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Bio-efficacy of Different Bio-pesticides Against Aphid [*Myzus persicae* (Sulzer)] in Cumin

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Abstract: A field experiment was undertaken to investigate the effectiveness of certain bio-pesticides against the cumin aphid, *Myzus persicae* (Sulzer). The study was done on the Gujarat cumin-4 (GC-4) variety, which was cultivated at the Agricultural University, Jodhpur during *Rabi*, 2020-21. First spray of bio- pesticides was carried out at initiation of pest and second after 20 days. Among the evaluated bio-pesticides, *Verticillium lecanii* 1.15 WP and *Metarhizium anisopliae* 1.15 WP were found effective against aphids on cumin. The higher production of cumin seeds as well as net realization was obtained from *Verticillium lecanii* and *Metarhizium anisopliae* treated plots against control. However, the standard check (imidachloprid 17.8 SL) was found most effective which was also reflected in yield as well as in the economics. Among biopesticides *Verticillium lecanii* 1.15 WP and *Metarhizium anisopliae* 1.15 WP obtained highest ICBR 1:26.96 and 1:22.40, respectively.

Key words: Cumin, *Myzus persicae*, bio-pesticides, pest, management, incremental cost benefit ratio.

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India is the largest consumer as well as their largest producer in the world. Among them cumin (*Cuminum cyminum* L.) is an important seed spice crop belonging to family Apiaceae. It believes to have originated in Mediterranean region. Cumin seeds contain 2.5 - 4.5% volatile oil consisting of cuminaldehyde (20-40%) which is used as raw material in perfumery and also for flavoring liquors and cordials. In addition to this, seeds also contain a 10% fixed oil with a strong aromatic flavor as carminative and it is also used in the oil, fat and soap industries (Meena *et al*., 2018). Cumin cultivation cover about 1.27 m ha in India with giving an annual production of 0.91 mt (Anonymous, 2021). Cumin crop is largely cultivated in Rajasthan and Gujarat and both the states collectively contribute more than 90% of total country's cumin production. In Rajasthan, cumin is cultivated in an area of 0.78 mha with annual production of 0.43 mt (Anonymous, 2021). The major cumin producing districts in Rajasthan are Jodhpur, Jalore, Barmer, Nagaur, Pali and Bikaner. Cumin productivity is often impacted by insect pests. Many insect pests have been recorded in cumin viz., aphid, *Myzus persicae* (Sulz.), *Aphis gossypii* (Glover), *Hyadaphis coriandri* (Das), mirid bug, *Orthops* (=*Lygus*) *compestris* Fallen, thrips, *Thrips tabaci* Lind., *Scirtothrips dorsalis* Hood, *Frankliniella schultzei* Trybom

and jassids, *Empoasca* spp. (Meena *et al*., 2018, Suthar *et al*., 2018). But among these aphids are known to cause maximum damage to the crop.

Major cumin importing countries are coming out with more stringent legislations on quality requirements. Farmers are not aware about the quality problems of cumin for export. They use chemicals as per the advice of local traders which creates issues of residual effect on cumin seeds resulting in the failure of the samples during quality test. The demand for organic seed spices is also emerging and will increase in the future and at present sufficient quantity of organically produced cumin seed is not available (Gondalia *et al*., 2019). Organic production in seed spices, particularly in cumin is very difficult due to high risk of pests and diseases. Therefore, there is need to develop specific biopesticides for organic production of cumin. Hence, in view of these, the present study was carried out with an objective of evaluating the bio-efficacy and economics of different bio-pesticides (efficacy of these bio-pesticides compared against imidachloprid 17.8 SL) against aphids on cumin.

Materials and Methods

Field experiment was conducted during *Rabi*, 2020-21 to assess the bio-efficacy of different bio-pesticides and compared their efficacy against insecticide, imidachloprid 17.8 SL, in a randomized block design (RBD) at the Instructional farm, College of Agriculture, Agricultural University, Jodhpur, Rajasthan. Cumin variety GC-4 was sown by line sowing method in the plots of 3.5 x 3.0 m^2 size. All the recommended agronomical practices were followed for raising the crop. There was total seven treatments replicated three times. The treatments included *Beauveria bassiana* 1.15% WP, *Metarhizium anisopliae* 1.15% WP, *Verticillium lecanii* 1.15% WP, Azadirachtin 10,000 µg ml^{-1}, Azadirachtin 3,000 µg ml^{-1} and imidacloprid 17.8% SL (standard check) along with untreated control. The bio-pesticides were purchased from Utkarsh Agrochem Pvt. Ltd.). All the bio-pesticides were applied as foliar spray in morning hours on the crop using pre-calibrated knapsack sprayer when the pest population built up to 54.23 to 60.50 aphids per three umbels per plant. The spray was repeated after 20 days of the first spray when pest populations again reached between (25.38 to 53.46 aphids three $umbels^{-1}$ $plant^{-1}$). An untreated check was maintained for comparison. The observations on population of aphid were recorded on three umbels from the five randomly selected and tagged plants in each replication at one day before and 1,3,7 and 15 days after application of treatments in both the sprays (where the same plants were tagged and used throughout the experimental period). Yield data of seed were recorded at harvest and converted to per hectare basis.

The data obtained just before treatment and one, three, seven, and fifteen days after the spray were taken into consideration to find out the per cent reduction in the population which was determined using the Henderson and Tilton (1955) equation referring it to be modification of Abbott (1925):

$$\text{Per cent reduction in pest population} = 1 - \frac{T_a \times C_b}{T_b \times C_a} \times 100$$

where,

T_a= Number of insects after treatment;

T_b= Number of insects before treatment

C_a= Number of insects in untreated check after treatment

C_b= Number of insects in untreated check before treatment

The per cent data thus obtained were subjected to analyses after transforming them into angular transformed values (Gomez and Gomez, 1976). The avoidable loss and increase in seed yield over control was also calculated for each treatment.

Results and Discussion

The variations in number of aphids per three umbels per plant recorded in all the treatments before spray were non-significant indicating homogenous distribution of aphid population in all the treatments which ranged from 54.23 to 60.50 (Table 1). All the biopesticides or insecticide applied as foliar spray were found significantly superior over the untreated control in reducing the aphid population up to fifteen days of sprays; however, there existed a considerable difference among them.

Imidacloprid (standard check) was found significantly superior over all the treatments of bio-pesticides in reducing aphid population

Table 1. Bio-efficacy of different bio-pesticides against aphid on cumin

Treatments	First spray						Second spray					
		Mean per cent reduction days after treatment						Mean per cent reduction days after treatment				
	PTP#	One	Three	Seven	Fifteen	Mean	PTP#	One	Three	Seven	Fifteen	Mean
Beauveria bassiana 1.15 WP @ 1 x 10^8 CFU g^{-1}	56.23	41.96	52.24	46.56	34.99	43.94	35.33	43.72	61.23	48.76	36.59	47.58
		(40.37)	(46.28)	(43.02)	(36.27)	(41.52)		(41.39)	(51.49)	(44.29)	(37.22)	(43.61)
Metarhizium anisopliae 1.15 WP @ 1 x 10^8 CFU g^{-1}	58.70	43.41	53.41	47.88	36.58	45.32	32.75	46.34	62.06	51.61	38.85	49.72
		(41.21)	(46.96)	(43.78)	(37.22)	(42.31)		(42.90)	(51.98)	(45.92)	(38.56)	(44.84)
Verticillium lecanii 1.15 WP @ 1 x 10^8 CFU g^{-1}	54.23	46.10	55.57	50.85	38.99	47.88	28.88	47.74	63.85	53.14	42.73	51.87
		(42.76)	(48.20)	(45.48)	(38.64)	(43.78)		(43.70)	(53.04)	(46.80)	(40.82)	(46.07)
Azadirachtin 10,000 µg ml^{-1}	59.75	27.16	36.64	34.93	20.58	29.83	35.46	27.84	47.87	36.67	21.34	33.43
		(31.41)	(37.25)	(36.23)	(26.98)	(33.10)		(31.85)	(43.78)	(37.27)	(27.51)	(35.32)
Azadirachtin 3,000 µg ml^{-1}	55.75	32.66	39.95	36.42	24.95	33.49	37.16	32.24	52.71	39.94	27.48	38.09
		(34.85)	(39.20)	(37.12)	(29.97)	(35.36)		(34.60)	(46.55)	(39.20)	(31.62)	(38.11)
Imidacloprid 17.8 SL @ 0.01%	60.50	77.84	89.45	84.48	65.39	79.29	25.38	79.31	90.81	84.58	71.82	81.63
		(61.92)	(71.05)	(66.80)	(53.96)	(62.93)		(62.94)	(72.35)	(66.88)	(57.94)	(64.62)
Untreated Control	55.25	-	-	-	-	-	53.46	-	-	-	-	-
SEm±		1.36	1.46	1.38	1.23	-		1.39	1.61	1.40	1.29	-
CD at 5%		4.07	4.38	4.13	3.67	-		4.16	4.82	4.21	3.87	-

*Figures in parentheses are angular transformed values; #PTP- Pre-Treatment Population (no. of aphids 3umbels^{-1}plant^{-1})

(79.29%) up to 15 days of first spray. Among the bio-pesticides the maximum aphid population reduction (47.88%) was recorded with *Verticillium lecanii* followed by *Metarrihizium anisopliae* (45.32%) and *Beauveria bassiana* 43.94. *Metarrihizium anisopliae* and *Beauveria bassiana* were statistically at par in their efficacy. The minimum reduction was found in Azadirachtin 10,000 µg ml^{-1} and Azadirachtin 3,000 µg ml^{-1} which gave 29.83 and 33.49% reduction, respectively, which were statistically inferior to all the other treatments. Similar to the first, efficacy of *Verticillium lecanii* in second spray was also maximum followed by the spray of *Metarrihizium anisopliae* and *Beauveria bassiana*. All the three treatments were found statistically at par in their efficacy but significantly superior over rest of the treatments except imidacloprid 17.8 SL. The minimum reduction of 33.43% was recorded for Azadirachtin 10,000 µg ml^{-1}. Spray of Azadirachtin 3,000 µg ml^{-1} was statistically at par with the spray of 1000 µg ml^{-1}.

Jid (2011) reported that imidacloprid (0.006%) proved most effective for the suppressing *M. persicae* on cumin. Results of Ola *et al*. (2013) showed that the imidacloprid (0.005%) was highly effective against aphid, *H. coriandri* on coriander. However, Dangi *et al*. (2017) reported that imidacloprid was least effective against aphid, *M. persicae* on cumin. Shewale and Borad (2020) reported that imidacloprid (0.005%) was moderately effective against the population of fennel aphid (*Hydaphis coriandri*) on fennel. Among biopesticides, the next most effective treatments were *Verticillium lecanii* 1.15 WP followed by *Metarrihizium anisopliae* 1.15 WP and *Beauveria bassiana* 1.15 WP in the present investigation. The results are agreement with the findings of Vu *et al*. (2007), they found *Lecanicillium lecanii* most effective biocontrol agent for the aphids, *M. persicae* as compared to *B. bassiana* and *M. anisopliae*. Pati and Bhattacharya (2015) also found *V. lecanii* as an effective entomopathogenous fungus of cabbage aphid. Likewise, Jasim and Mohammed (2019) reported that *V. lecanii* and *Isaria fumosorosea* were effective against *M. persicae* on cucumber which fully supports the present findings. Kant *et al*. (2013) reported that *M. anisopliae* was effective in controlling the aphid on coriander. Whereas, Selvaraj *et al.* (2012) and Selvaraj and Kaushik (2014) reported that *B. bassiana* can be used as potential biocontrol agent against *H. coriandri* on coriander and *Aphis craccivora* on fenugreek. The treatments viz., Azadirachtin 10,000 µg ml^{-1} followed by Azadirachtin 3,000 µg ml^{-1} were found least effective against aphid population. The results are in conformity with Ola *et al*. (2013) who found Azadirachtin (0.5%) least effective against aphid in coriander. Choudhary *et al.* (2015) reported that Neem oil (1.0%) is moderately effective in the control of aphid on coriander crop. However, Sarvaiya *et*

Table 2. Assessment of avoidable losses caused by aphid on cumin and increase in yield over control

Treatments	Conc. (%) dosage	Yield (t ha^{-1})	Total avoidable losses (t ha^{-1})	Percent avoidable losses	Total increase yield untreated check (t ha^{-1})	Percent increase in yield over untreated check
Beauveria bassiana 1.15 WP (1 x 10^8 CFU g^{-1})	5 g L^{-1}	0.56	0.21	27.38	0.18	46.75
Metarhizium anisopliae 1.15 WP (1 x 10^8 CFU g^{-1})	5 g L^{-1}	0.58	0.20	25.84	0.19	49.87
Verticillium lecanii 1.15 WP (1 x 10^8 CFU g^{-1})	5 g L^{-1}	0.59	0.18	23.78	0.21	54.03
Azadirachtin 10,000 µg ml^{-1}	2.5 ml	0.52	0.26	33.03	0.14	35.32
Azadirachtin 3,000 µg ml^{-1}	7.5 ml	0.54	0.24	30.85	0.15	39.74
Imidacloprid 17.8 SL	0.01%	0.78	0.00	0.00	0.39	102.08
Untreated control	-	0.38	0.39	50.51	0.00	0.00
SEm±		0.30				
CD at 5%		0.08				

al. (2018) reported Azadirachtin (0.0006%) and Neem oil (0.3%) effective in suppressing the aphid population on fenugreek.

The maximum seed yield of 0.78 t ha^{-1} was recorded in the plots treated with Imidacloprid followed by *Verticillium lecanii* (0.59 t ha^{-1}), *Metarrihizium anisopliae* (0.58 t ha^{-1}) and *Beauveria bassiana* (0.565 t ha^{-1}). The present findings are in agreement with the results of Jid (2011) and Ola *et al*. (2013). The seed yield (0.52 t ha^{-1}) recorded in the plots treated with Azadirachtin 10,000 µg ml^{-1} and Azadirachtin 3,000 µg ml^{-1} were statistically at par but still higher than control. The minimum yield was recorded in control (0.38 t ha^{-1}) due to heavily aphid infestation of aphids. Similar observations have been reported by Suthar *et al.* (2018).

The avoidable loss in plots treated with Imidacloprid was taken as zero as the highest seed yield was obtained in this treatment (Table 2). This was followed by *Verticillium lecanii*, *Metarrihizium anisopliae* and *Beauveria bassiana* which had 23.78, 25.84 and 27.38% of avoidable losses, respectively. The maximum avoidable loss of 50.51% was recorded in untreated control with an absolute seed loss of 0.393 t ha^{-1}. Similarly, the maximum per cent increase in yield over control, i.e. 102.08% was recorded in plots treated with Imidacloprid. It was followed by plots treated with *Verticillium lecannii*, *Metarrihizium anisopliae* and *Beauveria bassiana* in which per cent increase in yield over control was 54.03, 49.87 and 46.75% respectively. Increase in yield over control in plots treated with Azadirachtin 10,000

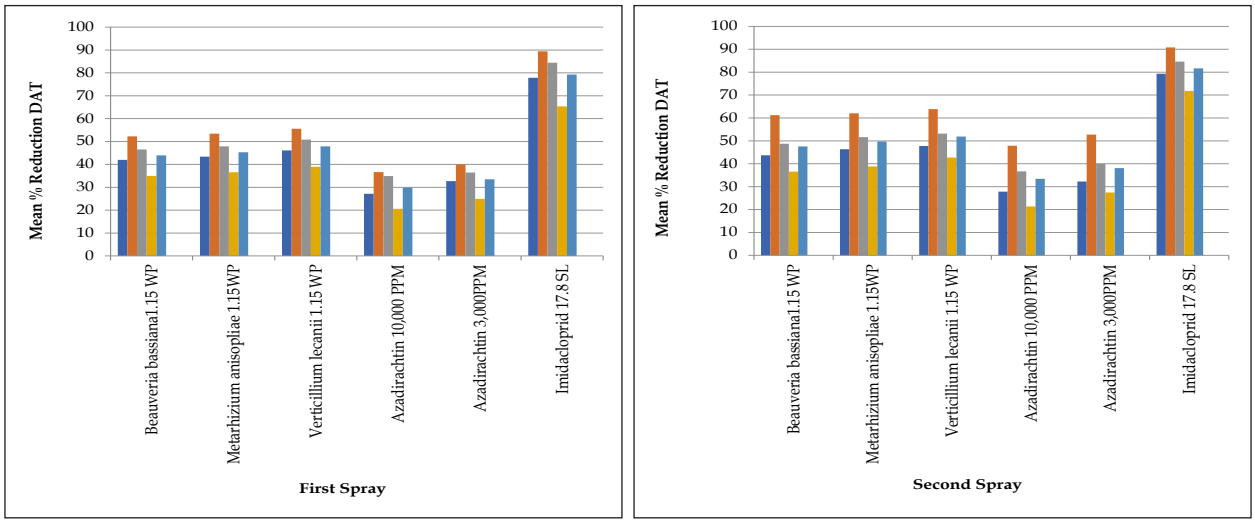

Fig. 1. Comparative bio-efficacy at one, three, seven and fifteen days after treatment (DAT) of different bio-pesticides/insecticides against aphid on cumin.

Table 3. Comparative economics of insecticidal treatments on cumin

Treatments	Conc. (%) dosage	Yield (t ha^{-1})	Increase in yield over untreated check (t ha^{-1})	Return of increase yield (Rs ha^{-1}) *	Total cost of expenditure (Rs ha^{-1})**	Net profit (Rs ha^{-1})	Incremental cost benefit ratio
*Beauveria bassiana*1.15 WP (1 x 10^8 CFU/g)	5 g L^{-1}	0.56	0.18	19800.0	3285	16515.0	1:6.03
Metarhizium anisopliae 1.15 WP (1 x 10^8 CFU g^{-1})	5 g L^{-1}	0.58	0.19	21120.0	3185	17935.0	1:6.63
Verticillium lecanii 1.15 WP (1 x 10^8 CFU g^{-1})	5 g L^{-1}	0.59	0.21	22880.0	3185	19695.0	1:7.18
Azadirachtin 10,000 µg ml^{-1}	2.5 ml	0.52	0.14	14960.0	2278.75	12681.3	1:6.57
Azadirachtin 3,000 µg ml^{-1}	7.5 ml	0.54	0.15	16830.0	3716.25	13113.8	1:4.53
Imidacloprid 17.8 SL	0.01%	0.78	0.39	43230.0	2560	40670.0	1:16.89
Untreated control	_	0.38	0.00	0.0	0	0.0	0.00

* Cost of seed of cumin at prevailing market price at the time of threshing i.e. Rs. 110000 t^{-1}
** It includes cost of insecticides and labor charges @ Rs. 260 $labor^{-1}$ day^{-1} (3 laborers spray ha^{-1})

µg ml^{-1} and Azadirachtin 3,000 µg ml^{-1} was 35.32 and 39.74%, respectively. The results are in close conformity with Bana *et al*. (2011) who reported highest yield in imidacloprid (0.005%) and maximum loss reduction. In the study highest net profit (Rs. 40670.00 ha^{-1}) was recorded in the treatment of imidacloprid followed by *Verticillium lecanii* (Rs. 19695.0 ha^{-1}), *Metarrihizium anisopliae* (Rs. 17935.0 ha^{-1}) and *Beauveria bassiana* (Rs.16515.0 ha^{-1}). The minimum net profit (Rs. 12681.3 ha^{-1}) was recorded in the plots treated with Azadirachtin 10,000 µg ml^{-1} followed by Azadirachtin 3,000 µg ml^{-1} (Rs. 13113.8 ha^{-1}). As data depicted in table 3, the maximum incremental cost benefit ratio (ICBR) (1:16.89) was recorded in the treatment of imidacloprid 17.8 SL. The higher ICBR was also obtained in the treatment of *Verticillium lecanii* 1.15 WP followed by *Metarrihizium anisopliae* 1.15 WP and *Beauveria bassiana*1.15 WP with the benefit cost ratio of 1:7.18, 1:6.63 and 1:6.03, respectively. The minimum ICBR was obtained in the treatments of Azadirachtin 3,000 µg ml^{-1} followed by Azadirachtin 10,000 µg ml^{-1} which exhibited benefit cost ratio of 1:4.53 and 1:6.57, respectively. The present findings corroborate with the findings of Bana *et al.* (2011) who reported that highest benefit cost ratio was

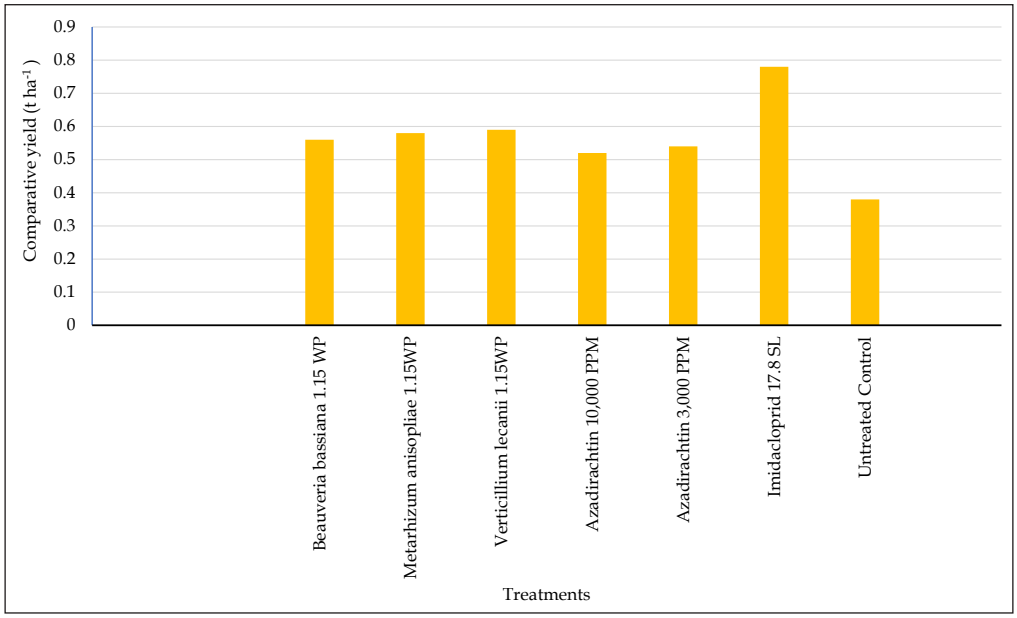

Fig. 2. Comparative yield (t ha^{-1}) in different bio-pesticides/insecticides treated plots.

obtained in the plots treated with imidacloprid 17.8 SL (0.005%) in coriander crop.

Conclusion

Considering the efficacy of different insecticides/biopesticides in this present investigation concluded that imidacloprid 17.8 SL (standard check) proved most effective against aphid, whereas among biopesticides *Verticillium lecanii* 1.15 WP found most effective followed by *Metarrihizium anisopliae* 1.15 WP and *Beauveria bassiana* 1.15 WP. The maximum seed yield 7.78 q ha^{-1} was obtained in the standard check (imidacloprid 17.8 SL) plots followed by *V. lecanii*1.15 WP, *M. anisopliae*1.15 WP and *B. bassiana* 1.15 WP. The maximum ICBR of 1:16.89 was recorded in the treatment of imidacloprid 17.8 SL followed by *V. lecanii* 1.15 WP (1:7.18), *M. anisopliae* 1.15 WP (1:6.63) and *B. bassiana* 1.15 WP (1:6.03).

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