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Bioefficacy of Biopesticides and Pesticides for the Management of Coriander Powdery Mildew caused by *Erysiphe polygoni*, Seed Yield and Economics of Coriander (*Coriandrum sativum* L.)

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ABSTRACT: Powdery mildew caused by *Erysiphe polygoni* DC is one of the major constraints in the production of coriander. In order to find out the effective biopesticides and fungicides against *Erysiphe polygni* experiment was carried out in field condition & the plots were laid out in Randomised Block Design (RBD) with three replications. Different combinations of biopesticides and fungicides were tested in different concentrations to see how effective they were. Among the different combinations of treatments, *Lecanicillium lecanii* + Carbendazim (first spray) + Propiconazole (second spray) was the most effective with mean 3.98 Percent Disease Index after first spray and 3.50 PDI after second spray over untreated control 6.23 PDI (first spray) and 6.15 (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). The frequent incidence of powdery mildew in coriander demand for effective combination of biopesticides and fungicides.

Keywords: Fungicides, Biopesticides, *Erysiphe polygni*, Powdery mildew, Percent Disease Index (PDI).

INTRODUCTION

In all parts of the world, powdery mildew has long been recognized as a serious plant disease. *Erysiphe polygoni* DC, which causes powdery mildew, was described by Salmon (1900). Coriander (*Coriandrum sativum* L.) belongs to the family of *Apiaceae* and commonly known as *Cilantro*, Chinese parsley or *Dhania*. This is a significant spice seed crop with the chromosomal number 2n=22. It is a native of Italy, and is presently cultivated in Central & Eastern Europe, Mediterranean regions (Morocco, Malta, Egypt) & Asia (China, Pakistan, India & Bangladesh). It's an annual herbaceous plant that thrives in the months of October through February. It's tender aerial parts stem, leaf, fruits are used due to aromatic flavour. The crop is grown in practically every state in the country; however the biggest coriander-growing states are Rajasthan, Madhya Pradesh, Uttar Pradesh, and Uttarakhand. Rajasthan produces high-quality coriander and has a large share of the country's land and production.As per the 2017-2018 forecast, the total coriander area is 665190 ha with output of 866800 tonnes. Madhya Pradesh is the leading state with 277,410 ha and 39,1460 tonnes of seed coriander production, respectively, in area and production (Spices Board 2019). The essential oil is contained (0.03 to 2.6 percent) (Nadeem *et al.*, 2013)

Powdery mildew (*Erysiphe polygoni*) is a very important disease of coriander resulting in heavy losses. Kalra *et al.* (2000) observed effect of powdery mildew on yield and yield components of early and late maturing cultivars of coriander. The disease is caused by *Erysiphe polygoni* DC. The disease is air borne in nature and spreads in entire field within short duration under moderately cool and dry weather condition (25-30°C). Powdery white masses are observed sprinkled on the foliage and tender plant parts which cover the whole foliage and plant parts. The leaves turn yellow then brown. A broad array of fungicides and insecticides are used to control insect-pest and disease by the growers and often these control agents are used in judiciously being an export commodity the importers are very much conscious about the residue levels of various insecticides as a consequence, persistent residues of these chemicals contaminate oil quality and disperse in the environment.

Bio-pesticides are pesticides manufactured from naturally occurring compounds that use non-toxic methods to keep the environment safe and pests at away. There are no alternatives to chemical fungicides such as biopesticides or biological control agents that could be used for managing powdery mildew in Sweden today. Sulphur, which is categorised as a

preventative fungicide, is permitted, but is commonly not used due to high risk of phytotoxicity in cucumber, especially at high temperatures in the greenhouse (Cerkauskas and Ferguson 2014); H. Hermans, Innocrop Consulting, pers. comm.).

As a prevention measure, bio-pesticides are mostly used, but they do not work as quickly as other conventional chemical pesticides do.As a response, the current research aims to identify an alternative to bio-pesticides, such as new compounds and combinations of bio-pesticides and other chemicals, for the control of aphids and powdery mildew without causing harm to the crop, natural enemies, pollinators, or the environment. Several workers reported that, propiconazole, myclobutanil, triadimefon and hexaconazole were found to be effective in reducing powdery mildew incidence in different crops (Sharma, 1991; Sharmila *et al*., 2004; Singh, 2006; Pramod and Dwivedi, 2007; Akhileshwari *et al.,* 2012). From previous studies of powdery mildew controlled by the different combinations of treatments but the current investigation conclude that the combination of *Lecanicillium lecanii* + Carbendazim (first spray) + Propiconazole (second spray) could be utilize as an effective control.

MATERIAL AND METHODS

The field trial was carried out in Horticulture complex, Maharajpur, Department of Horticulture. During the Rabi season of 2019-2020, the Jawaharlal Nehru Krishi Vishwa Vidyalaya in Jabalpur, Madhya Pradesh tested a variety of coriander called Cimpoo S 33 in a randomised block design with three replications and 10 treatments.Combinations of *Lecanicillium lecanii* 1.15 percent WP @ 40 g/10 L, Acetamiprid 20 SP @ 0.2 ml/plot, Imidachloprid 17.8 percent SL @ 14.2 ml/3 plot, Propiconazole 25 EC @ 1.7 ml/plot, Imidachloprid 17.8 percent 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 (Table 2). For crop production, all the suggested agricultural practices have been adopted. Bio-pesticide and fungicide 2 sprays (First spray at the onset of disease was given as soon as infestation of powdery mildew appeared on crop and second spray at 15 days after first spray). Pre and post treatment of PDI recorded at 3,7,15 and 21 days after spraying. Observations on disease intensity were recorded from five plants randomly selected from each treatment after fifteen days of last spray using 0-4 scale. By scoring the percentage of disease severity, each plant was evaluated for its disease response. As per Table 1, disease scoring was done using 0-4 scale. (Anon., 2004).

Table 1: Disease Scoring scale.

Powdery mildew disease rating	Percent leaf area infected
0.0 -	Healthy
1.0 -	whitish small spots on leaf
2.0 -	whitish growth covering entire leaf
3.0 -	growth on leaf and stem
4.0 -	growth on leaf, stem and umbel

Table 2: 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 (1×10^9 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 (1×10^9cfu / 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 (1×10^9 cfu / g) + Spray of Propiconazole 25 EC @ 0.05% (first spray) + Spray of Carbendazim 50 WP @ 0.1% (secondspray).
T_6	Two foliar sprays of *Lecanicillium lecanii* 1.15WP (1×10^9 cfu / g) + Spray of Carbendazim 50 WP @ 0.1% (first spray) + Spray of Propiconazole 25 EC @ 0.05% (secondspray).
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)
T_{10}	Untreated control

The percent disease index (PDI) was calculated according to the formula suggested by Datar and Mayee (1981).

PDI = [(Total grade)/(Maximum grade)] × [(100)/(No. of leaves scored]

RESULT AND DISCUSSION

The results on Percent Disease Index (PDI) after first and second spray presented in Table 3.

Result of the present study was showed that there was non-significant difference among different treatments before spray indicating uniform distribution of Disease Index among different treatments. Present findings are in accordance with Ushamalini and Nakkeeran (2016). It is seen from the data that there was a substantial difference in the percentage severity of coriander disease during the year.

Table 3: Bioefficacy of different biopesticides and pesticides against coriander powdery mildew (*Erysiphe polygoni*).

Treatment			Pre Treatment PDI	After First Spray				Mean of first spray	After Second Spray				
				3 DAS	7 DAS	15 DAS	21 DAS		3 DAS	7 DAS	15 DAS	21 DAS	Mean of second spray
T_1	Propiconazole *Lecanii*	+ 	38.38 (6.2)	31.13 (5.66)	29.55 (5.52)	26.52 (5.24)	22.85 (4.88)	5.33	20.98 (4.68)	16.91 (4.22)	22.04 (4.79)	14.29 (3.89)	4.40
T_2	Propiconaole Acetamiprid	+ 	38.70 (6.3)	29.68 (5.53)	27.73 (5.36)	26.67 (5.26)	23.88 (4.99)	5.28	22.40 (4.83)	20.9 (4.67)	19.39 (4.50)	18.25 (4.36)	4.59
T_3	Carbendazim *Lecanii*	+ 	39.37 (6.3)	27.12 (5.30)	24.41 (5.04)	23.65 (4.96)	21.09 (4.69)	5.00	22.07 (4.80)	20.51 (4.63)	18.72 (4.43)	17.6 (4.25)	4.53
T_4	Carbendazim Acetamiprid	+ 	39.28 (6.34)	28.02 (5.38)	26.60 (5.25)	23.54 (4.95)	28.27 (5.41)	5.25	28.20 (5.40)	23.04 (4.90)	20.14 (4.59)	19.55 (4.51)	4.85
T_5	*Lecanii* Carbendazim	+ 	38.75 (6.30)	32.14 (5.75)	31.13 (5.66)	29.57 (5.52)	28.83 (5.46)	5.60	27.02 (5.29)	25.24 (5.12)	12.14 (3.61)	21.4 (4.72)	4.68
T_6	*Lecanii*+ Carbendazim +Propiconazole		39.41 (6.35)	19.02 (4.47)*	16.62 (4.19)*	13.61 (3.82)*	11.01 (3.46)*	3.98*	14.14 (3.89)*	11.15 (3.47)*	10.13 (3.33)*	9.98 (3.30)*	3.50*
T_7	Acetamiprid Propiconazole+ Carbendazim	+ 	38.59 (6.29)	22.1 (4.80)	20.29 (4.61)	18.36 (4.40)	16.69 (4.20)	4.50	15.53 (4.06)	13.79 (3.84)	14.67 (3.94)	10.69 (3.41)	3.81
T_8	Acetamiprid Carbendazim Propiconazole	+ +	38.76 (6.30)	23.11 (4.90)	22.10 (4.80)	19.78 (4.55)	17.73 (4.31)	4.64	21.16 (4.70)	18.18 (4.37)	16.35 (4.15)	15.73 (4.07)	4.33
T_9	Imidacloprid+ SAAF Carbendazim	+ 	38.87 (6.31)	32.06 (5.63)	30.06 (5.57)	26.27 (5.22)	27.49 (5.33)	5.44	25.88 (5.18)	24.67 (5.06)	22.76 (4.87)	21.87 (4.77)	4.97
T_{10}	Control		38.97 (6.32)	37.36 (6.19)	38.87 (6.31)	37.81 (6.23)	37.59 (6.20)	6.23	37.26 (6.18)	36.81 (6.14)	36.48 (6.11)	36.85 (6.15)	6.15
CD at 5%			N/S	0.16	0.09	0.12	0.37	0.19	0.17	0.28	0.50	0.67	0.40
SE (m)±			0.03	0.05	0.03	0.04	0.12	0.06	0.05	0.09	0.17	0.22	0.13
C.V.%			0.83	1.77	1.02	1.46	4.44	2.17	2.00	3.51	6.63	9.02	5.29

**Figures in parentheses are √x+0.5 square root transformed values, NS= Non- significant, DAS (days after spray).

The mean of disease incidence are varied from 6.23 to 3.98 PDI among the treatment after first spray. Efficacy of different treatments along with reduction in mean disease index in descending order are summarized below: T10 (6.23) > T5 (5.60) > T9 (5.44) >T1 (5.33) > T2 (5.28) > T4 (5.25) > T3 (5.00) > T8 (4.64) > T7(4.50) > T6 (3.98). The lowest PDI 3.98 was reported in treatment combination of *Lecanicillium lecanii* + Carbendazim over untreated control 6.23 PDI. After second spray accordance to the data presented in Table 3 significantly varied PDI from 6.15 to 3.50. Application of different treatments and their result with reduction in mean disease index in descending order are presented below:

T10 (6.15) > T9 (4.97) > T4 (4.85) > T5 (4.68) > T2 (4.59) > T3 (4.53) > T1

(4.40) > T8 (4.33) > T7 (3.81) > T6 (3.50). Treatment combination of *Lecanicillium lecanii* + Propiconazole observed minimum PDI 3.50. The present results are in conformity with the results of Amin *et al.* (2019). Six fungicides (Tebuconazole 0.1%, Propineb 0.2%, Azoxystrobin 0.1%,Wettable sulphur 2%, Hexaconazole 0.1% and Propiconazole 0.1%) were evaluated& the minimum disease intensity and higher yield were recorded when the plots sprayed with propiconazole (0.1%), which was at par with hexaconazole (0.1%) and wettable sulfur (0.2%).Deshmukh *et al*. (2018) also reported similar result with among the six fungicide evaluated under field conditions, three sprays of Hexaconazole@ 0.1% and Propiconazole@ 0.1% was found more effective in reducing disease severity and yield which was at par with each other. At the point of the first development of haustoria, propiconazole works on the fungal pathogen within the plant. It prevents fungal growth by interfering with the biosynthesis of sterols in the membranes of the cells. While preventive, curative or eradicative use is allowed by the biological mode of action of propiconazole, the best results are obtained when the substance is administered when the disease is present but still active in the early stage of development. Similar findings were also reported by Singh (2006), who reported that spraying Azole compounds was effective in reducing the occurrence of powdery mildew in coriander and the effectiveness of propiconazole against powdery mildew. Ushamalini and Nakkeeran (2016), also studied, were found to be effective in reducing the incidence of powdery mildew by spraying propiconazole (0.15 percent).The efficacy of Propiconazole against powdery mildew was also reported in chilli (Sharmila *et al.*, 2004) and in okra (Vijaya, 2004); Khunt *et al.* (2017) also reported that the efficacy of six different fungicides in different concentration and among the different fungicides, Propiconazole (0.025%) was the most effective fungicide with mean 4.43 per cent (pooled) disease intensity and maximum disease control of 79.28 per cent followed by Wettable sulphur (0.2%).

It is evident from the data presented in Table 4 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) 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. Arvindarajan *et al.* (2017) also reported similar result with the treatment 0.006 percent Dinetofuran, which was statistically equal 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), produced the highest cowpea grain yield of 853 kg/ha.

Table 4: Effect of biopesticides and pesticides on seed yield.

Treatment		Seed yield/plot (g)	seed yield (kg/ha)
T1	Propiconazole + *Lecanii*	671.39	932.00
T2	Propiconaole + Acetamiprid	671.59	932.00
T3	Carbendazim + *Lecanii*	660.56	917.00
T4	Carbendazim + Acetamiprid	562.15	780.00
T5	*Lecanii* + Carbendazim	785.19	1,090.00
T6	*Lecanii*+ Carbendazim +Propiconazole	671.50	932.00
T7	Acetamiprid + Propiconazole+ Carbendazim	827.32	1149.00
T8	Acetamiprid + Carbendazim + Propiconazole	678.74	952.00
T9	Imidacloprid + SAAF + Carbendazim	668.35	928.00
T10	Control	548.10	761.00
SE(m)±		0.621	62.145
CD at 5%		135.69	186.073

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}), netincome (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 5).

Present findings are in accordance with Parmar and Arvindrajan (2017) 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).

Table 5: Effect of different dose of biopesticides and pesticides on economics.

Treatment	Treatment Detail	Seed Yield(q/ha)	Gross Income (Rs/ha)	Expenditure (Rs/ha)	Net income (Rs/ha)	C:B Ratio
T1	P + L	9.32	83,880	43,252	40,628	1:1.93
T2	P + A	9.32	83,880	43,131	40,749	1:1.94
T3	C + L	9.17	82,530	42,602	39,928	1:1.93
T4	C + A	7.80	70,200	42,481	27,719	1:1.65
T5	L + P + C	10.90	98,100	44,137	53,963	1:2.22
T6	L + C + P	9.32	83,880	44,137	39,743	1:1.90
T7	A + P + C	11.49	103,410	44,016	59,394	1:2.34
T8	A + C + P	9.52	85,680	44,016	41,664	1:1.94
T9	I + SAAF + C	9.28	83520	42,570	40,950	1:1.96
T10	CONTROL	7.61	68,490	42,317	16,234	1:1.61

CONCLUSION

The present research concluded that biopesticides are a set of tools whose applications will help farmers transit from highly toxic conventional chemical pesticides into an era of truly sustainable agriculture. In light of the experimental findings summarized above, it may be concluded that among various treatments the best treatment for powdery mildew control after first and second spray was T6 i.e. Two foliar sprays of *Lecanicillium lecanii* (1×10^9 cfu/g) + Spray of Carbendazim @ 0.1% (first spray) + Spray of Propiconazole @ 0.05% (second spray). Even though T7 *i.e.* Two foliar sprays of Acetamiprid (0.004%) + Propiconazole @ 0.05% (first spray) + spray of Carbendazim @ 0.1% (second spray) keeping the fact of the highest gross income and B:Cratio.

FUTURE SCOPE

The following suggestions are put forth for further research work:

1. Studies on pesticide residue analysis should be conducted.
2. The experiment should be repeated for two or three years for confirmation of the results.
3. The same experiment should be performed with different varieties suitable for cultivation in Madhya Pradesh.
4. Studies regarding the effect of pesticide and biopesticidal spray on natural predators and pollination in Coriander should be studied.
5. Risk perception and risk assessment of pesticides and their alternative should be studied.

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Conflict of Interest. None.

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