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Bhavana Yadav
M.Sc. Student, Department of Horticulture, College of Agriculture, JNKVV, Jabalpur, Madhya Pradesh, India

Dr. Reena Nair
Assistant Professor, Department of Horticulture, College of Agriculture, JNKVV, Jabalpur, Madhya Pradesh, India

Dr. AK Saxena
Associate Professor, Department of Entomology, College of Agriculture, JNKVV, Jabalpur, Madhya Pradesh, India

Nazneen Hussain
M.Sc. Student, Department of Horticulture, College of Agriculture, JNKVV, Jabalpur, Madhya Pradesh, India

Corresponding Author:
Bhavana Yadav
M.Sc. Student, Department of Horticulture, College of Agriculture, JNKVV, Jabalpur, Madhya Pradesh, India

Bioefficacy of biopesticides and pesticides against coriander aphid *Hyadaphis coriandri* (Das) for seed yield and economics in coriander (*Coriandrum sativum* L.)

Bhavana Yadav, Dr. Reena Nair, Dr. AK Saxena and Nazneen Hussain

Abstract
Coriander aphid *Hyadaphis coriandri* (DAS) is one of the major constraints in the production of coriander. In order to find out the effective biopesticides and fungicides against *Hyadaphis coriandri* experiment was carried out in field condition. The relative efficacies of different combinations of biopesticides and pesticides were tested in different concentration. Among the different combinations of treatments, Acetamiprid + Propiconazole (first spray) + Carbendazim (second spray) was the most effective with mean 1.48 AI after first spray and 1.29 AI after second spray over untreated control 2.26 AI (first spray) and 2.79 AI (second spray). The highest seed yield kg/ha (1149.00), gross income Rs 103,410 ha^{-1}, net income Rs 59394 ha^{-1} and B:C ratio 2.34:1 was obtained in the treatments combination of Acetamiprid + Propiconazole (first spray) + Carbendazim (second spray) closely followed by *Lecanicillium lecanii* + Propiconazole (first spray) + Carbendazim (second spray).

Keywords: *Hyadaphis coriandri*, coriander, biopesticides, pesticides, acetamiprid, *Lecanicillium lecanii*

Introduction

Coriander (*Coriandrum sativum* L.) belongs to the family of Apiaceae and commonly known as *Cilantro,* Chinese parsley or *Dhania*. It is an important seed spices crop having chromosome number 2n=22. It is native to Italy and is currently grown in Central and Eastern Europe, the Mediterranean (Morocco, Malta, Egypt) and Asia (China, Pakistan, India & Bangladesh).

In preserving human health and civilizing the quality of human life, plants have played a crucial role for thousands of years (Dhankar *et al.*, 2011) [5]. In early stage of growth, the plant requires a cool climate & a warm weather at late maturity stage. It is an annual herbaceous plant best grown between October and February. It's tender aerial parts stem, leaf, fruits are used due to aromatic flavour. The crop is grown almost all the states of the country but Rajasthan, Madhya Pradesh, Uttar Pradesh, Uttarakhand are the major coriander growing states. Rajasthan produce quality coriander and enjoy major share in area and production in the country. As per the estimate for 2017-2018, the total area under coriander is 665190 ha with production of 866800 tonnes. Madhya Pradesh is the leading state with 277410 ha and 391460 tonnes of production respectively in the field and production of seed coriander. (Spices Board, 2019) [21].

India is the world's largest coriander manufacturer, consumer and exporter with an annual output of about three lakh tonnes. The essential oil is contained (0.03 to 2.6 percent) (Nadeem *et al.*, 2013) [9]. Either steam-distilled essential oil or solvent derived from oleoresin is prepared using green herbs (Nadia and Kandi, 2012) [10]. Three Aphid species i.e. *Hyadaphis coriandri* (Das), *Myzus persicae* and *Aphis craccivora* (Hemiptera: Aphididae) have been reported as a major pest on the crop.(Meena *et al.*, 2016 and Amin *et al.*, 2018) [12, 13]. Hyadaphis coriandri, the coriander aphid, has been identified in Rajasthan and other parts of the nation as a frequent and major coriander pest. The insect feeds in colonies on the tender portion of the shoots, lower portion of leaves, entire umbels and in case of severe infestation whole plants covered with young and adult aphids. Consequently, plants become weakened with stunted growth which reduce the seed yield and quality. If plant protection measures not applied timely, it may causes nearly 40-50% yield losses. (Pareek *et al.*, 2013 and Meena *et al.*, 2017) [17, 14].

Biopeticides are preparations made from naturally occurring substances that are environmentally safe and pest-friendly by non-toxic mechanisms. Biopesticide are used mainly as preventive measure, so they do not work as quickly as some synthetic chemical pesticide do. Therefore the present work carried to find out an alternative of biopesticides, as new molecules as well as combination of biopesticides and other chemical for the management of aphids and powdery mildew for the without causing any adverse effect on crop, natural enemies, pollinator and environment.

Material and Methods

The field trial was carried out in Vegetable Research Complex, Maharajpur, Department of Horticulture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh during *Rabi* season of 2019-2020 on variety of coriander Cimpoo S 33 in a Randomized Block Design with three replications and ten treatments. Treatments combinations of *Lecanicillium lecanii* 1.15% WP @ 40 g/10 L, Acetamiprid 20 SP @ 0.2 ml/plot, Imidachloprid 17.8% SL @ 14.2 ml/3 plot, Propiconazole 25 EC @ 1.7 ml/plot, Carbendazim 50WP @ 100g/10 plot, SAAF (12% Carbendazim + 63% Mencozab) @ 0.25% were tested in comparison with untreated control (Table1).

Two foliar sprays of respective Insecticides, fungicides and biopesticides will be given. First spray will be made at threshold level 1.0 aphid index and second spray to be made at 10 days of the first spray. Observations on number of aphids was recorded one day prior to spray and 3, 7, 15 and 21 days after spraying, Effectiveness of the treatments was judged based on the efficacy of the biopesticides and pesticides against coriander aphid *Hyadaphis coriandri* (Das), seed yield and economics.

The seed rate used for sowing was 20 kg/ha and seeds were cleaned and broken into two halves and treated with *Trichoderma harzianum* @ 10g/kg prior to sowing. Seeds of variety Cimpoo S 33 and was sown in line sowing at a depth of 1-2 cm and covered with soil at a row spacing 30 cm. After 30 days sowing, thinning was carried out to maintain plant to plant distance of 10 cm. The recommended dose of N, P and K @ 60:40:20 kg/ha were applied in the form of urea, single super phosphate and muriate of potash. Urea was applied in the three splits, the first as basal application and the other two doses at 25 and 50 days after sowing. The entire dose of single super phosphate and muriate of potash was applied at the time of sowing as basal dose.

Five plants from each replication were selected randomly and tagged with label for observations. Aphid was estimated by adopting aphid index (zero to five scale) throughout the observation. For assigning the aphid index, on each selected plant, 3 branches were randomly selected and aphid was counted from 10 cm terminal twigs of each branch. Data were statistically analyzed for assessing the least susceptible treatment against the aphid (*H. coriandri)* on coriander.

The aphid index will be fixed as per Patel (1980) [18] for estimating the average aphid index was worked out by adopting the following formula.

$$\text{Average aphid index} = \frac{0N + 1N + 2N + 3N + 4N + 5N}{\text{Total number of plants observed}}$$

Where the aphid index is 0, 1, 2, 3, 4, 5,
N = Number of plants with respective aphid index

Indices Description

0	=	The aphid free plant.
1	=	Aphid present but not built up colonies. No injury due to pest appearance on plant.
2	=	Small colonies of aphid present on leaves of plant. Such leaves exhibit slight curling due to aphid feeding.
3	=	Large colonies of aphid present on leaves and other parts, damage symptoms visible due to aphid feeding.
4	=	Most leaves are covered with colonies of aphids. Counts are not possible and the plant shows more damage symptoms due to aphid feeding.
5	=	The plant is completely covered with aphid colonies and due to pest feeding, plant growth is impeded.

Result and Discussion

The data obtained on average aphid index were analyzed after transforming them into square root while, the data on yield were analyzed without any transformation and is depicted in Table 2 and 3 respectively. The data on the efficacy of various biopesticides and pesticides treatments on reducing aphids infestation after first and second spraying was observed that the pretreatment Aphid index (AI) were made a day before spraying indicating that there was non-significant difference among the treatment. Aphid index before spray presented in Table 2 and it was varied from 2.73 to 20.82 AI.

The present findings are in agreement with Palthiya and Nakat (2017) [16], who studied pretreatment counts were made a day before spraying indicated that there was non-significant difference among the treatments. Sarvariya *et al.*, (2018) [19] also observed non-significant difference among different treatments before spray indicating uniform distribution of aphid population. On the basis of overall mean population reduction after first spray have been presented in Table 2. It varied from 1.48 to 2.26 among the treatment. The treatments along with reductions in aphid in descending order are presented below:

T10 (2.26) > T4 (2.03) > T2 (1.92) >T3 (1.85) > T1 (1.84) > T6 (1.82) > T9 (1.79) > T8 (1.69) > T5 (1.68) > T7 (1.48) the data after first spray indicated that, all the treatments were found superior in suppressing the aphid's infestation as compared to untreated control.

The treatment was combination of Acetamiprid + Propiconazole was significantly superior over other treatments recorded minimum aphid index 1.48 and this was followed by the treatments combination of *Lecanicillium lecanii* + Propiconazole observed 1.68 AI.

Overall mean data after second spray indicated in Table 2 that, all the treatments were found superior in suppressing the aphid's infestation as compared to untreated control. Mean population reduction have been presented in Table 8 and it varied from 1.29 to 2.79, the treatments along with reductions in aphid index descending order are presented below:

T10 (2.79) > T4 (1.90) > T3 (1.79) > T1 (1.75) > T2 (1.69) > T6 (1.55) > T9 (1.55) > T8 (1.48) > T5 (1.41) > T7 (1.29)

The treatment was combination of Acetamiprid + Carbendazim was significantly superior over other treatment recorded minimum aphid index 1.29 and this was followed by the treatment combination of *Lecanicillium lecanii* + Carbendazim recorded 1.41 AI. The percentage reduction in aphid population after the second spraying was considerably lower than the reduction observed after the first spraying. It may be due to weather parameters. This result is in conformity with of Nayak (2013) [15] on cabbage aphid. The reduction in pest load cause reduced damage to the crop. Aphids do not show any visible symptoms / damage but causes quantitative and qualitative losses to the crop by sucking the sap. Hence treatment two foliar sprays of Acetamiprid + spray of Propiconazole (first spray) + spray of Carbendazim (second spray) which harboured less pest yielded more.

The present findings are in line with the results of Matsuda and Takahaski (1996) [11], who also stated the suitability of Acetamiprid for the control of insect pests belonging to the Hemiptera, Thysanoptera, Lepidoptera, Coleoptera and Isoptera orders. Jayewar *et al*. (2003) [8] also reported that Acetamiprid had excellent activity against aphids on chilli crops. Gowtham *et al*. (2016) also evaluated that Acetamprid 20 SL @ 0.125g/ml proved to be highly effectiveness against cow pea aphid. The effectiveness of Acetamiprid 20 SP @ 0.004 percent against aphid in summer cowpea has been reported by Anandmurthy *et al*., 2017 [1]

Acetamiprid exhibited satisfactory level of pest suppression. Chemical pesticides performed better than biopesticides. Neonicotinoids are a new class of insecticides with widespread use in crop production. The neonicotinoid insecticides Acetamiprid and Imidacloprid have a relatively low risk and high target specificity for insects in non-target species and in the environment. Today the class of neonicotinoids are part of a single mode of action group as defined by the Insecticide Resistance Action Committee (IRAC; Crop Life Expert Committee) for the purposes of pest control. Neonicotinoids have touch, stomach, and systemic activity as active broad-spectrum insecticides. Due to their physicochemical properties, they are particularly involved in hemiptera pest organisms, such as aphids, which are useful for a broad variety of different application techniques.

The present investigation collaborate with Palthiya and Nakat (2017) [16], who studied the combination of *Entomopathogenic fungi* as *V. lecanii* 1.15% WP + *M. anisopliae* 1.15% WP was found to be most effective treatment for suppression of aphid population on okra. El-salam *et al*. (2012) [6] reported the most effective treatment was *V. lecanii* followed by Nimbecidine, *M. anisopliae, P. fumosoroseus and B. bassiana* against *A. craccivora* in broad bean. It has been well documented that V. lecanii is highly pathogenic to many aphid species (e.g. Askary *et al*., 1997; Fournier and Brodeur 2000; Shah and Pell 2003; Powell and Pell 2007) [2, 7, 20]. Shah and Pell (2003) [20] Entomopathogenic fungi as biological control agents. Chavan *et al*., (2008) [3] summarised that liquid formulation of *lecanii* showed significantly greater efficacy, irrespective of dosage, in controlling aphids and reported up to 96.70 percent death of the insect.

It is evident from the data presented in table 3 that all the treatment combinations significantly increased the coriander yield. The highest seed yield (1149 kg/ ha) has been observed in treatment combination of Acetamiprid + Propiconazole + Carbendazim which was followed by *Lecanicillium lecanii* + Propiconazole + Carbendazim reported (1090 kg/ ha) over untreated control (761 kg/ha).

The present findings are in agreement with Daunde *et al.*, (2018) [4] who reported that among the nine treatments, Propiconazole (0.1%) was superior over all other treatments with maximum fruit yield of 36.13 q/ha which is followed by Myclobutanil (0.1%) with the fruit yield of 34.56 q/ha. Parmar and Arvindarajan (2017) [1]. The highest cowpea grain yield of 853 kg/ha was reported from the treatment of 0.006 percent Dinetofuran, which was statistically equivalent to 0.004 percent Acetamiprid (816 kg/ha), 0.08 percent Spiromesifen (795 kg/ha), 0.03 percent Dimethoate (790 kg/ha) and 0.02 percent Flonicamid (752 kg/ha). Application of Acetamiprid + Propiconazole + Carbendazim caused significant influence on gross income, net income and B:C ratio. It was recorded maximum gross income (Rs 103,410 ha^{-1}), net income (Rs 59394 ha^{-1}) and B:C ratio (2.34:1) this was followed by combination of spray *Lecanicillium lecanii* + Propiconazole + Carbendazim on gross income (Rs 98,100 ha^{-1}), net income (Rs 53963 ha^{-1}) and B:C ratio (2.22:1) over untreated control (1.61:1) (Table 4.)

Present findings are in accordance with Parmar and Arvindrajan (2017) [1] on the basis of economics, Acetamiprid 0.004 per cent (1: 21.8) proved to be most economically viable treatment followed by 0.03 per cent Dimethoate (1:21.2), 0.08 per cent Spiromesifen (1:9.8), 0.006 per cent Dinetofuran (1:9.4), 0.0075 per cent Chlorfenapyr (1:5.8), 0.003 per cent Clothianidin (1:5.5) and 0.02 per cent Flonicamid (1:4.8). The current study concluded that biopesticides are a range of resources for farmers to transition from highly toxic traditional chemical pesticides to an age of truly sustainable agriculture. In light of the experimental findings summarized above, it may be concluded that among various treatments T7 i.e. Two foliar sprays of Acetamiprid (0.004%) + spray of Propiconazole @ 0.05% (first spray) + spray of Carbendazim @ 0.1% (second spray) showed better response with respect to seed yield kg/ha, superior treatment for coriander aphid (*Hyadaphis coriandri* L.) and B:C ratio over control after first and second spray.

Table 1: Treatment details for management of insect pests on coriander

T_1	Spray of Propiconazole 25 EC @ 0.05% (first & second spray) + Two foliar sprays of *Lecanicillium lecanii* 1.15WP (1×109 cfu / g)
T_2	Spray of Propiconazole 25 EC @ 0.05% (first & second spray) + Two foliar sprays of Acetamiprid 20SP (0.004%).
T_3	Spray of Carbendazim 50 WP @ 0.1% (first & second spray) + Two foliar sprays of *Lecanicillium lecanii* 1.15WP (1×109cfu / g)
T_4	Spray of Carbendazim 50 WP @ 0.1% (first & second spray) + Two foliar sprays of Acetamiprid 20SP (0.004%).
T_5	Two foliar sprays of *Lecanicillium lecanii* 1.15WP (1×109 cfu / g) + Spray of Propiconazole 25 EC @ 0.05% (first spray) + Spray of Carbendazim 50 WP @ 0.1% (second spray).
T_6	Two foliar sprays of *Lecanicillium lecanii* 1.15WP (1×109 cfu / g) + Spray of Carbendazim 50 WP @ 0.1% (first spray) + Spray of Propiconazole 25 EC @ 0.05% (second spray).
T_7	Two foliar sprays of Acetamiprid 20SP (0.004%) + Spray of Propiconazole 25 EC @ 0.05% (first spray) + Spray of Carbendazim 50 WP @ 0.1% (second spray).
T_8	Two foliar sprays of Acetamiprid 20SP (0.004%) + Spray of Carbendazim 50 WP @ 0.1% (first spray) + Spray of Propiconazole 25 EC @ 0.05% (second spray).
T_9	Two foliar spray of Imidachloprid (0.05%) + One foliar spray of SAAF (12% Carbendazim + 63% WP Mancozeb) @ 0.25% (first spray) + One spray Carbendazim 50 WP @ 0.1% (20gm/10L water) (second spray)
T10	Untreated control

Table 2: Bioefficacy of different biopesticides and pesticides against coriander aphid *Hyadaphis coriandari* (Das)

Treatment	Treatment details	Pre Treatment	After First Spray				MEAN of first spray	After Second Spray				MEAN of second spray
			3 DAS	7 DAS	15 DAS	21 DAS		3 DAS	7 DAS	15 DAS	21 DAS	
T1	Propiconazole + *Lecanii*	6.86 (2.80)	3.39 (2.09)	1.97 (1.72)	1.76 (1.66)	2.70 (1.92)	1.84	1.78 (1.63)	0.57 (1.25)	3.37 (2.07)	3.39 (2.07)	1.75
T2	Propiconaole + Acetamiprid	6.96 (2.81)	4.35 (2.31)	1.95 (1.71)	1.81 (1.66)	3.00 (1.99)	1.92	1.03 (1.42)	0.95 (1.39)	2.60 (1.89)	3.30 (2.07)	1.69
T3	Carbendazim + *Lecanii*	6.61 (2.75)	3.31 (2.07)	2.20 (1.73)	1.96 (1.71)	2.53 (1.86)	1.85	0.96 (1.39)	0.78 (1.32)	3.19 (2.04)	4.35 (2.43)	1.79
T4	Carbendazim + Acetamiprid	6.89 (2.80)	5.43 (2.53)	2.80 (1.91)	2.27 (1.80)	2.53 (1.86)	2.03	1.36 (1.52)	0.68 (1.29)	2.73 (1.92)	7.35 (2.88)	1.90
T5	*Lecanii* + Carbendazim	6.81 (2.78)	2.19 (1.78)	1.64 (1.62)	1.33 (1.51)	2.29 (1.80)	1.68	0.38 (1.17)	0.21 (1.09)	1.63 (1.61)	2.19 (1.74)	1.41
T6	*Lecanii*+ Carbendazim +Propiconazole	6.98 (2.82)	3.13 (2.03)	1.91 (1.70)	1.64 (1.62)	2.70 (1.92)	1.82	0.83 (1.34)	0.41 (1.18)	1.82 (1.67)	3.13 (2.02)	1.55
T7	Acetamiprid + Propiconazole+ Carbendazim	6.67 (2.76)	1.27 (1.50)	1.33 (1.52)	1.23 (1.49)	1.01 (1.41)	1.48	0.23 (1.10)	0.19 (1.09)	1.13 (1.45)	1.27 (1.50)	1.29
T8	Acetamiprid + Carbendazim + Propiconazole	6.93 (2.81)	2.24 (1.80)	1.66 (1.62)	1.40 (1.54)	2.32 (1.81)	1.69	0.44 (1.19)	0.34 (1.15)	2.12 (1.76)	2.24 (1.79)	1.48
T9	Imidacloprid+ SAAF + Carbendazim	6.51 (2.73)	2.46 (1.84)	1.72 (1.64)	2.40 (1.82)	2.53 (1.87)	1.79	0.89 (1.36)	0.41 (1.18)	2.44 (1.83)	2.46 (1.84)	1.55
T10	Control	6.99 (2.82)	8.27 (3.04)	2.96 (1.98)	2.89 (1.97)	3.22 (2.05)	2.26	9.96 (3.30)	2.73 (1.93)	7.43 (2.89)	8.27 (3.04)	2.79
SE (m)±		0.10	0.07	0.05	0.04	0.08	0.06	0.08	0.06	0.11	0.16	0.10
CD at 5%		N/S	0.23	0.16	0.14	0.26	0.20	0.26	0.18	0.33	0.48	0.31

**Figures in parentheses are √x+0.5 square root transformed values, DAS (days after spray)

Table 3: Effect of biopesticides and pesticides on seed yield and economics

Treatment	Treatment details	Seed yield/plot (g)	Seed yield (kg/ha)	Seed Yield (q/ha)	Gross Income (Rs/ha)	Expenditure (Rs/ha)	Net income	C:B Ratio
T1	P + L	671.39	932	9.32	83,880	43,252	40,628	1:1.93
T2	P + A	671.59	932	9.32	83,880	43,131	40,749	1:1.94
T3	C + L	660.56	917	9.17	82,530	42,602	39,928	1:1.93
T4	C + A	562.15	780	7.8	70,200	42,481	27,719	1:1.65
T5	L + P + C	785.19	1,090	10.9	98,100	44,137	53,963	1:2.22
T6	L + C + P	671.5	932	9.32	83,880	44,137	39,743	1:1.90
T7	A + P + C	827.32	1149	11.49	1,03,410	44,016	59,394	1:2.34
T8	A + C + P	678.74	952	9.52	85,680	44,016	41,664	1:1.94
T9	I + SAAF + C	668.35	928	9.28	83520	42,570	40,950	1:1.96
T10	CONTROL	548.1	761	7.61	68,490	42,317	16,234	1:1.61
SE(m)±		0.621	62.145					1:1.93
CD at 5%		135.69	186.073					1:1.94

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