regions of India. It is popularly known as 'Variali' or 'Variari' in Gujarati and 'Saunf' in Hindi, and is regarded as an important spice crop. In India, fennel is predominantly cultivated in Gujarat and Rajasthan, with limited cultivation in Uttar Pradesh, Karnataka, Andhra Pradesh, Punjab, Madhya Pradesh, Bihar, Haryana, and Jammu & Kashmir. Gujarat is considered the leading state for fennel production. As of 2020–21, fennel was cultivated over 80,000 hectares in India, yielding 129,000 metric tonnes annually, with a productivity of 1,687 kg/ha (Anonymous, 2021a). The crop thrives in cool, dry climates with well-drained loamy or sandy soils rich in organic matter. In Rajasthan, major fennel-growing districts include Sirohi, Tonk, Jodhpur, Baran, Pali, Bikaner, Dausa, Alwar, Sawai Madhopur, and Jaipur. The state covered 28.10 thousand hectares under fennel cultivation, producing 29.30 thousand metric tonnes with a productivity of 1,089 kg/ha during 2022–23 (Anonymous, 2022-23b). Fennel seeds are nutritionally rich, containing 9.5% protein, 10.0% fat, 18.5% crude fiber, 42.3% carbohydrates, 13.4% minerals, along with vitamins and volatile oil ranging from 2.17% to 2.60% (Pruthi, 1976). Several insect pests affect fennel crops, especially sap-sucking insects such as aphids (*Hyadaphis coriandri* Das, *Aphis gossypii*), jassids (*Empoasca kerri*), thrips (*Thrips tabaci*, *Thrips flavus*, *Scirtothrips dorsalis*), Lygus bugs, seed midges (*Systole coriandri*, *Systole spp.*), pentatomid bugs (*Calcoris noregicus*), and fennel flower bugs (*Otinotus bipennis*). Among these, aphids, particularly *H. coriandri*, cause the most damage. *Hyadaphis coriandri*, from the family Aphididae, order

Hemiptera, and suborder Homoptera, damages the crop in both nymph and adult stages by sucking sap from tender stems, leaves, inflorescences, and developing seeds. They also excrete honeydew, which promotes fungal growth. Rapid population growth enables them to quickly infest apical shoots, leading to leaf yellowing, curling, drying, and the formation of shriveled seeds. It is common observation that the pest population is bought down by the application of insecticides due to high initial kill of the insect pest and their natural enemies, but at the same time the surviving individuals soon built up their population because of high rate of multiplication of aphid and absence of natural enemies. Keeping in this view, (Kant *et al.,* 2013, Choudhary *et al.,* 2015, Yadav *et al.,* 2020 and Swami *et al.,* 2021) have emphasized the use of bio pesticides for the control of aphid. As such, this study included a range of different bio pesticides and plant extracts for evaluating an effective control schedule.

Materials and Methods

The experiment was conducted at the Research Farm and Laboratory of the Department of Entomology, College of Agriculture, Bikaner during the Rabi season of 2021–22. Fennel variety RF-143 was sown on 31 October 2021 in plots measuring 3.0 × 2.4 m with spacing of 40 cm between rows and 20 cm between plants. Recommended agronomic practices were followed throughout the crop season. Spraying operations were carried out using a pre-calibrated knapsack sprayer. The first spray was applied when aphid population reached economic significance, while the second spray was given fifteen days after the first application. Two sprays in total were administered during the crop period using 500 litres of water per hectare. Nine treatments including control, i.e., *Beauveria bassiana* (5 g/lit.), *Verticilium lecani* (5 g/lit.), Azadirachtin (4 ml/lit.), Neem oil 0.3 %, NSKE 5%, Khimp, *Leptadenia pyrotechnica* extract 5%, Tumba, *Citrullus colocynthis* extract 5%, and Aak, *Calotropis procera* extract 5% were selected for experimentation. The population of aphid was recorded from twenty randomly selected and tagged plants. The visits of the experimental field were made early in the morning at weekly interval to observe the occurrence of aphid regularly before and 1, 3 , 7 and 10 days after each spray. The yield of fennel seed per plot per kg was recorded at the end of season and then converted into quintal per hectare and then statistically analyzed. The statistical analysis (analysis of variance) of the data was carried out by transforming the per cent reduction data into angular transformation values (Gomez and Gomez, 1976).

Results and Discussion

The results clearly demonstrated that all tested biopesticides reduced aphid population compared with untreated control. Among the treatments, *Verticillium lecanii* @ 5 g/litre was found most effective against *H. coriandari*. During the first spray, the treatment recorded 54.58 per cent reduction in aphid population, while in the second spray it showed 53.01 per cent reduction. The treatment remained statistically at par with *Beauveria bassiana* @ 5 g/litre and Azadirachtin @ 4 ml/litre.The treatments tested in the present study were not evaluated earlier against aphid on fennel. Hence, the efficacy of these treatments tested on other relevant crops discussed to support the present findings. The results are in conformity with that of Kant *et al*. (2013) evaluated the efficacy of botanical & microbials as a maximum population reduced after first and second.

Table 1: Bioefficacy of different biopesticide against *H. coriandari* on fennel during *Rabi*, 2021-22 (First spray).

S. No.	Treatments	Doses (ml or gm/litre)	Per cent reduction in aphid population days after spray			
			1 Days	3 Days	7 Days	10 Days
1	*Beauveria bassiana*	5gm/ltr.	62.14 (52.12)	69.87 (56.82)	72.96 (58.76)	53.36 (45.21)
2	*Verticilium lecani*	5gm/ltr.	64.30 (53.36)	72.63 (58.60)	74.67 (59.90)	54.58 (46.74)
3	Azadirachtin	4ml/ltr.	48.64 (44.21)	54.43 (47.56)	57.75 (49.51)	33.92 (38.09)
4	NSKE	5%	47.59 (43.61)	52.34 (46.35)	56.72 (48.95)	33.04 (35.88)
5	Neem oil	0.3%	46.40 (42.89)	51.59 (45.91)	55.03 (47.91)	32.10 (35.40)
6	Tumba extract	5%	32.45 (34.71)	38.82 (38.47)	38.56 (38.37)	15.94 (24.57)
7	Aak extract	5%	28.71 (32.24)	37.22 (37.50)	35.37 (36.36)	14.45 (23.46)

8	Khimp extract	5%	30.67 (33.52)	38.43 (38.15)	36.45 (37.09)	15.41 (24.22)
9	Untreated control	-	0.00	0.00	0.00	0.00
	S.Em±		**2.56**	**2.73**	**2.88**	**1.98**
	CD at 5 %		**7.61**	**8.11**	**8.56**	**5.89**
	CV		**10.55**	**10.24**	**10.59**	**10.27**

* Figures in parenthesis are angular transformed values

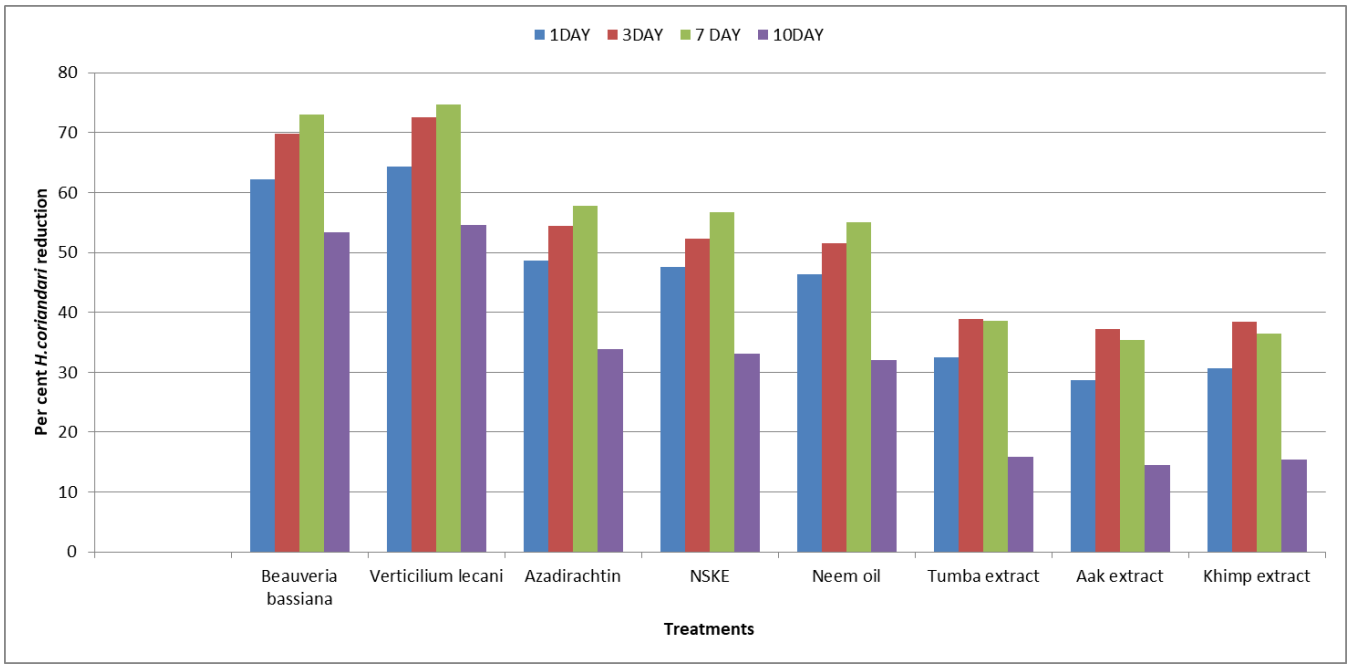

Fig. 1 : Bio-efficacy of different bio pesticide against *H. coriandari* on fennel during *Rabi*, 2021-22 (First spray)

Table 2: Bioefficacy of different biopesticide against *H. coriandari* on fennel during *Rabi*, 2021-22 (Second application).

S. No.	Treatments	Doses (ml or gm/litre)	Per cent reduction in aphid population days after spray			
			1 Days	3 Days	7 Days	10 Days
1	*Beauveria bassiana*	5gm/ltr.	60.19 (50.96)	67.82 (55.53)	73.55 (59.07)	50.40 (45.21)
2	*Verticilium lecani*	5gm/ltr.	62.35 (52.19)	70.58 (57.27)	75.47 (60.43)	53.01 (46.74)
3	Azadirachtin	4ml/ltr.	46.69 (43.08)	52.38 (46.37)	55.60 (48.25)	38.17 (38.09)
4	NSKE	5%	45.64 (42.48)	50.29 (45.16)	54.57 (47.67)	34.43 (35.88)
5	Neem oil	0.3%	44.45 (41.75)	49.54 (44.73)	52.88 (46.66)	33.58 (35.40)
6	Tumba extract	5%	30.50 (33.51)	35.12 (36.25)	36.41 (37.09)	17.35 (24.57)
7	Aak extract	5%	26.76 (30.97)	30.38 (33.24)	33.22 (35.04)	15.94 (23.46)
8	Khimp extract	5%	28.72 (32.28)	34.52 (35.93)	34.30 (35.79)	16.90 (24.22)
9	Untreated control	-	0.00	0.00	0.00	0.00
	S.Em±		2.58	2.65	2.83	2.20
	CD at 5 %		7.66	7.86	8.42	6.54
	CV		10.91	10.34	10.61	11.14

* Figures in parenthesis are angular transformed values

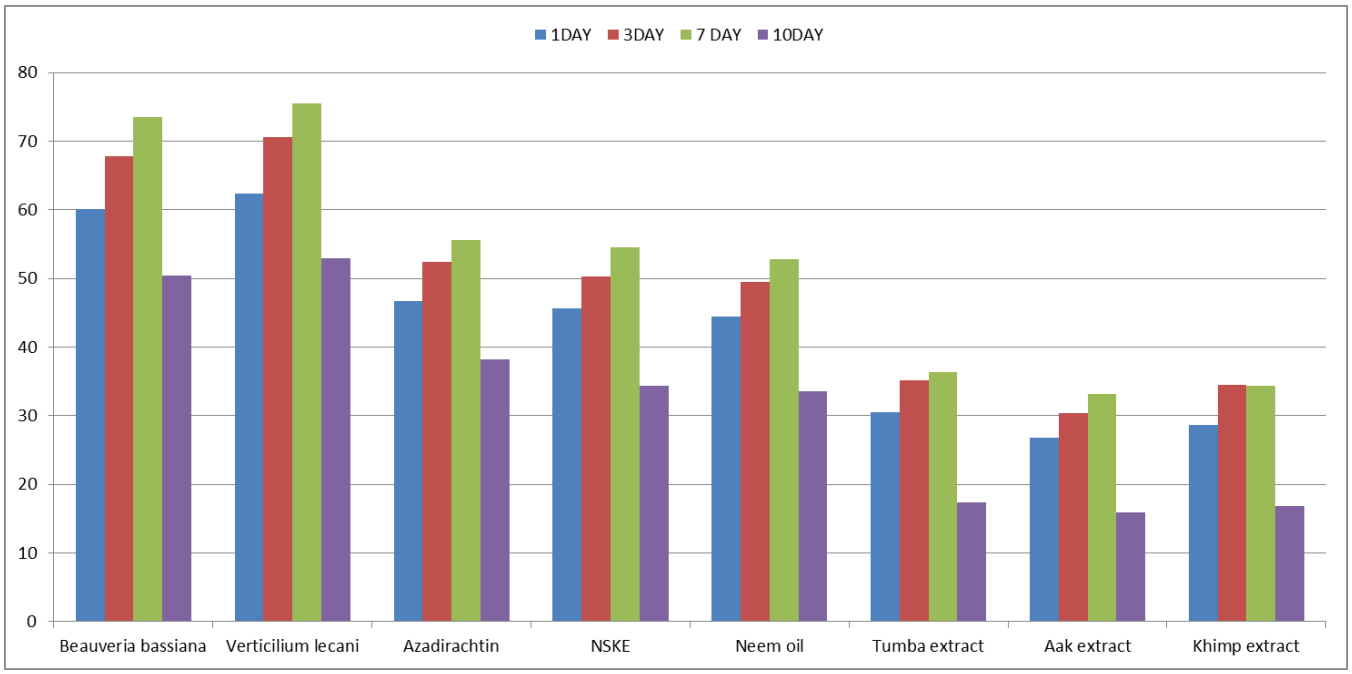

Fig. 2 : Bio-efficacy of different bio pesticide against *H. coriandari* on fennel during *Rabi*, 2021-22 (Second spray).

spray of *Beauveria bassiana.* Studies conducted by Devi *et al.* (2008) revealed neemarin (0.2%) as a most effective treatment against aphid followed by NSKE and neem leaf extract support the present findings. Basavaraju *et al.* (2015) found that NSKE was found good in reducing *M. persicae* population which was support the present findings. The minimum reduction in *H. coriandari* population was recorded in plots treated with aak extract, khimp extract and tumba extract. The present results are in agreement that of Meena *et al*. (2016) who reported that dhatura extract was least effective treatment against *M. persicae* and *H. coriandari*. The other treatments of azadirachtin , NSKE and neem oil were in the moderate order of efficacy. Choudhary (2015) who reported that different Neem based bio pesticides against *H. coriandari* found most effective *viz.*, Azadirachtin found most effective and Neem oil & NSKE showed moderate efficacy. Pareek (2009), Sachan *et al.* (2010), Bana *et al*. (2011) and Choudhary *et al.* (2015), also found that neem oil, azadirachtin and NSKE were moderately effective against aphid, *H. coriandari* support the present findings.

Table 3 : Comparative economics and incremental cost benefit ratio of different treatments during *Rabi*, 2021-22

S. No.	Treatments	Conc. (%) /Doses (ml or gm/litre)	Mean yield (q ha^{-1})	Increase yield over control (q ha^{-1})	Return increased yield (Rs. /ha*)	Total cost of protection (Rs./ha**)	Net profit (Rs./ha)	Incremental benefit cost ratio
1	*Beauveria bassiana*	5gm	11.90	3.5	37100	5000	32100	6.42
2	*Verticilium lecani*	5gm	12.10	3.7	39220	4000	35220	8.80
3	Azadirachtin	4ml	11.25	2.85	30210	4800	25410	5.29
4	NSKE	5%	10.93	2.53	26818	6000	20818	3.46
5	Neem oil	0.3%	10.38	1.98	20988	3350	17638	5.26
6	Tumba extract	5%	10.15	1.75	18550	4000	14550	3.63
7	Aak extract	5%	9.22	0.82	8692	4000	4692	1.17
8	Khimp extract	5%	9.83	1.43	15158	4000	11158	2.78
9	Untreated control	-	8.40	-	-	-	-	-

*Cost of seed grains of fennel at current season was Rs.= 10600 per quintal
**Includes cost bio pesticides and labour charges only

[Table 3 reveals that The maximum net profit of Rs.35220 was recorded from the treatment of *Verticilium lecani* followed by *Beauveria bassiana* Rs.32100. The lowest net profit of Rs. 4692 was obtained from Aak extract treated plot which followed by Khimp extract and Tumba extract with net profit of

Rs.11158 and 14550 respectively. The net profit of Rs.17638, 20818 and 25410 was obtained from the treatment of Neem oil, NSKE and Azadirachtin respectively. The maximum profit was recorded from the plots treated with *Verticilium lecani* (5gm/ltr.) which gave benefit cost ratio of 8.80, followed by *Beauveria bassiana* (5gm/ltr.) of 6.42. The benefit cost ratio of 5.29, 3.46 and 5.26 were recorded in the treatment of Azadirachtin(4ml/ltr.), NSKE and Neem oil, respectively. The lowest benefit cost ratio of 1.17 was recorded in the treatment of Aak extract (5%) followed by Khimp extract (5%) and Tumba extract (5%) with a benefit cost ratio of 2.78 and 3.63 respectively. Swami *et al*. (2021) reported that benefit cost ratio was 7.01, 5.90 and 5.30 was obtained in the treatment of *Metarhizium anisopliae*, NSKE and Neem oil respectively. The minimum benefit cost ratio was recorded in aak extract (1.17) followed by khimp extract (2.78) and NSKE (3.46). Jat *et al*. (2009) who reported the lowest benefit cost ratio in the treatment of Neem products *viz*., NSKE, neem oil and margocide-CK 20EC. And Bana *et al*. (2011) also recorded the lowest benefit cost ratio in neem products *viz*., Azadirachtin 20EC and NSKE, support the present findings.

Table 4 : Effect of biopesticides treatments on seed yield of fennel during *Rabi*, 2021-22

S. No.	Treatments	Conc. (%) / Doses (ml or gm/litre)	Mean Yield (q ha^{-1})
1	*Beauveria bassiana*	5gm	11.90
2	*Verticilium lecani*	5gm	12.10
3	Azadirachtin	4ml	11.25
4	NSKE	5%	10.93
5	Neem oil	0.3%	10.38
6	Tumba extract	5%	10.15
7	Aak extract	5%	9.22
8	Khimp extract	5%	9.83
9	Untreated control	-	8.40
	S.Em.±		**0.619**
	CD at 5 %		**1.870**

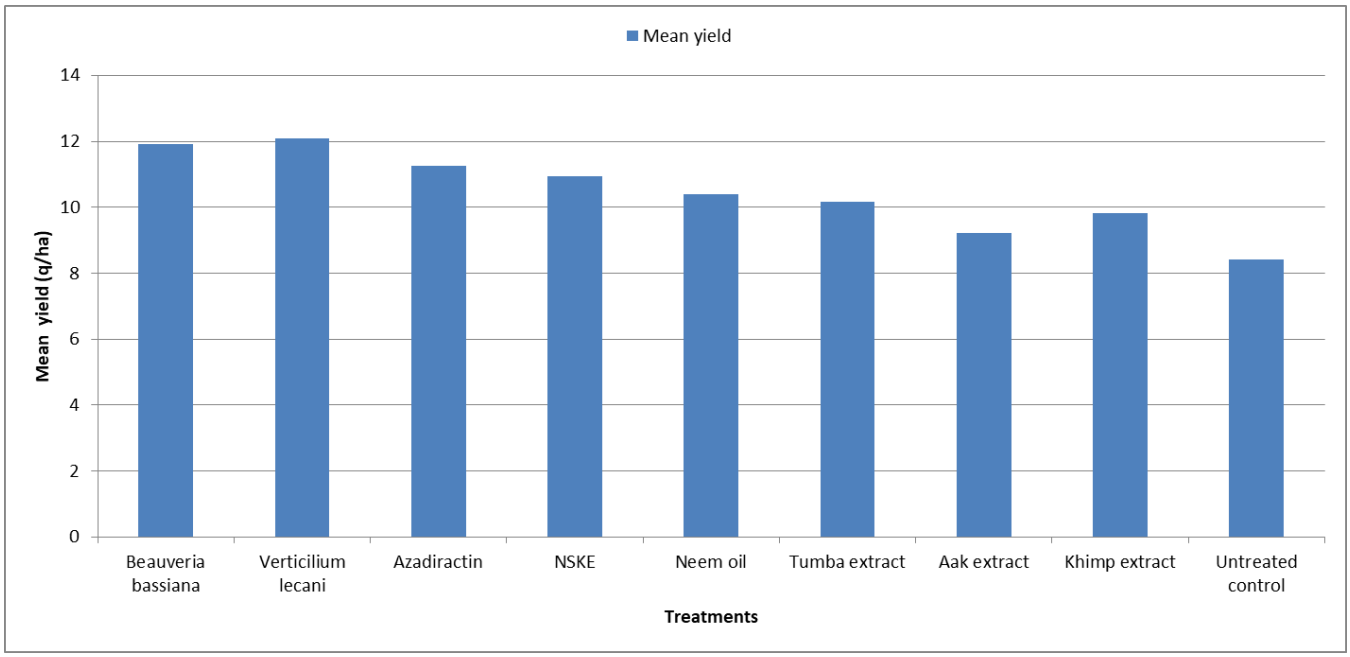

Fig. 3: Effect of bio pesticides treatments on seed yield of fennel during *Rabi*, 2021-22

The highest seed yield of 12.10 q/ha was recorded in plots treated with *Verticillium lecanii* @ 5 g/litre. This treatment was statistically comparable with *Beauveria bassiana* @ 5 g/litre, which yielded 11.90 q/ha. Azadirachtin, NSKE, and neem oil treatments produced seed yields of 11.25, 10.93, and 10.38 q/ha,

respectively. The lowest seed yield (9.22 q/ha) was obtained in plots treated with Aak extract. Khimp extract and Tumba extract also produced comparatively lower yields. The increase in seed yield under effective treatments may be attributed to reduced aphid infestation and healthier crop growth. Similar observations have been reported earlier where *Verticillium lecanii* and *Beauveria bassiana* significantly improved fennel seed yield.

Conclusions

The investigation indicated that *Verticillium lecanii* @ 5 g/litre was the most effective treatment for managing fennel aphid, *Hyadaphis coriandari*. The treatment significantly reduced aphid infestation and produced maximum seed yield along with the highest economic returns. *Beauveria bassiana* and Azadirachtin also proved effective and may be recommended as eco-friendly alternatives for aphid management in fennel cultivation. The study highlights the importance of biopesticides in sustainable pest management and supports their use as safer substitutes to chemical insecticides.

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Conflict of Interest

All authors declare that they have no direct or indirect conflict of interest related to the present research work.

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