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Bio-efficacy of various insecticides against aphid, *Myzus persicae* Sulzer infesting cumin (*Cuminum cyminum* L.)

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Abstract
A field experiment was conducted at Agronomy farm, B. A. College of Agriculture, Anand Agricultural University, Anand (Gujarat) during *rabi*, 2015-16 to evaluate the efficacy of different nine insecticides (imidacloprid 0.005%, thiamethoxam 0.0125%, clothianidin 0.025%, carbosulfan 0.05%, acephate 0.075%, diafenthiuron 0.05%, dimethoate 0.03%, flonicamid 0.015% and tolfenpyrad 0.03%) against cumin aphid, *Myzus persicae* compared to control. The tolfenpyrad 0.03% was observed significantly superior insecticide followed by flonicamid 0.015. The population of *coccinellids* (predators)/5cm shoot showed non-significant difference among treatments and were as good as control indicating no any hazardous effect of tested insecticides. The highest seed yield of cumin was obtained from the plots treated with tolfenpyrad 0.03% (22.41 q/ha) followed by flonicamid 0.015% (21.70 q/ha). The flonicamid 0.015% (3.15%) recorded lowest avoidable losses followed by clothianidin 0.025% (18.49%). The highest increase in seed yield over control and maximum net realization were registered from the plot treated with tolfenpyrad 0.03% (145.22% and 161131 ₹/ ha) followed by flonicamid (137.45% and 154938 ₹/ ha). Maximum ICBR was registered in the treatment of imidacloprid 0.0052% (1:106.18) followed by flonicamid 0.015% (1:76.14).

Keywords: Cumin aphid, *Myzus persicae*, bio-efficacy, insecticides, cumin

Introduction
Cumin (*Cuminum cyminum* Linnaeus) belongs to family *Umbelliferae* which mainly used as a spice in Indian cookery. The seeds have long been considered as an indigenous medicine for stimulative and carminative activity. In India, cumin is cultivated from very ancient times. It is grown in almost all the states except, West Bengal and Assam. Its extensive cultivation is confined to states of Rajasthan and Gujarat. In Gujarat, total area under cumin is 0.28 million hectares having total production of 0.28 million tonnes with the productivity 1.02 MT/hectare during the year 2016-17 [1].

Among the different factors responsible for low production of cumin, insect pests are one of the limiting factors for higher production of good quality seeds. Aphid, thrips, cutworm, tobacco caterpillar and root-knot nematode are attacking the cumin crop in field, while cigarette beetle & drugstore beetle are attacking in storage under Indian condition. Among the pest infesting the cumin crop, aphid**,** *Myzus persicae* (Sulzer) is reported as a serious pest of cumin [2].

To control this pest in field, number of new molecules are available in the market and they are also less toxic to natural enemies as well as human being. Therefore, the present study was carried out to evaluate the bio-efficacy of different insecticide, toxicity to natural enemies as well as economics.

2. Materials and methods
Field experiment was conducted during *rabi*, 2015-16 to assess the bio-efficacy of different insecticides in a Randomized Block Design (RBD) at Agronomy farm, B. A. College of Agriculture, Anand Agricultural University, Anand (Gujarat). For the purpose, cumin variety Gujarat cumin-4 was sown by broadcasting method having plot size 3.0 x 1.5 m. All the recommended agronomical practices were followed for raising the crop. There were total 10 ten treatments replicated three times. The treatments included imidacloprid 0.005%, thiamethoxam 0.0125%, clothianidin 0.025%, carbosulfan 0.05%, acephate 0.075%, diafenthiuron 0.05%, dimethoate 0.03%, flonicamid 0.015% and tolfenpyrad 0.03% along with untreated control.

Only one spray of respective insecticide was made after the buildup of sufficient population of aphid on crop with knapsack sprayer fitted with holocone nozzle. To record aphid population in respective treatment, five plants were selected randomly from net plot area. On each plant, 3 shoot were observed critically and aphid populations as well as natural enemies were recorded on 5 cm length of each shoot. The aphid population was recorded before and after 1, 3, 5, 7 and 9 days of spray. The data were statistically analyzed after following standard statistical procedure. Crop was harvested at proper maturity stage and seed yield was weighed treatment-wise from each net plot area. Based on recorded seed yield from each net plot, it was converted in to quintal per hectare.

On the basis of cumin seed yield harvested from various treatments under study, the avoidable losses due to aphid, *M. persicae* was calculated with the help of formula described by Khosla [4].

$$\text{Avoidable losses (\%)} = \frac{\text{Yield of treatment which gave the highest yield} - \text{Yield of respective treatment}}{\text{Yield of treatment which gave the highest yield}} \times 100$$

Increase in seed yield over control

$$\text{Percent increasing yield over control} = \frac{\text{Yield in treatment} - \text{Yield in control treatment}}{\text{Yield in control treatment}} \times 100$$

3. Results and Discussion

The data on number of aphid/5cm shoot recorded before spray was found non-significant in all the treatments indicating homogenous population in all the treatments under study and it was in the range of 39.82 to 47.94 aphids/5 cm shoot (Table 1).

After one day after spraying, the analysis of data on aphid population/5 cm shoot revealed that all the insecticide treatments were found significantly superior and recorded lower aphid population as compared to control. The treatment of tolfenpyrad 15 EC 0.03% recorded the lowest aphid population (2.46 aphids/5 cm shoot) and it was at par with flonicamid 50 WG 0.015% (4.56). The data on aphid population/5cm shoot revealed that all the insecticides were found effective in reducing aphid population as compared to control after third day of spraying. The tolfenpyrad 0.03% (1.11) maintained its superiority by recording the lowest number of aphid population. The data on aphid population/5cm shoot after 5th day of spraying indicated the superiority of tolfenpyrad 0.03% (0.40) by recording the lowest population of aphid. After seventh day of spraying, all the insecticidal treatments were found significantly superior over control. The tolfenpyrad 0.03% (5.12) recorded lowest number of aphid and maintained its superiority over rest of the insecticides except flonicamid 0.015% (7.34). The data on aphid population/5cm shoot after 9th day of spraying indicated the superiority of tolfenpyrad 0.03% (5.95) by recording the lowest population of aphid. The flonicamid 0.015% (8.14) was found next best treatment and it was at par with most effective insecticide tolfenpyrad 0.03% as well as clothianidin 0.025% (8.92), carbosulfan 0.05% (9.05), imidacloprid 0.0052% (11.06) and thiamethoxam 0.0125% (11.40).

The data on aphid population/5 cm shoot pooled over periods (Table 1) revealed that there was significant difference among various insecticides. The order of various insecticides based on aphid population (given in bracket after each treatment) was: tolfenpyrad 0.03% (2.63) < flonicamid 0.015% (4.98) < carbosulfan 0.05% (5.36) < clothianidin 0.025% (5.65) < imidacloprid 0.0052% (7.91) < thiamethoxam 0.0125% (8.20) < acephate 0.075% (9.93) < diafenthiuron 0.05% (12.68) < dimethoate 0.03% (14.09) < control (43.99). Tolfenpyrad 0.03% was significant superior over rest of the insecticides. Flonicamid 0.015%, carbosulfan 0.05% and clothianidin 0.025% were at par with each other but differed significantly from rest of the insecticides. Patel *et al.* [6] reported that the tolfenpyrad 15 EC @ 150 g. a.i. /ha was found more effective against cumin aphid at Jagudan (Gujarat). Jid [3] reported that the imidacloprid 0.006 per cent proved to be the most effective and economical treatment followed by acetamiprid 0.004 per cent and carbosulfan 0.05% for the suppression of *M. persicae* in cumin.

3.1 Relative effect of different insecticides on *coccinellid* predators

Considering the importance of these biotic fauna, the data on locally available predators of aphid, *M. persicae* were recorded from the trials carried out to evaluate the bio-efficacy of insecticide against aphid, *M. persicae* infesting cumin. The results are presented in Table 2.

The data on population of *coccinellids* (predators)/5cm shoot recorded from various plots treated with different insecticide showed non-significant difference among treatments and were as good as control during all the observations made before and after 1, 3, 5, 7 and 9 days after spray (Table 2). The *coccinellid* predators declined slowly till 5th days after spraying. The above results showed that there was no any adverse effect of evaluated insecticides on the activity of *coccinellids* in cumin crop. Patel [5] observed higher activity of coccinelids in the plot treated with flonicamid 50 WG 0.015% and clothianidin 50 WDG 0.025% at Anand (Gujarat).

3.2 Yield, avoidable losses, increase in seed yield over control and economics

The data on seed yield (q/ha), avoidable losses, increase in yield over control are presented in Table 3, while data on economics of various treatments are presented in Table 4.

3.2.1 Yield

The highest seed yield of cumin was obtained from the plots treated with tolfenpyrad 0.03% (22.41 q/ha) and it was at par with flonicamid 0.015% (21.70 q/ha). The clothianidin 0.025% (18.49) was next better treatment in recording the seed yield of cumin and was found at par with carbosulfan (17.21), imidacloprid 0.0052% (16.69) and thiamethoxam 0.0125% (16.01). Thus, tolfenpyrad 0.03% and flonicamid 0.015% were most effective insecticides and recorded higher seed yield of cumin.

3.2.2 Avoidable losses

The flonicamid 0.015% (3.15%) recorded lowest avoidable losses followed by clothianidin 0.025% (17.51%). The avoidable losses were 23.22, 25.54 and 28.54 per cent in carbosulfan 0.05%, imidacloprid 0.0052% and thiamethoxam 0.0125%, respectively. The avoidable losses were calculated as 40.31, to 41.74and 43.17 per cent in the treatments of acephate 0.075%, diafenthiuron 0.05% and diamethoate 0.03%, respectively. The highest avoidable losses was recorded in the control treatment (59.20%).

3.2.3 Increase yield over control

The highest increase in seed yield over control was registered from the plot treated with tolfenpyrad 0.03% (145.22%) followed by flonicamid 0.015% (137.45%).

3.2.4 Economics of different insecticides

The details of Incremental Cost Benefit Ratio (ICBR) calculated for different treatments of insecticides are presented in Table 4. Data indicated that maximum net realization was found in the treatment of tolfenpyrad 0.03% (161131₹/ha) followed by flonicamid 0.015% (154938₹/ha), clothianidin 0.025% (112500 ₹/ha), carbosulfan 0.05% (99190₹/ha) and imidacloprid 0.0052% (93404₹/ha) Maximum ICBR was registered in the treatment of imidacloprid 0.0052% (1:106.18) followed by flonicamid 0.015% (1:76.14), carbosulfan 0.05% (1:62.92) and thiamethoxam 0.0125% (1:53.94). From the overall results, it can be inferred that tolfenpyrad 0.03% was most effective treatment from the efficacy point of view but it remained far behind by registering lower ICBR. Thus, imidacloprid, flonicamid and carbosulfan were found most effective and economical treatments. According to Jid (2011), imidacloprid 0.006% had Protection Cost Benefit Ratio of 1: 20.24 followed by acetamiprid 0.004% (1:9.26) for controlling *M. persicae* in cumin crop.

Table 1: Bio-efficacy of various insecticides against aphid, *M. persicae* infesting cumin

	No. of aphid(s) /5 cm shoot						
Treatments	**Before spray**	**1 DAS**	**3 DAS**	**5 DAS**	**7 DAS**	**9 DAS**	**Pooled over periods**
Imidacloprid 0.0052%	6.91 (47.25)	2.83bcd (7.51)	2.58cd (6.16)	2.43cd (5.40)	3.26bc (10.13)	3.40cd (11.06)	2.90c (7.91)
Thiamethoxam 0.0125%	6.84 (46.29)	2.88bcd (7.79)	2.64cd (6.47)	2.49d (5.70)	3.32bc (10.52)	3.45cd (11.40)	2.95c (8.20)
Clothianidin 0.025%	6.69 (44.26)	2.43bc (5.40)	2.09bc (3.87)	1.87b (1.87)	2.93b (8.08)	3.07bc (8.92)	2.48b (5.65)
Carbosulfan 0.05%	6.35 (39.82)	2.30ab (4.79)	1.86b (2.96)	1.91bc (3.15)	2.94b (8.14)	3.09bc (9.05)	2.42b (5.36)
Acephate 0.075%	6.58 (42.80)	3.16cde (9.49)	2.95de (8.20)	2.81de (7.40)	3.56cd (12.17)	3.68de (13.04)	3.23d (9.93)
Diafenthiuron 0.05%	6.56 (42.53)	3.56de (12.17)	3.38e (10.92)	3.27e (10.19)	3.92de (14.87)	4.03e (15.74)	3.63e (12.68)
Dimethoate 0.03%	6.77 (45.33)	3.81e (14.02)	3.54e (12.03)	3.34e (10.66)	4.15e (16.72)	4.25e (17.56)	3.82e (14.09)
Flonicamid 0.015%	6.83 (46.15)	2.27ab (4.56)	1.95b (3.30)	1.76b (2.60)	2.80ab (7.34)	2.94ab (8.14)	2.34b (4.98)
Tolfenpyrad 0.03%	6.58 (42.80)	1.72a (2.46)	1.27a (1.11)	0.95a (0.40)	2.37a (5.12)	2.54a (5.95)	1.77a (2.63)
Control (untreated)	6.96 (47.94)	6.63f (43.46)	6.53f (42.14)	6.48f (41.49)	6.83f (46.15)	6.89f (46.97)	6.67f (43.99)
S.Em ± Treatment (T)	0.32	0.22	0.18	0.16	0.17	0.17	0.17
Period (P)	-	-	-	-	-	-	0.02
T X P	-	-	-	-	-	-	0.07
F test (T)	NS	S	S	S	S	S	S
(P)	-	-	-	-	-	-	S
T X P	-	-	-	-	-	-	S
C. V.(%)	8.17	11.83	10.98	9.92	8.21	8.10	9.60

Notes: 1.Figures in parentheses are retransformed values and those outside are $\sqrt{X + 0.5}$ transformed. 2. DAS: Days After Spray
3. Figures with letter(s) in common are statistically at par as per DNMRT, 4. S= Significant, 5. NS = Non Significant

Table 2: Toxicity of various insecticides to *coccinellids*

Treatments	**No. of *coccinelids* (Grub and adult) / 5cm shoot**						
	Before spray	**1 DAS**	**3 DAS**	**5 DAS**	**7 DAS**	**9 DAS**	**Pooled**
Imidacloprid 17.8 SL, 0.0052%	0.98 (0.46)	0.84 (0.21)	0.82 (0.17)	0.80 (0.14)	0.82 (0.17)	0.84 (0.21)	0.82 (0.17)
Thiamethoxam 25 WG, 0.0125%	1.00 (0.50)	0.88 (0.27)	0.87 (0.26)	0.84 (0.21)	0.86 (0.24)	0.87 (0.26)	0.86 (0.24)
Clothianidin 50 WDG, 0.0125%	0.97 (0.44)	0.88 (0.27)	0.87 (0.26)	0.87 (0.26)	0.90 (0.31)	0.91 (0.33)	0.89 (0.29)
Carbosulfan 25 EC, 0.05%	0.99 (0.48)	0.82 (0.17)	0.81 (0.16)	0.81 (0.16)	0.82 (0.17)	0.83 (0.19)	0.82 (0.17)
Acephate 75 SP, 0.075%	0.95 (0.40)	0.86 (0.24)	0.84 (0.21)	0.80 (0.14)	0.85 (0.22)	0.86 (0.24)	0.84 (0.21)
Diafenthiuron 50 WP, 0.05%	0.98	0.78	0.78	0.78	0.82	0.83	0.80

	(0.46)	(0.11)	(0.11)	(0.11)	(0.17)	(0.19)	(0.14)
Dimethoate 30 EC, 0.03%	0.93 (0.36)	0.88 (0.24)	0.86 (0.24)	0.86 (0.24)	0.88 (0.27)	0.89 (0.29)	0.87 (0.26)
Flonicamid 50 WG, 0.015%	0.99 (0.48)	0.82 (0.17)	0.81 (0.16)	0.80 (0.14)	0.80 (0.14)	0.81 (0.16)	0.81 (0.16)
Tolfenpyrad 15 EC, 0.03%	0.97 (0.44)	0.88 (0.17)	0.86 (0.24)	0.82 (0.17)	0.86 (0.24)	0.88 (0.27)	0.86 (0.24)
Control (untreated)	0.99 (0.48)	0.92 (0.27)	0.93 (0.36)	0.93 (0.36)	0.95 (0.40)	0.96 (0.42)	0.94 (0.38)
S.Em ± Treatment (T)	0.05	0.03	0.03	0.03	0.03	0.03	0.01
(P)	-	-	-	-	-	-	0.01
T X P	-	-	-	-	-	-	0.03
F test at 5% (T)	NS	NS	NS	NS	NS	NS	NS
(P)	-	-	-	-	-	-	NS
T X P	-	-	-	-	-	-	NS
C. V. (%)	8.01	5.65	5.92	6.36	6.12	6.16	5.93

Notes: 1. Figures in parentheses are retransformed values; those outside are $\sqrt{X + 0.5}$ transformed values. 2. NS = Non Significant, 3. DAS = Days after Spray.

Table 3: Effect of various insecticides on seed yield and avoidable losses due to *M. persicae* in cumin

Treatments	Seed yield (q/ha)	Avoidable losses (%)	Increase in seed yield over Control (%)
Imidacloprid 0.0052%	16.69b	25.54	82.57
Thiamethoxam 0.0125%	16.01bc	28.54	75.20
Clothianidin 0.0125%	18.49b	17.51	102.26
Carbosulfan 0.05%	17.21b	23.22	88.26
Acephate 0.075%	13.38cd	40.31	46.35
Diafenthiuron 0.05%	13.06cd	41.74	42.85
Dimethoate 0.03%	12.74d	43.17	39.35
Flonicamid 0.015%	21.70a	3.15	137.45
Tolfenpyrad 0.03%	22.41a	0.00	145.22
Control (untreated)	9.14e	59.20	-
S. Em. ± (T)	1.04	-	-
F test at 5% (T)	S	-	-
C. V. (%)	11.25	-	-

Note: Figures with letter(s) in common are statistically at par as per Duncan's New Multiple Range Test, S= significant

Table 4: Economics of various insecticides evaluated against aphid, *M. persicae* infesting cumin

Sr. No	Treatments	Amount of insecticide required for 1 spray/ha	Total cost of plant protection (₹/ ha)	Yield (q/ha)	Gross realization (₹/ ha)	Net realization (₹/ ha)	ICBR
1	Imidacloprid 17.8 SL, 0.0052%	150 ml	888	16.69	94292	93404	1: 106.18
2	Thiamethoxam 25 WG, 0.0125%	250 g	1592	16.01	85875	84283	1: 53.94
3	Clothianidin 50 WDG, 0.0125%	250 g	4292	18.49	116792	112499	1: 27.21
4	Carbosulfan 25 EC, 0.05%	1000 ml	1602	17.21	100792	99189	1: 62.92
5	Acephate 75 SP, 0.075%	500 g	998	13.38	52917	51918	1: 53.02
6	Diafenthiuron 50 WP, 0.05%	500 g	2542	13.06	48917	46374	1: 19.24
7	Dimethoate 30 EC, 0.03%	500 ml	842	12.74	44917	44074	1: 53.35
8	Flonicamid 50 WG, 0.015%	150 g	2062	21.70	157000	154938	1: 76.14
9	Tolfenpyrad 15 EC, 0.03%	1000 ml	4744	22.41	165875	161131	1: 34.97
10	Control (untreated)	Control	-	9.14	-	-	-

Notes: 1. Labour charge: 296 ₹/day
2. No. of labour required: 2/hectare
3. Market price of cumin: 12500 ₹/quintal

4. Conclusion

From present study, it may be concluded that the application of tolfenpyrad 15 EC @ 20 ml/10 litre and flonicamid 50 WG @ 3gm/ 10 litre were found effective for suppression of aphid population and also recorded highest seed yield. Further, the increased in yield over control was found to be higher in plots treated with tolfenpyrad 0.03% and flonicamid 0.015%. Hence, the above two chemicals may be suggested for alternate application towards mitigating the losses of *M. persicae* in cumin crop.

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