Crossref
IJBSM April 2025, 16(4): 01-08
Article AR5589
Research Article
Stress Management
DOI: HTTPS://DOI.ORG/10.23910/1.2025.5589

Evaluation of Various Combination of Insecticidal Seed Treatments and Biopesticides Foliar Application against Aphid Infesting Coriander

A. H. Barad[1], H. N. Prajapati[1], N. P. Trivedi[1] and R. D. Dodiya[2]

[1]Dept. of Plant Protection, College of Horticulture, Anand Agricultural University, Anand, Gujarat (388 110), India
[2]Dept. of Entomology, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat (385 506), India

Open Access

Corresponding anilbarad@aau.in

0009-0004-0057-7085

ABSTRACT

The field experiment was carried at Horticulture Farm, College of Horticulture, Anand Agricultural University, Anand during *rabi*, (November–February, 2019–20 and November–February, 2020–21) following randomized block design (factorial) with three replications and twelve different treatments. Present need in agriculture is not only getting higher production but also safety to environment and pollinators along with the management of insect-pests. Coriander is one of the important spices grown in India of which green leaves are utilised for culinary purpose and seeds in almost all Indian foods as an essential spice. A soft-bodied insect-pest, aphid infests the crop during its vegetative stage and umbel formation sucking cell-sap from tender shoots as well as seeds ultimately reducing their quality affecting yield. Insecticidal sprays have become very essential and frequent to mitigate aphids which also prove extremely harmful to flower visiting pollinators. With a view to reduce the load and dependency on chemical insecticides along with encouraging a healthy and safe agricultural ecosystem for pollinators and human beings, current experiment was formulated to test different chemical insecticides as seed treatments and biopesticides as foliar sprays as well as their combinations. The results show that use of chemical insecticide, imidacloprid 48 FS as seed treatment along with two foliar applications of *Lecanicillium lecanii* 1.15 WP can be effective in management of aphids as well as getting higher return in coriander.

KEYWORDS: Coriander aphid, seed treatments, biopesticides, sustainable management

Citation* (VANCOUVER)*: Barad et al., Evaluation of Various Combination of Insecticidal Seed Treatments and Biopesticides Foliar Application against Aphid Infesting Coriander. *International Journal of Bio-resource and Stress Management,* 2025; 16(4), 01-08. HTTPS://DOI.ORG/10.23910/1.2025.5589.

Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

Conflict of interests: The authors have declared that no conflict of interest exists.

RECEIVED on 04th July 2024 RECEIVED in revised form on 10th March 2025 ACCEPTED in final form on 29th March 2025 PUBLISHED on 08th April 2025

1. INTRODUCTION

Spices have significant importance in various aspects of life, including culinary, medicinal, cultural, economic, and spiritual uses. Coriander is regarded as a medicinal herb in traditional medicine due to its diverse properties, including anti-diuretic, anti-diabetic, anti-hypertensive, aphrodisiac, anti-microbial, antioxidant, analgesic, anti-inflammatory, and anti-asthmatic effects (Thakur et al., 2021). They add flavour and aroma to food, have medicinal properties and play a significant role in cultural and religious ceremonies, trade and beauty practices. In India, spices were grown under 44.87 lakh ha area with total production of 108.14 lakh MT of which the production of coriander was 8.24 lakh mt in 6.39 lakh ha area (Anonymous, 2023).

Coriander (*Coriandrum sativum* Linnaeus), a seed spice also known as dhania, is widely used in cooking and medicine. The states of Rajasthan and Gujarat are major producers of seed spices in India, contributing more than 80% of the country's total (Mali et al., 2022).

The sucking insect-pests are the limiting factors for higher production as well as good quality seeds. Aphids are the leading yield-limiting factor in coriander as well as other seed spices. Their feeding not only stunts plant growth but also transmits plant viruses, further exacerbating the damage. Consequently, effective management of aphids and other sucking pests is crucial for maintaining healthy crops and ensuring optimal yields (Yadav et al., 2023). Coriander crop is mainly infested by three species of aphids *i.e.*, *Hyadaphis corianderi* (Das), *Myzus persicae* (Sulzer) and *Aphis craccivora* (Koch) which belong to order hemiptera and family aphididae (Kumar et al., 2023; Chaudhary et al., 2015; Choudhary et al., 2013; Chaudhary et al., 2009).

It feeds by sucking the cell sap from inflorescence as well as umbel during growing season (Patel et al., 2021; Regar et al., 2022; Kala et al., 2023). *Aphis gossypii* Glover was also recorded as a pest of coriander for the first time under Gujarat conditions (Ghetiya and Butani, 1995). Aphids rapidly multiply and completely engulf new growth on coriander plants. Their constant feeding weakens the plant, causing leaves to turn yellow, curl up and dry out. They also secrete honey dew and leave a sticky residue that promotes the growth of sooty mold, further hindering the plant's ability for photosynthesis. Heavy infestations can even cause the umbels to droop and deform the seeds (Meena et al., 2016; Swami et al., 2022; Nair et al., 2021; Steinhaus, 1949). Thus, it is posing a threat to coriander cultivations.

Farmers are often unaware of the quality issues affecting cumin exports. They follow the chemical usage recommendations of local traders, which leads to residual effects on cumin seeds, causing samples to fail quality tests (Gondalia et al., 2019). The demand for organic seed spices is rising and is expected to grow in the future, but currently, there is an insufficient supply of organically produced cumin seeds to meet this demand (Choudhary et al., 2024). While synthetic insecticides can be effective against aphids, they harm honeybees and other beneficial insects that naturally control aphid populations (Ndakidemi et al., 2016; Calvo-Agudo et al., 2021; Shonga and Getu, 2021). Additionally, since coriander is a low-input crop with high export potential and also used for food; using expensive and persistent insecticides is not at all advisable.

Today's focus on environmental protection has led to a growing interest in biopesticides. Unlike synthetic chemical insecticides, biopesticides are naturally derived and pose minimal harm to beneficial insects and the environment. Given the significant damage aphids can cause to coriander, this study investigated the effectiveness of various biopesticides as a management strategy.

2. MATERIALS AND METHODS

2.1. Study sites

A two years field experiment was carried out on coriander (*cv.* Gujarat Coriander 2) by adopting all standard agronomical practices at Horticulture Farm, College of Horticulture, Anand Agricultural University, Anand, Gujarat, India during *rabi*, (November–February, 2019–20 and 2020–21) following randomized block design (factorial) with three replications and twelve different treatments (Table 1).

Table 1: Treatments utilized in the experiment

Sl. No.	Treatments		Dose	Quantity required (ml or g 10 l^{-1})
Factor-S (Seed treatment)				
1.	Imidacloprid 48 FS	S_1	7.5 ml kg^{-1}	-
2.	Thiamethoxam 30 FS	S_2	7.5 ml kg^{-1}	-
3.	Control (without seed treatment)	S_3	-	-
Factor-F (Foliar application)				
1.	*Beauveria bassiana* 1.15 WP (1×10^9 cfu g^{-1})	F_1	1.60 kg ha^{-1}	40
2.	*Metarhizium anisopliae* 1.15 WP (1×10^9 cfu g^{-1})	F_2	1.60 kg ha^{-1}	40
3.	*Lecanicillium lecanii* 1.15 WP (1×10^9 cfu g^{-1})	F_3	1.60 kg ha^{-1}	40
4.	Control	F_4	-	-

Note: 400-liter water ha^{-1} was used in the spray solution

2.2. Methodology and data collection

For seed treatment, slurry of insecticides was prepared in a way that the final volume of the mixture of the chemical (as per dose mentioned) and water was 25 ml to treat 1 kg of seeds. Coriander seeds were treated in a polythene bag followed by air dry in shade before sowing.

First spray was made at initiation of aphid population and second spray after 10 days of first spray by using manually operated knapsack sprayer. The population of aphids was recorded before first spray as well as 3, 7 and 10 days after each spray. For the purpose, five plants were selected randomly from each net plot area. For each plant, three top shoots each of 5 cm were observed critically by adopting standard method of zero to four indices (Patel et al., 2011).

Indices	Description
0	Plant free from aphids
1	Aphids present but colonies were not builds up
2	Small colonies of aphid present
3	Large colonies of aphid present on tender parts (counting of the aphid colonies was possible and tender plant parts show the damage symptoms due to aphids)
4	Entire plants were covered by aphids (counts of aphids in colonies was impossible and plants show the damage symptoms due to aphids) and finally plant dies

The average aphid index was worked out by following formula

Average aphid index=0N+1N+2N+3N+4N/total number of plants observed……………………….(1)

Where,

0, 1, 2, 3, 4 are aphid index

N=number of plants showing respective aphid index

The data thus obtained were statistically analyzed after adopting square root transformation.

3. RESULTS AND DISCUSSION

3.1. Seed treatments and foliar applications

The aphid population was homogeneous in all the treatments before spray as differences among the treatments were non-significant.

The data on pooled over periods of first application indicated that the effect of seed treatments was non-significant but foliar application of *L. lecanii* 1.15 WP found the most effective in comparison with other treatments and recorded minimum (22.34 aphids 3 shoots^{-1}) aphid population (Table 2). Among various interaction effect of seed treatments and foliar applications of biopesticides, interaction effect (S1F3) of seed treatment with imidacloprid 48 FS and foliar application of *L. lecanii* 1.15 WP found most effective than rest of the interaction effects and recoded minimum (15.74 aphids 3 shoots^{-1}) population of aphids (Table 3).

The data on pooled over periods of second spray also exhibited a non-significant effect of various seed treatments (Table 2) but the foliar application of *L. lecanii* 1.15 WP recorded minimum (9.11 aphids 3 shoots^{-1}) aphid

Table 2: Evaluation of seed treatments and foliar applications against aphid in coriander (Pooled: 2019–20 and 2020–21)

Treatments	No. of aphid(s) 3 shoots^{-1} at indicated days after application									Pooled over periods, applications and years
		First application			Pooled over periods	Second application			Pooled over periods	
	Before	5 DAA	7 DAA	10 DAA		5 DAA	7 DAA	10 DAA		
Factor–S (Seed treatment)										
Imidacloprid 48 FS	7.49 (55.60)	6.29 (39.06)	4.93 (23.80)	4.48 (22.92)	5.23 (26.85)	4.00 15.50)	3.78 (13.78)	3.58 (12.31)	3.79 13.86)	4.51 (19.84)
Thiamethoxam 30 FS	7.53 (56.20)	6.57 (42.66)	5.78 (32.90)	5.38 (28.44)	5.90 (34.31)	4.73 (21.87)	4.46 (19.39)	4.17 (16.88)	4.45 (19.30)	5.18 (26.33)
Control (without seed treatment)	7.61 (57.41)	6.83 (46.14)	6.21 (38.06)	5.73 (32.33)	6.26 (38.68)	5.29 (27.48)	5.03 (24.80)	4.76 (22.15)	5.03 (24.80)	5.64 (31.30)
SEm± (S)	0.12	0.09	0.16	0.18	0.13	0.15	0.18	0.15	0..16	0.15
CD (p=0.05) (S)	NS	0.26	NS	NS	NS	NS	NS	NS	NS	NS
Factor-F (Foliar application)										
Beauveria bassiana 1.15 WP (1×10^9 cfu g^{-1})	7.53 (56.20)	6.68 (44.12)	5.70 (31.99)	5.22 (26.74)	5.87 (33.95)	4.65 (21.12)	4.35 (18.42)	4.03 (15.74)	4.35 (18.42)	5.11 (25.61)
Metarhizium anisopliae 1.15 WP (1×109 cfu g^{-1})	7.52 (56.05)	6.25 (38.56)	5.18 (26.33)	4.64 (21.02)	5.36 (28.22)	4.03 (15.74)	3.69 (13.11)	3.34 (10.65)	3.69 (13.11)	4.52 (19.93)

Table 2: Continue...

Treatments	No. of aphid(s) 3 shoots^{-1} at indicated days after application									Pooled over periods, applications and years
	First application				Pooled over periods	Second application			Pooled over periods	
	Before	5 DAA	7 DAA	10 DAA		5 DAA	7 DAA	10 DAA		
Lecanicillium lecanii 1.15 WP (1×109 cfu g^{-1})	7.50 (55.75)	5.85 (33.72)	4.50 (19.75)	3.99 (15.42)	4.78 (22.34)	3.34 (10.65)	3.14 (9.35)	2.80 (7.34)	3.10 (9.11)	3.94 (15.02)
Control	7.63 (57.71)	7.46 (55.15)	7.17 (50.90)	6.93 (47.52)	7.19 (51.19)	6.66 (43.85)	6.50 (41.75)	6.51 (41.80)	6.74 (44.92)	6.87 (46.69)
SEm± (F)	0.14	0.10	0.10	0.08	0.09	0.09	0.08	0.16	0.13	0.14
CD (p<0.05) (F)	NS	0.31	0.28	0.25	0.43	0.28	0.24	0.72	0.74	0.51
S×F	NS	NS	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
CV %	8.08	7.02	7.59	7.20	7.17	8.96	8.17	7.45	8.06	7.64

Figures in parentheses are retransformed values; those outside are √(x+0.5) transformed values; DAA: Days After Application, NS: Non-significant, Sig.: Significant; Significant parameters and their interactions: Y, SP, P, F, Y×SP, Y×F, S×SP, F×SP, P×S, F×P and Y×SP×P

Table 3: Interaction effect of seed treatments and foliar applications on aphid in coriander (Pooled: 2019–20 and 2020–21)

Interaction factor	No. of aphid(s) 3 shoots^{-1} at indicated days after application							Pooled over periods, applications and years
	First application			Second application				
	7 DAA	10 DAA	Pooled over periods	5 DAA	7 DAA	10 DAA	Pooled over periods	
S_1F_1	4.80 (22.54)	4.26 (17.64)	5.15 (26.02)	3.67 (12.96)	3.36 (10.78)	3.03 (8.68)	3.36 (10.78)	4.26 (17.64)
S_1F_2	4.29 (17.90)	3.70 (13.19)	4.64 (21.02)	3.14 (9.35)	2.90 (7.91)	2.68 (6.68)	2.91 (7.96)	3.77 (13.71)
S_1F_3	3.54 (12.03)	3.12 (9.23)	4.03 (15.74)	2.70 (7.29)	2.47 (5.60)	2.20 (4.34)	2.46 (5.55)	3.25 (10.06)
S_1F_4	7.09 (49.76)	7.05 (49.20)	7.11 (50.05)	6.79 (45.60)	6.61 (43.19)	6.49 (41.62)	6.42 (40.71)	6.76 (45.19)
S_2F_1	6.16 (37.44)	5.72 (32.21)	6.21 (38.06)	5.04 (24.90)	4.77 (22.25)	4.36 (18.50)	4.73 (21.87)	5.47 (29.42)
S_2F_2	5.28 (27.37)	4.91 (23.60)	5.51 (29.86)	4.11 (16.39)	3.77 (13.71)	3.30 (10.39)	3.73 (13.41)	4.62 (20.84)
S_2F_3	4.60 (20.66)	4.07 (16.06)	4.84 (22.92)	3.36 (10.78)	3.10 (9.11)	2.83 (7.51)	3.10 (9.11)	3.97 (15.26)
S_2F_4	7.05 (49.20)	7.11 (50.05)	7.07 (49.48)	6.58 (42.79)	6.45 (41.10)	6.38 (40.20)	6.35 (39.82)	6.66 (43.85)
S_3F_1	6.14 (37.19)	5.68 (31.76)	6.47 (40.96)	5.24 (26.95)	4.93 (23.80)	4.69 (21.49)	4.95 (24.00)	5.60 (30.86)
S_3F_2	5.96 (35.02)	5.30 (27.59)	5.92 (34.54)	4.83 (22.82)	4.39 (18.77)	4.05 (15.90)	4.42 (19.03)	5.17 (26.22)
S_3F_3	5.35 (28.12)	4.76 (22.15)	5.47 (29.42)	3.98 (15.34)	3.85 (14.32)	3.37 (10.85)	3.74 (13.48)	4.60 (20.66)
S_3F_4	7.37 (53.81)	7.18 (51.05)	7.29 (52.64)	7.04 (49.06)	6.94 (47.66)	6.95 (47.80)	7.00 (48.50)	7.05 (49.20)
SEm± (S×F)	0.17	0.15	0.09	0.17	0.14	0.12	0.14	0.14
CD (p<0.05)	0.50	0.43	0.27	0.49	0.42	0.36	0.40	0.39
CV (%)	7.59	7.20	7.17	8.96	8.17	7.45	8.06	7.64

Figures in parentheses are retransformed values; those outside are √(x+0.5) transformed values; DAA: Days After Application, NS: Non-significant

population and it was at par with foliar application of *Metarhizium anisopliae* 1.15 WP (13.11 aphids 3 shoots^{-1}). Among the various interaction effect of seed treatment and foliar applications of biopesticides, interaction effect (S_1F_3) seed treatment with imidacloprid 48 FS and foliar application of *L. lecanii* 1.15 WP found most effective than the other interaction effect and recoded minimum (5.55 aphids 3 shoots^{-1}) population of aphids (Table 3).

The data on pooled over periods, applications and years revealed that seed treatments effect was found non-significant (Table 2). In foliar application of biopesticides, *L. lecanii* 1.15 WP found most effective than other treatments and recorded minimum (15.02 aphids 3 shoots^{-1}) aphid population. Among various interaction effect of seed treatment and foliar application of biopesticides, interaction effect (S_1F_3) of seed treatment with imidacloprid 48 FS and foliar application of *L. lecanii* 1.15 WP found most effective than the other interaction effect and recoded minimum (10.06 aphids 3 shoots^{-1}) population of aphids (Table 3).

3.2. Seed yield

The data on coriander seed yield revealed that the highest (1263 kg ha^{-1}) seed yield recorded in seed treatment with imidacloprid 48 FS (Table 4) and it was at par with thiamethoxam 30 FS (1183 kg ha^{-1}). While, in foliar application highest seed yield recorded in *L. lecanii* 1.15 WP (1353 kg ha^{-1}) and it was at par with *Metarhizium anisopliae* 1.15 WP (1252 kg ha^{-1}). Of all the interaction effects, the highest (1460 kg ha^{-1}) seed yield was recorded in the interaction of seed treatment with imidacloprid 48 FS+foliar application of *L. lecanii* 1.15 WP but result was found non-significant (Table 5).

Table 4: Effect of seed treatments and foliar applications on coriander yield (Pooled: 2019–20 and 2020–21)

Treatments		Seed yield (kg ha^{-1})		
		2019–20	2020–21	Pooled
Factor-S (Seed treatment)				
Imidacloprid 48 FS		1246	1280	1263
Thiamethoxam 30 FS		1195	1171	1183
Control (without seed treatment)		1078	1082	1080
SEm±	(S)	41.00	49.00	32.00
CD (p<0.05)	(S)	120.00	144.00	92.00
Factor-F (Foliar application)				
Beauveria bassiana 1.15 WP (1×10^{9} cfu g^{-1})		1110	1124	1117
Metarhizium anisopliae 1.15 WP (1×10^{9} cfu g^{-1})		1258	1246	1252
Lecanicillium lecanii 1.15 WP (1×10^{9} cfu g^{-1})		1349	1355	1353
Control		975	986	980
SEm±	(F)	48.00	57.00	37.00
CD (p<0.05)	(F)	139.00	167.00	105.00
S×F		NS	NS	NS
CV %		12.09	14.44	13.33

Note: NS: Non-significant

Table 5: Interaction effect of seed treatments and foliar applications on coriander yield (Pooled: 2019–20 and 2020–21)

Interaction factor		Seed yield (kg ha^{-1})		
		2019–20	2020–21	Pooled
S_1F_1		1162	1184	1173
S_1F_2		1398	1399	1399
S_1F_3		1433	1488	1460
S_1F_4		988	1053	1020
S_2F_1		1102	1072	1087
S_2F_2		1271	1230	1251
S_2F_3		1406	1366	1386
S_2F_4		997	1016	1006
S_3F_1		1066	1116	1091
S_3F_2		1104	1111	1108
S_3F_3		1206	1210	1208
S_3F_4		935	891	913
SEm±	(S×F)	81.87	90.53	64.27
CD (p<0.05)		NS	NS	NS
CV (%)		12.09	13.01	13.33

NS: Non-significant

3.3. Economics

The seed treatment of imidacloprid 48 FS registered the highest (1: 8.70) ICBR followed by thiamethoxam 30 FS (1: 8.65). In foliar application of biopesticides, *L. lecanii* 1.15 WP exhibited the highest (1: 8.04) ICBR followed by *Metarhizium anisopliae* 1.15 WP (1: 5.31). Among the various interaction effects, interaction of seed treatment with imidacloprid 48 FS+foliar application of *L. lecanii* 1.15 WP registered the highest (1: 10.19) ICBR (Table 6).

Prajapati et al. (2018) found the least (5.95%) per cent aphid infestation in the plots treated with imidacloprid 600 FS @ 7 ml kg^{-1} seeds at 60 days after sowing followed by thiamethoxam 30 FS @ 7 ml kg^{-1} seeds (7.96%). Seed treatment of thiamethoxam 70 WS @ 4.2 g kg^{-1} seeds can also manage aphids in coriander with cost benefit ratio of 1:4.94 (Anonymous, 2006).

Among different botanicals and biopesticides, *Metarhizium anisopliae* @ 1 g l^{-1} (77.51%) and *Verticillium lecanii* @ 1 g l^{-1} (75.79%) were found with the highest reduction in aphid population in coriander as well as benefit cost ratio of 7.01 and 4.34, respectively (Swami et al., 2022). Nair et al. (2021) recorded lower (5.59%) aphid population in the plots sprayed twice with *L. lecanii* 1.15 WP (1×10^{9} cfu g^{-1}) (40 g 10 l^{-1}) as compared to control (7.95%) and also achieved the highest (12.02 q ha^{-1}) seed yield in coriander. Prajapati and Amin (2019), considering only biopesticides, found lower

Table 6: Economics of seed treatments and foliar applications of biopesticides against aphid on coriander

Tr. No.	Treatments	QST	Cost of treatments (₹ ha^{-1})	Labour cost (₹ ha^{-1})	Total cost of plant protection (₹ ha^{-1})	Seed yield (kg ha^{-1})	Net gain over control (kg ha^{-1})	Realization (₹ ha^{-1})	ICBR
1	Seed treatment of Imidacloprid 48 FS+Foliar application of *Beauveria bassiana* 1.15 WP	150+3.2	855+528 =1383	2374	3757	1173	260	19670	1:5.24
2	Seed treatment of Imidacloprid 48 FS+Foliar application of *Metarhizium anisopliae* 1.15 WP	150+3.2	855+528 =1383	2374	3757	1399	486	34020	1:9.06
3	Seed treatment of Imidacloprid 48 FS+Foliar application of *Lecanicillium lecanii* 1.15 WP	150+3.2	855+528 =1383	2374	3757	1460	547	38290	1:10.19
4	Seed treatment of Imidacloprid 48 FS	150	855	333	861	1020	107	7490	1:8.70
5	Seed treatment of Thiamethoxam 30 FS+Foliar application of *Beauveria bassiana* 1.15 WP	150+3.2	420+528 =948	2374	3322	1087	174	12180	1:3.67
6	Seed treatment of Thiamethoxam 30 FS+Foliar application of *Metarhizium anisopliae* 1.15 WP	150+3.2	420+528 =948	2374	3322	1251	338	23660	1:7.12
7	Seed treatment of Thiamethoxam 30 FS+Foliar application of *Lecanicillium lecanii* 1.15 WP	150+3.2	420+52 =948	2374	3322	1386	473	33110	1:9.97
8	Seed treatment of Thiamethoxam 30 FS	150	420	333	753	1006	93	6510	1:8.65
9	Foliar application of *Beauveria bassiana* 1.15 WP	3.2	528	2041	2569	1091	178	12460	1:4.85
10	Foliar application of *Metarhizium anisopliae* 1.15 WP	3.2	528	2041	2569	1108	195	13650	1:5.31
11	Foliar application of *Lecanicillium lecanii* 1.15 WP	3.2	528	2041	2569	1208	295	20650	1:8.04
12	Control	-	-	-	-	913	-	-	-

QST: Quantity of seed treatments (ml kg^{-1} of seed ha^{-1}) & foliar application of biopesticides for 2 applications (kg ha^{-1}); Labour charges @ ₹ 332.20 day^{-1}×2 labour=664.40 ₹ ha^{-1} and 178 day-1×2 labour=356 ₹ ha-1 664.4+356=1020.40×2 spray=2041; Price of coriander seed=70 ₹ kg-1; For seed treatments Labour charges @ ₹ 332.20 day^{-1}×1 labour=332.20; Cost of Imidacloprid 48 FS=5700 ₹ l^{-1}; Thiamethoxam 30 FS=2800; *Beauveria bassiana* 1.15 WP=165 ₹ kg^{-1}; *Metarhizium anisopliae* 1.15 WP=165 ₹ kg^{-1}; *Lecanicillium lecanii* 1.15 WP=165 ₹ kg^{-1}; Seed rate @ 20 kg ha^{-1}; 1US$=INR 71.59 and 72.80 (Average monthly for Feb, 2020 and 2021, respectively)

(1.96) mean aphid index in the plots sprayed with [*L. lecanii* 1.15 WP and *Beauveria bassiana* (1×10^9 cfu g^{-1})] followed by [*L. lecanii* 1.15 WP and *L. lecanii* 1.15 WP (1×10^9 cfu g^{-1})] (2.16) at 7 days after second spray in coriander as compared to control plots (3.46). The treatment of *L. lecanii* 1.15 WP and *B. bassiana* (1×10^9 cfu g^{-1}) recorded higher seed yield (1172 kg ha^{-1}) as well as ICBR (1:4.51) followed by *L. lecanii* 1.15 WP and *L. lecanii* 1.15 WP (1023 kg ha^{-1} seed yield and 1:2.08 ICBR) as compared to control plots (834 kg ha^{-1}). Earlier findings are more or less in accordance with the current investigation but slight difference in the outcomes might be due to different agro-climatic conditions, soil, variety of the crop, source of biopesticides utilised in the experiment, etc.

4. CONCLUSION

The use either any of the chemical insecticide, imidacloprid 48 FS @ 7.5 ml kg^{-1} seeds or thiamethoxam 30 FS @ 7.5 ml kg^{-1} seeds for conducting only seed treatments to manage aphids in coriander are effective similarly. But for seed treatment along with foliar spray, imidacloprid 48 FS @ 7.5 ml kg^{-1} seeds and two sprays of *L. lecanii* 1.15 WP (1×10^9 cfu g^{-1}) @ 40 g 10 l^{-1} of water can reduce aphid population as well as fetch higher return in coriander.

5. REFERENCES

Anonymous, 2006. Research recommendations for farming community. In: Proceedings of AGRESCO Report - 2006, Junagadh Agricultural University, Junagadh, pp. 19. Available from https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwidw9CK9YyHAxWpTmwGHU8OAWU4ChAWegQIEhAB&url=http%3A%2F%2Fjau.in%2Fattachments%2Fproceedings%2F2PlantProtectionF.pdf&usg=AOvVaw3SKNVnlodZwlGMXzxzjMUO&opi=89978449. Accessed on 3rd July, 2024.

Anonymous, 2023. Agricultural statistics at a glance 2022. Ministry of Agriculture and Farmers Welfare. Available from https://agriwelfare.gov.in/Documents/CWWGDATA/Agricultural_Statistics_at_a_Glance_2022_0.pdf. Accessed on 3rd July, 2024.

Calvo-Agudo, M., Tooker, J.F., Dicke, M., Tena, A., 2021. Insecticide-contaminated honeydew: risk for beneficial insects. Biological Reviews 97(2), 664–678. DOI: https://doi.org/10.1111/brv.12817.

Chaudhary, H.C., Singh, D., Singh, R., 2009. Diversity of aphids (homoptera: aphididae) on the field crops in terai of eastern Uttar Pradesh. Journal of Aphidology 23(1–2), 69–76.

Chaudhary, H.R., Ali, M., Verma, P., Ram, B., Jadon, C., 2015. Management of coriander aphid (*Hyadaphis coriandri* Das) under soybean - coriander cropping system. International Journal of Seed Spices 5(1), 98–99.

Choudhary, D., Kalra, V.K., Singh, R., Kumar, R., 2013. Biology of coriander aphid (*Hyadaphis coriandri* Das) on eight genotypes of coriander. Annals of Agri-Bio Research 18(2), 250–254.

Choudhary, N., Kumawat, M.M., Sundria, M.M., Saharan, K., 2024. Bio-efficacy of different bio-pesticides against aphid [*Myzus persicae* (Sulzer)] in cumin. Annals of Arid Zone 63(2), 147–153. DOI: https://doi.org/10.56093/aaz.v63i2.135386.

Ghetiya, L.V., Butani, P.H., 1995. Population dynamics of aphids (*Aphis gossypii* Glover) on coriander in relation to ecological and biological parameters. Gujarat Agricultural University Research Journal 21(1), 193–196.

Gondalia, V.K., Kathiria, K.B., Jadav, K.S., Shaikh, A.S., Devi, G., Bansal, R., Macwan, J., 2019. Growth and prospects of export of major seed spices from India. Directorate of Research, Anand Agricultural University, Anand, Gujarat, India pp. 126. Available from https://www.aau.in/sites/default/files/book1.pdf.

Kala, S., Agarwal, A., Kant, K., Mishra, B.K., Sogan, N., Kumar, N., Jawle, C.K.D., Hazara, D.K., Kumar, J., 2023. An environmentally benign oil dispersion/phytoextract system for improved retention upon foliage and control of aphids in spice crops. Journal of Cleaner Production 414, 137449. DOI: https://doi.org/10.1016/j.jclepro.2023.137449.

Kumar, V., Deshwal, H.L., Mahendra, Gurjar, M.K., Kumawat, R., 2023. Population dynamics of the coriander aphids in hyper arid region of Rajasthan and their correlation with biotic and abiotic factors. International Journal of Environment and Climate Change 13(11) 384–389. DOI: https://doi.org/10.9734/ijecc/2023/v13i113181.

Mali, G.R., Khan, T., Pagaria, P., Jat, B.L., 2022. Analysis for causes of low productivity, measures for yield sustainability for cumin in Barmer district of Rajasthan. The Pharma Innovation Journal 11(2), 560–562.

Meena, N.K., Singh, B., Lal, G., Kant, K., Meena, R.D., 2016. Sustainable management of aphid in coriander (*Coriandrum sativum* L.) through botanicals and bio-pesticides. International Journal of Seed Spices 6(1), 25–31.

Nair, R., Das, S.B., Jyothsna, J., 2021. Integrated management of aphid, *Hyadaphis coriandri* (Das) and powdery mildew in coriander. Journal of Entomology and Zoology Studies 9(2), 1019–1022.

Ndakidemi, B., Mtei, K., Ndakidemi, P.A., 2016. Impacts of synthetic and botanical pesticides on beneficial insects. Agricultural Sciences 7(6), 364–372. DOI: http://dx.doi.org/10.4236/as.2016.76038.

Patel, K.N., Thumar, R.K., Mohapatra, A., Barad, A.H., Parmar, K.D., 2021. Bio-efficacy of different biopesticides evaluated against aphids infesting coriander. International Journal of Current Microbiology and Applied Sciences 10(3), 2169–2178.

Patel, S.A., Patel, I.S., Patel, J.K., Patel, P.S., 2011. Seasonal abundance of fennel aphid, *Hyadaphis coriandri* Das and associated bioagents in fennel crop. Trends in Bioscience, 4(1), 116–117.

Prajapati, B.G., Amin, A.U., 2019. Field evaluation of different synthetic insecticides as well as bio-pesticides against coriander aphid, *Hyadaphis coriandri* (Das). International Journal of Seed Spices 9(2), 44–51.

Prajapati, B.G., Patel, N.R., Amin, A.U., 2018. Bio-efficacy of imidacloprid 600FS as seed treatment against aphid and thrips in cumin. International Journal of Seed Spices 8(2), 72–76.

Regar, P.K., Mahla, M.K., Lekha, Parihar, A., Chhangani, G., 2022. Population dynamics of coriander aphid and occurrence of their natural enemies in organic coriander. The Pharma Innovation Journal 11(6), 1201–1205.

Shonga, E., Getu, E., 2021. Efficacy of plant derived and synthetic insecticides against cabbage aphid, *Brevicoryne brassicae* (L.) (Homoptera: Aphididae) and their effect on coccinellid predators. Ethiopian Journal of Health Sciences 44(1), 27–37. DOI: https://dx.doi.org/10.4314/sinet.v44i1.3.

Steinhaus, E.A., 1949. Principles of insect pathology. McGraw Hill Book Company, New York, USA, 757.

Swami, D., Jat, B.L., Dostasara, S.K., 2022. Management of coriander aphid, *Hyadaphis coriandri* (Das) with safer insecticides. Indian Journal of Entomology 84(1), 164–167. DoI.: https://doi.org/10.55446/IJE.2021.288.

Thakur, S., Kumari, I., Chaudhary, S., Madhusudan, S., Kaurav, H., Chaudhary, G., 2021. Coriander (*Coriandrum sativum*): a common Indian traditional spice and ayurvedic remedy. International Journal of Research in Ayurveda and Pharmacy 12(2), 74–81. DOI: http://dx.doi.org/10.7897/2277-4343.120250.

Yadav, T., Chhangani, G., Yadav, A., 2023. A review on impact of biotic and abiotic components on aphid species infesting in seed spices. Biological Forum – An International Journal 15(10), 204–207.