

Bio-efficacy of newer molecules of insecticides against cumin aphid

B.G. Prajapati*, H.B. Patel and A.U. Amin

Seed Spices Research Station, S.D. Agricultural University, Jagudan- 382 710, Mehsana, Gujarat, India

Abstract

Field trials were conducted at Seed Spices Research Station, Jagudan for three years, *Rabi* 2014-15, 2016-17 and 2017-18, to evaluate the bio-efficacy of different treatments against cumin aphid, *Myzus persicae*. A total of ten treatments include commonly used insecticides, bioagents alone and in combinations and untreated control. Thiamethoxam 25WG (25g a.i. ha⁻¹) followed by thiacloprid 21.7 SC (25g a.i. ha⁻¹) had registered significantly the least aphid infestation (2.08%) at 7 days after second spray and found significantly superior over rest of the treatments. Untreated control, carbosulfan 25EC (250g a.i. ha⁻¹) followed by *Lecanicillium lecanii* 1.15WP (40g 10lit.⁻¹) and acetamiprid 20SP (20g a.i. ha⁻¹) followed by *Lecanicillium lecanii* 1.15 WP (4g lit.⁻¹) had recorded 2.87, 2.69 and 2.69 predatory coccinellids plant⁻¹, respectively. The plots sprayed with thiamethoxam 25WG (25g a.i. ha⁻¹) followed by thiacloprid 21.7SC (25g a.i. ha⁻¹) had obtained the highest seed yield of cumin (216 kg ha⁻¹). Thiamethoxam 25WG (25g a.i. ha⁻¹) followed by thiacloprid 21.7 SC (25g a.i. ha⁻¹) treated plots gave maximum benefit (PCBR= 1:21.64)

Key words : Bio-efficacy, coccinellids, cumin, cumin aphid, *Myzus persicae*.

Introduction

Cumin (*Cuminum cyminum* L.), an important spice crop, is mostly cultivated in the arid regions of Gujarat and Rajasthan states of India. The productivity of this crop is mainly constrained by important insect pests viz., aphid, *Myzus persicae* Sultzer, thrips, *Thrips tabaci* Lindeman, green bug, *Lygus compestris*, chalcid fly, *Systole albipennis* Walker, gram pod borer, *Helicoverpa armigera* (Hubner) Hardwick and brown wheat mite, *Petrobia latens*. Among them, cumin aphid is an important sucking pest in cumin growing regions. Cumin aphid causes serious damage at flowering stage of the crop by desaping the cell sap, as a result of which yellowing and curling of the leaves is exhibited at the initial stage, later the plants showed stunted growth and the inflorescence set few seeds which are shriveled. In case of severe attack, seed yield of cumin is reduced drastically. The information on efficacy of certain newer molecules of insecticides against cumin aphid is scanty. Hence, the present field experiment on the bio-efficacy of newer molecules of insecticides was planned during *Rabi* 2014-15, 2016-17 and 2017-18 so as to manage cumin aphid effectively and economically.

Materials and methods

A field experiment was laid out at the Seed Spices Research Station, Jagudan, Gujarat during *Rabi* 2014-15, 2016-17 and 2017-18 to find out the bio-efficacy of newer

molecules of insecticides against cumin aphid. A total of ten treatments viz. thiamethoxam 25WG (25g a.i. ha⁻¹) followed by thiacloprid 21.7SC (25g a.i. ha⁻¹), thiamethoxam 25WG (25g a.i. ha⁻¹) followed by clothianidin 50WDG (20g a.i. ha⁻¹), thiamethoxam 25WG (25g a.i. ha⁻¹) followed by *Lecanicillium lecanii* 1.15WP (4g lit.⁻¹), acetamiprid 20SP (20g a.i. ha⁻¹) followed by thiacloprid 21.7SC (25g a.i. ha⁻¹), acetamiprid 20SP (20g a.i. ha⁻¹) followed by clothianidin 50WDG (20g a.i. ha⁻¹), acetamiprid 20SP (20g a.i. ha⁻¹) followed by *Lecanicillium lecanii* 1.15WP (4g lit.⁻¹), carbosulfan 25EC (250g a.i. ha⁻¹) followed by thiacloprid 21.7SC (25g a.i. ha⁻¹), carbosulfan 25EC (250g a.i. ha⁻¹) followed by clothianidin 50WDG (20g a.i. ha⁻¹), carbosulfan 25EC (250g a.i. ha⁻¹) followed by *Lecanicillium lecanii* 1.15WP (4g lit.⁻¹) and untreated control. The trial was laid out in a randomized block design (RBD) with ten treatments and three replications. The size of each plot measured 3.00m x 2.40m. The variety of Gujarat Cumin 4 was spaced at 30cm and all the recommended agronomic practices were adopted as per package of practices. Twenty plants were selected to record the observations. Number of umbels infested by cumin aphid and total number of umbels were recorded and per cent umbels infested were worked out prior to spray and 3 and 7 days after each spray. Population of predatory coccinellids was recorded on twenty plants and mean population of coccinellids were worked out. These data were analyzed for its statistical interpretation with

necessary data transformation so as to compare the efficacy different treatments.

Results and discussion

Per cent umbels aphid infestation

Percent umbels aphid infestation prior to spray as well as 3 and 7 days after spray are presented in table 1 to 5. Perusal of the pooled results revealed that per cent umbels aphid infestation differed significantly at 3 and 7days of both the sprays. The data revealed from the table 2 that treatment of thiamethoxam 25WG (25g a.i. ha⁻¹) followed by thiacloprid 21.7SC (25g a.i. ha⁻¹) showed least per cent umbels aphid infestation (25.59%) at 3 days after first spray and remained significantly superior over rest of the treatments. Similarly, perusal of pooled data on per cent umbels aphid infestation at 7 days after first spray presented in table 3 revealed that the plots sprayed with thiamethoxam 25WG (25g a.i. ha⁻¹) followed by thiacloprid 21.7SC (25g a.i. ha⁻¹) registered significantly lowest aphid infestation (14.25%) at 7days after first spray. It can be seen from the data presented in table 4 that the plots sprayed with thiamethoxam 25WG (25g a.i. ha⁻¹) followed by thiacloprid 21.7SC (25g a.i. ha⁻¹) had registered

significantly lowest aphid infestation (5.27%) at 3 days after second spray.

Pooled data on aphid index at 7 days after second spray are presented in table 5. It can be indicated that the plots sprayed with thiamethoxam 25WG (25g a.i. ha⁻¹) followed by thiacloprid 21.7SC (25g a.i. ha⁻¹) had registered significantly least aphid infestation (2.08%) at 7 days after second spray and found significantly superior over rest of the treatments. Thiamethoxam 25WG (25g a.i. ha⁻¹) followed by clothianidin 50WDG (20g a.i. ha⁻¹) ranked second and exhibited 4.56% aphid infestation at 7days after second spray. Unprotected plots of cumin had registered the highest 34.40% aphid infestation at 7days after second spray.

Coccinellids

The results of individual and pooled analysis on population of predatory coccinellids presented in the table 6, 7 and 8. The data revealed that the coccinellids population differed significantly at 3 and 7 days after second spray. Perusal of the pooled data at 3 days after second spray revealed that untreated control, carbosulfan 25EC (250g a.i. ha⁻¹) followed by *Lecanicillium lecanii* 1.15WP (40g 10lit.⁻¹), acetamiprid 20SP (20g a.i. ha⁻¹) followed by

Table 1. Percent umbels infestation in different treatments.

Treat No.	Treatments	% Umbels aphid infestation (Before spray)			
		2014-15	2016-17	2017-18	Pooled
1.	Thiamethoxam 25WG (25g a.i. ha ⁻¹) followed by Thiacloprid 21.7SC (25g a.i. ha ⁻¹)	47.52* (54.40)	38.26* (39.65)	41.29* (43.52)	42.36* (45.40)
2.	Thiamethoxam 25WG (25g a.i. ha ⁻¹) followed by Clothianidin 50WDG (20g a.i. ha ⁻¹)	48.90 (56.79)	38.79 (39.25)	41.82 (44.46)	43.17 (46.80)
3.	Thiamethoxam 25WG (25g a.i. ha ⁻¹) followed by <i>Lecanicillium lecanii</i> 1.15WP (4g lit. ⁻¹)	46.87 (53.28)	38.50 (38.75)	41.54 (43.09)	42.30 (45.30)
4.	Acetamiprid 20SP (20g a.i. ha ⁻¹) followed by Thiacloprid 21.7SC (25g a.i. ha ⁻¹)	47.77 (54.82)	38.00 (37.90)	41.04 (43.11)	42.27 (45.25)
5.	Acetamiprid 20SP (20g a.i. ha ⁻¹) followed by Clothianidin 50WDG (20g a.i. ha ⁻¹)	47.73 (54.78)	37.65 (37.31)	40.69 (42.50)	42.03 (44.81)
6.	Acetamiprid 20SP (20g a.i. ha ⁻¹) followed by <i>Lecanicillium lecanii</i> 1.15WP (4g lit. ⁻¹)	47.87 (55.00)	38.45 (38.66)	41.49 (43.89)	42.60 (45.81)
7.	Carbosulfan 25EC (250g a.i. ha ⁻¹) followed by Thiacloprid 21.7SC (25g a.i. ha ⁻¹)	47.93 (55.10)	38.53 (38.80)	41.56 (44.01)	42.67 (45.92)
8.	Carbosulfan 25EC (250g a.i. ha ⁻¹) followed by Clothianidin 50WDG (20g a.i. ha ⁻¹)	48.19 (55.55)	39.33 (40.18)	42.37 (45.41)	43.29 (47.01)
9.	Carbosulfan 25EC(250g a.i. ha ⁻¹) followed by <i>Lecanicillium lecanii</i> 1.15WP (4g lit. ⁻¹)	48.27 (55.70)	38.81 (39.29)	41.85 (44.51)	42.98 (46.49)
10.	Untreated control	47.87 (55.00)	38.80 (39.28)	41.84 (44.50)	42.83 (46.21)
	S.Em.±	0.90	0.51	0.51	0.38
	C.D.at 5%	NS	NS	NS	NS
	C.V.%	3.27	2.28	2.11	2.70
	YXT				NS

* Arcsin transformed values

Figures in parenthesis are retransformed values

Table 2. Percent umbels infestation at 3days after first spray in different treatments.

Treat No.	Treatments	% Umbels aphid infestation at 3days after first spray			
		2014-15	2016-17	2017-18	Pooled
1.	Thiamethoxam 25WG (25g a.i. ha ⁻¹) followed by Thiocloprid 21.7SC (25g a.i. ha ⁻¹)	37.50* (37.05)	28.27* (22.42)	25.41* (18.41)	30.39* (25.59)
2.	Thiamethoxam 25WG (25g a.i. ha ⁻¹) followed by Clothianidin 50WDG (20g a.i. ha ⁻¹)	39.97 (41.18)	30.19 (25.29)	28.84 (23.28)	33.00 (29.68)
3.	Thiamethoxam 25WG (25g a.i. ha ⁻¹) followed by <i>Lecanicillium lecanii</i> 1.15WP (4g lit. ⁻¹)	38.97 (39.45)	30.84 (26.29)	31.07 (26.62)	33.63 (30.68)
4.	Acetamiprid 20SP (20g a.i. ha ⁻¹) followed by Thiocloprid 21.7SC (25g a.i. ha ⁻¹)	40.70 (42.51)	32.39 (28.70)	32.00 (28.09)	35.03 (32.97)
5.	Acetamiprid 20SP (20g a.i. ha ⁻¹) followed by Clothianidin 50WDG (20g a.i. ha ⁻¹)	41.73 (44.30)	32.80 (29.35)	32.68 (29.15)	35.74 (34.11)
6.	Acetamiprid 20SP (20g a.i. ha ⁻¹) followed by <i>Lecanicillium lecanii</i> 1.15WP (4g lit. ⁻¹)	42.93 (46.49)	34.21 (31.61)	34.63 (32.30)	37.26 (36.65)
7.	Carbosulfan 25EC (250g a.i. ha ⁻¹) followed by Thiocloprid 21.7SC (25g a.i. ha ⁻¹)	42.93 (46.49)	35.53 (33.78)	35.66 (33.99)	38.04 (37.98)
8.	Carbosulfan 25EC (250g a.i. ha ⁻¹) followed by Clothianidin 50WDG (20g a.i. ha ⁻¹)	44.22 (48.62)	37.60 (37.24)	37.06 (36.31)	39.63 (40.69)
9.	Carbosulfan 25EC(250g a.i. ha ⁻¹) followed by <i>Lecanicillium lecanii</i> 1.15WP (4g lit. ⁻¹)	45.30 (50.51)	37.11 (36.40)	38.15 (38.18)	40.19 (41.65)
10.	Untreated control	47.93 (55.10)	38.19 (38.22)	40.73 (42.59)	42.29 (45.29)
	S.Em.±	0.88	0.44	0.63	0.58
	C.D.at 5%	2.60	1.33	1.86	1.72
	C.V.%	3.60	2.29	3.23	3.20
	YXT				1.91

* Arcsin transformed values

Figures in parenthesis are retransformed values

Table 3. Percent umbels infestation at 7days after first spray in different treatments.

Treat No.	Treatments	% Umbels aphid infestation at 7days after first spray			
		2014-15	2016-17	2017-18	Pooled
1.	Thiamethoxam 25WG (25g a.i. ha ⁻¹) followed by Thiocloprid 21.7SC (25g a.i. ha ⁻¹)	28.60* (22.91)	18.76* (10.34)	19.18* (10.79)	22.18* (14.25)
2.	Thiamethoxam 25WG (25g a.i. ha ⁻¹) followed by Clothianidin 50WDG (20g a.i. ha ⁻¹)	31.90 (27.92)	21.97 (14.00)	22.13 (14.19)	25.33 (18.30)
3.	Thiamethoxam 25WG (25g a.i. ha ⁻¹) followed by <i>Lecanicillium lecanii</i> 1.15WP (4g lit. ⁻¹)	32.03 (28.12)	24.62 (17.35)	25.07 (17.95)	27.24 (20.95)
4.	Acetamiprid 20SP (20g a.i. ha ⁻¹) followed by Thiocloprid 21.7SC (25g a.i. ha ⁻¹)	34.63 (32.30)	27.67 (21.58)	28.26 (22.41)	30.19 (25.29)
5.	Acetamiprid 20SP (20g a.i. ha ⁻¹) followed by Clothianidin 50WDG (20g a.i. ha ⁻¹)	36.70 (35.71)	30.80 (26.21)	31.19 (26.81)	32.90 (29.50)
6.	Acetamiprid 20SP (20g a.i. ha ⁻¹) followed by <i>Lecanicillium lecanii</i> 1.15WP (4g lit. ⁻¹)	38.87 (39.41)	32.52 (28.90)	34.02 (31.30)	35.13 (33.11)
7.	Carbosulfan 25EC (250g a.i. ha ⁻¹) followed by Thiocloprid 21.7SC (25g a.i. ha ⁻¹)	39.90 (41.15)	32.84 (29.41)	36.28 (35.01)	36.34 (35.11)
8.	Carbosulfan 25EC (250g a.i. ha ⁻¹) followed by Clothianidin 50WDG (20g a.i. ha ⁻¹)	42.23 (45.18)	35.81 (34.22)	36.80 (35.89)	38.28 (38.39)
9.	Carbosulfan 25EC(250g a.i. ha ⁻¹) followed by <i>Lecanicillium lecanii</i> 1.15WP (4g lit. ⁻¹)	44.23 (48.68)	36.15 (36.48)	37.58 (37.20)	39.32 (40.15)
10.	Untreated control	46.27 (52.21)	38.10 (38.08)	39.12 (39.81)	41.16 (43.31)
	S.Em.±	0.89	0.52	0.43	0.60
	C.D.at 5%	2.63	1.55	1.28	1.79
	C.V.%	4.09	3.02	2.41	3.40
	YXT				1.83

* Arcsin transformed values

Figures in parenthesis are retransformed values

Table 4. Percent umbels infestation at 3 days after second spray in different treatments.

Treat No.	Treatments	% Umbels aphid infestation at 3days after second spray			
		2014-15	2016-17	2017-18	Pooled
1.	Thiamethoxam 25WG (25g a.i. ha ⁻¹) followed by Thiachloprid 21.7SC (25g a.i. ha ⁻¹)	20.57* (12.35)	9.93* (2.97)	9.35* (2.64)	13.28* (5.27)
2.	Thiamethoxam 25WG (25g a.i. ha ⁻¹) followed by Clothianidin 50WDG (20g a.i. ha ⁻¹)	24.90 (17.72)	12.41 (4.62)	12.80 (4.91)	16.70 (8.26)
3.	Thiamethoxam 25WG (25g a.i. ha ⁻¹) followed by <i>Lecanicillium lecanii</i> 1.15WP (4g lit. ⁻¹)	25.67 (18.77)	16.59 (9.13)	15.56 (7.20)	19.27 (9.83)
4.	Acetamiprid 20SP (20g a.i. ha ⁻¹) followed by Thiachloprid 21.7SC (25g a.i. ha ⁻¹)	30.07 (25.10)	19.20 (15.93)	18.46 (10.02)	22.58 (14.73)
5.	Acetamiprid 20SP (20g a.i. ha ⁻¹) followed by Clothianidin 50WDG (20g a.i. ha ⁻¹)	32.73 (29.22)	23.53 (22.02)	21.36 (13.27)	25.87 (19.03)
6.	Acetamiprid 20SP (20g a.i. ha ⁻¹) followed by <i>Lecanicillium lecanii</i> 1.15WP (4g lit. ⁻¹)	35.80 (34.21)	28.02 (22.02)	24.20 (16.80)	29.34 (24.01)
7.	Carbosulfan 25EC (250g a.i. ha ⁻¹) followed by Thiachloprid 21.7SC (25g a.i. ha ⁻¹)	37.87 (37.69)	28.77 (23.18)	27.41 (21.19)	31.35 (27.08)
8.	Carbosulfan 25EC (250g a.i. ha ⁻¹) followed by Clothianidin 50WDG (20g a.i. ha ⁻¹)	40.17 (41.61)	30.56 (25.85)	30.20 (25.30)	33.64 (30.69)
9.	Carbosulfan 25EC(250g a.i. ha ⁻¹) followed by <i>Lecanicillium lecanii</i> 1.15WP (4g lit. ⁻¹)	42.17 (45.08)	31.20 (26.82)	32.44 (28.78)	35.27 (33.35)
10.	Untreated control	47.07 (53.61)	35.85 (34.30)	37.81 (37.59)	40.24 (41.72)
	S.Em.±	0.79	0.61	0.32	0.55
	C.D.at 5%	2.79	1.82	0.95	1.65
	C.V.%	4.83	4.51	2.41	4.36
	YXT				1.91

* Arcsin transformed values

Figures in parenthesis are retransformed values

Table 5. Percent umbels infestation at 7days after second spray in different treatments.

Treat No.	Treatments	% Umbels aphid infestation at 7days after second spray			
		2014-15	2016-17	2017-18	Pooled
1.	Thiamethoxam 25WG (25g a.i. ha ⁻¹) followed by Thiachloprid 21.7SC (25g a.i. ha ⁻¹)	14.50* (6.26)	5.86* (1.04)	4.57* (0.64)	8.31* (2.08)
2.	Thiamethoxam 25WG (25g a.i. ha ⁻¹) followed by Clothianidin 50WDG (20g a.i. ha ⁻¹)	20.00 (11.70)	9.07 (2.47)	7.91 (1.89)	12.32 (4.56)
3.	Thiamethoxam 25WG (25g a.i. ha ⁻¹) followed by <i>Lecanicillium lecanii</i> 1.15WP (4g lit. ⁻¹)	22.07 (14.11)	12.87 (4.96)	11.21 (3.77)	15.38 (7.04)
4.	Acetamiprid 20SP (20g a.i. ha ⁻¹) followed by Thiachloprid 21.7SC (25g a.i. ha ⁻¹)	26.00 (19.21)	16.22 (7.80)	14.69 (6.44)	18.97 (9.52)
5.	Acetamiprid 20SP (20g a.i. ha ⁻¹) followed by Clothianidin 50WDG (20g a.i. ha ⁻¹)	29.27 (23.90)	20.03 (11.74)	18.78 (10.37)	22.69 (14.88)
6.	Acetamiprid 20SP (20g a.i. ha ⁻¹) followed by <i>Lecanicillium lecanii</i> 1.15WP (4g lit. ⁻¹)	33.40 (30.30)	24.89 (17.71)	21.89 (13.90)	26.73 (20.22)
7.	Carbosulfan 25EC (250g a.i. ha ⁻¹) followed by Thiachloprid 21.7SC (25g a.i. ha ⁻¹)	34.40 (31.91)	25.13 (18.03)	24.47 (17.16)	28.00 (22.03)
8.	Carbosulfan 25EC (250g a.i. ha ⁻¹) followed by Clothianidin 50WDG (20g a.i. ha ⁻¹)	37.23 (36.60)	28.30 (22.48)	27.56 (21.40)	31.03 (26.57)
9.	Carbosulfan 25EC(250g a.i. ha ⁻¹) followed by <i>Lecanicillium lecanii</i> 1.15WP (4g lit. ⁻¹)	38.93 (39.49)	28.34 (22.52)	29.19 (23.79)	32.15 (28.31)
10.	Untreated control	39.27 (40.08)	32.14 (28.30)	36.34 (35.11)	35.91 (34.40)
	S.Em.±	1.15	0.77	0.25	0.80
	C.D.at 5%	3.41	2.29	0.74	2.38
	C.V.%	6.74	6.58	2.20	6.07
	YXT				2.30

* Arcsin transformed values

Figures in parenthesis are retransformed values

Table 6. Mean population of predatory coccinellids plant-1 in different treatments.

Treat No.	Treatments	Predatory coccinellids plant ⁻¹ (Before spray)			
		2014-15	2016-17	2017-18	Pooled
1.	Thiamethoxam 25WG (25g a.i. ha ⁻¹) followed by Thiachloprid 21.7SC (25g a.i. ha ⁻¹)	1.64* (2.19)	1.79* (2.72)	1.90* (3.12)	1.78* (2.66)
2.	Thiamethoxam 25WG (25g a.i. ha ⁻¹) followed by Clothianidin 50WDG (20g a.i. ha ⁻¹)	1.70 (2.39)	1.83 (2.85)	1.90 (3.12)	1.81 (2.78)
3.	Thiamethoxam 25WG (25g a.i. ha ⁻¹) followed by <i>Lecanicillium lecanii</i> 1.15WP (4g lit. ⁻¹)	1.72 (2.46)	1.85 (2.92)	1.90 (3.12)	1.82 (2.82)
4.	Acetamiprid 20SP (20g a.i. ha ⁻¹) followed by Thiachloprid 21.7SC (25g a.i. ha ⁻¹)	1.68 (2.32)	1.79 (2.72)	1.87 (3.00)	1.78 (2.67)
5.	Acetamiprid 20SP (20g a.i. ha ⁻¹) followed by Clothianidin 50WDG (20g a.i. ha ⁻¹)	1.68 (2.32)	1.80 (2.73)	1.90 (3.12)	1.79 (2.72)
6.	Acetamiprid 20SP (20g a.i. ha ⁻¹) followed by <i>Lecanicillium lecanii</i> 1.15WP (4g lit. ⁻¹)	1.78 (2.67)	1.87 (2.98)	1.90 (3.12)	1.85 (2.92)
7.	Carbosulfan 25EC (250g a.i. ha ⁻¹) followed by Thiachloprid 21.7SC (25g a.i. ha ⁻¹)	1.84 (2.88)	1.92 (3.19)	1.95 (3.32)	1.90 (3.12)
8.	Carbosulfan 25EC (250g a.i. ha ⁻¹) followed by Clothianidin 50WDG (20g a.i. ha ⁻¹)	1.78 (2.67)	1.87 (2.98)	1.94 (3.25)	1.86 (2.96)
9.	Carbosulfan 25EC(250g a.i. ha ⁻¹) followed by <i>Lecanicillium lecanii</i> 1.15WP (4g lit. ⁻¹)	1.70 (2.39)	1.90 (3.12)	1.92 (3.19)	1.84 (2.89)
10.	Untreated control	1.89 (3.07)	1.90 (3.12)	1.94 (3.25)	1.91 (3.15)
	S.Em.±	0.099	0.034	0.025	0.04
	C.D.at 5%	NS	NS	NS	NS
	C.V.%	9.85	3.21	2.23	5.87
	YXT				NS

* $\sqrt{X + 0.5}$ transformed values

Figures in parenthesis are retransformed values

Table 7. Mean population of predatory coccinellids at 3 days after second spray.

Treat No.	Treatments	Predatory coccinellids/plant at 3days after second spray			
		2014-15	2016-17	2017-18	Pooled
1.	Thiamethoxam 25WG (25g a.i. ha ⁻¹) followed by Thiachloprid 21.7SC (25g a.i. ha ⁻¹)	1.62* (2.12)	1.77* (2.64)	1.85* (2.91)	1.72* (2.55)
2.	Thiamethoxam 25WG (25g a.i. ha ⁻¹) followed by Clothianidin 50WDG (20g a.i. ha ⁻¹)	1.66 (2.25)	1.76 (2.60)	1.83* (2.85)	1.68 (2.56)
3.	Thiamethoxam 25WG (25g a.i. ha ⁻¹) followed by <i>Lecanicillium lecanii</i> 1.15WP (4g lit. ⁻¹)	1.66 (2.25)	1.76 (2.59)	1.95 (3.32)	1.78 (2.70)
4.	Acetamiprid 20SP (20g a.i. ha ⁻¹) followed by Thiachloprid 21.7SC (25g a.i. ha ⁻¹)	1.60 (2.06)	1.62 (2.12)	1.79 (2.72)	1.60 (2.29)
5.	Acetamiprid 20SP (20g a.i. ha ⁻¹) followed by Clothianidin 50WDG (20g a.i. ha ⁻¹)	1.60 (2.06)	1.62 (2.12)	1.76 (2.59)	1.58 (2.25)
6.	Acetamiprid 20SP (20g a.i. ha ⁻¹) followed by <i>Lecanicillium lecanii</i> 1.15WP (4g lit. ⁻¹)	1.72 (2.46)	1.79 (2.72)	1.92 (3.19)	1.79 (2.78)
7.	Carbosulfan 25EC (250g a.i. ha ⁻¹) followed by Thiachloprid 21.7SC (25g a.i. ha ⁻¹)	1.76 (2.60)	1.78 (2.66)	1.79 (2.72)	1.65 (2.66)
8.	Carbosulfan 25EC (250g a.i. ha ⁻¹) followed by Clothianidin 50WDG (20g a.i. ha ⁻¹)	1.72 (2.46)	1.77 (2.64)	1.72 (2.45)	1.65 (2.52)
9.	Carbosulfan 25EC(250g a.i. ha ⁻¹) followed by <i>Lecanicillium lecanii</i> 1.15WP (4g lit. ⁻¹)	1.66 (2.25)	1.87 (3.00)	1.95 (3.32)	1.79 (2.84)
10.	Untreated control	1.64 (2.18)	1.92 (3.19)	1.99 (3.45)	1.84 (2.92)
	S.Em.±	0.047	0.029	0.041	0.04
	C.D.at 5%	NS	0.086	0.122	0.11
	C.V.%	4.92	2.82	3.82	3.90
	YXT				0.11

* $\sqrt{X + 0.5}$ transformed values

Figures in parenthesis are retransformed values

Table 8. Mean population of predatory coccinellids at 7days after second spray.

Treat No.	Treatments	Predatory coccinellids/plant at 7days after second spray			
		2014-15	2016-17	2017-18	Pooled
1.	Thiamethoxam 25WG (25g a.i. ha ⁻¹) followed by Thiachloprid 21.7SC (25g a.i. ha ⁻¹)	1.60* (2.06)	1.72* (2.46)	1.83* (2.85)	1.75* (2.45)
2.	Thiamethoxam 25WG (25g a.i. ha ⁻¹) followed by Clothianidin 50WDG (20g a.i. ha ⁻¹)	1.60 (2.06)	1.70 (2.38)	1.74 (2.52)	1.75 (2.31)
3.	Thiamethoxam 25WG (25g a.i. ha ⁻¹) followed by <i>Lecanicillium lecanii</i> 1.15WP (4g lit. ⁻¹)	1.62 (2.12)	1.79 (2.72)	1.92 (3.19)	1.79 (2.66)
4.	Acetamiprid 20SP (20g a.i. ha ⁻¹) followed by Thiachloprid 21.7SC (25g a.i. ha ⁻¹)	1.60 (2.06)	1.49 (1.72)	1.70 (2.39)	1.67 (2.05)
5.	Acetamiprid 20SP (20g a.i. ha ⁻¹) followed by Clothianidin 50WDG (20g a.i. ha ⁻¹)	1.58 (2.00)	1.53 (1.85)	1.64 (2.19)	1.66 (2.01)
6.	Acetamiprid 20SP (20g a.i. ha ⁻¹) followed by <i>Lecanicillium lecanii</i> 1.15WP (4g lit. ⁻¹)	1.66 (2.25)	1.81 (2.78)	1.89 (3.06)	1.81 (2.69)
7.	Carbosulfan 25EC (250g a.i. ha ⁻¹) followed by Thiachloprid 21.7SC (25g a.i. ha ⁻¹)	1.64 (2.18)	1.74 (2.53)	1.58 (2.00)	1.78 (2.23)
8.	Carbosulfan 25EC (250g a.i. ha ⁻¹) followed by Clothianidin 50WDG (20g a.i. ha ⁻¹)	1.66 (2.25)	1.64 (2.19)	1.64 (2.18)	1.74 (2.21)
9.	Carbosulfan 25EC (250g a.i. ha ⁻¹) followed by <i>Lecanicillium lecanii</i> 1.15WP (4g lit. ⁻¹)	1.66 (2.25)	1.85 (2.92)	1.85 (2.92)	1.83 (2.69)
10.	Untreated control	1.62 (2.12)	1.94 (3.25)	1.95 (3.32)	1.85 (2.87)
	S.Em.±	0.036	0.045	0.031	0.05
	C.D.at 5%	NS	0.134	0.092	0.15
	C.V.%	3.87	4.52	3.07	3.85
	YXT				0.11

* $\sqrt{X + 0.5}$ transformed values

Figures in parenthesis are retransformed values

Lecanicillium lecanii 1.15WP (4g lit.⁻¹) and thiamethoxam 25WG (25g a.i. ha⁻¹) followed by *Lecanicillium lecanii* 1.15WP (4g lit.⁻¹) had higher population of predatory coccinellids which recorded 2.92, 2.84, 2.78 and 2.70 plant⁻¹, respectively. Similarly, the pooled data on population of coccinellids at 7 days after second spray revealed that untreated control, carbosulfan 25EC (250g a.i. ha⁻¹) followed by *Lecanicillium lecanii* 1.15WP (4g lit.⁻¹), acetamiprid 20SP (20g a.i. ha⁻¹) followed by *Lecanicillium lecanii* 1.15WP (4g lit.⁻¹) and thiamethoxam 25WG (25g a.i. ha⁻¹) followed by *Lecanicillium lecanii* 1.15WP (4g lit.⁻¹) had higher population of which recorded 2.87, 2.69, 2.69 and 2.66 coccinellids plant⁻¹, respectively.

Seed yield of cumin (kg ha⁻¹)

The data on seed yield of cumin presented in table 9 revealed that the seed yield of cumin differed significantly in all the three individual years as well as in pooled analysis.

Among different insecticides, the plots sprayed with thiamethoxam 25WG (25g a.i. ha⁻¹) followed by thiachloprid 21.7SC (25g a.i. ha⁻¹) had obtained the highest seed yield of cumin (216 kg ha⁻¹). Thiamethoxam 25WG

(25g a.i. ha⁻¹) followed by clothianidin 50WDG (20g a.i. ha⁻¹) had exhibited 184 kg ha⁻¹ seed yield of cumin, whereas, unprotected plots of cumin gave significantly the lower seed yield (82 kg ha⁻¹) among all the treatments under testing.

Economics

Economics of different insecticides against cumin aphid was worked out considering prevailing market price of cumin seeds and cost of different treatments including labour charges (Table 10). The gross realization, net realization and Protection Cost Benefit Ratio (PCBR) were also worked out for different treatments. Looking to the economic analysis of different treatments, thiamethoxam 25WG (25g a.i. ha⁻¹) followed by thiachloprid 21.7SC (25g a.i. ha⁻¹) treated plots gave maximum benefit (PCBR= 1:21.64) followed by thiamethoxam 25WG(25g a.i. ha⁻¹) followed by clothianidin 50WDG (20g a.i. ha⁻¹) (PCBR= 1: 15.32) and Acetamiprid 20SP (20g a.i. ha⁻¹) followed by thiachloprid 21.7SC (25g a.i. ha⁻¹) (PCBR= 1:13.36).

Findings of present study are in agreement with Pachundkar *et al.*, (2013) who reported carbosulfan 25EC (0.025%) effective against thrips of cluster bean.

Table 9. Seed yield of cumin in different treatments.

Treat No.	Treatments	Seed Yield (kg ha ⁻¹)			
		2014-15	2016-17	2017-18	Pooled
1.	Thiamethoxam 25WG (25g a.i. ha ⁻¹) followed by Thiachloprid 21.7SC (25g a.i. ha ⁻¹)	155	141	304	216
2.	Thiamethoxam 25WG (25g a.i. ha ⁻¹) followed by Clothianidin 50WDG (20g a.i. ha ⁻¹)	132	106	280	184
3.	Thiamethoxam 25WG (25g a.i. ha ⁻¹) followed by <i>Lecanicillium lecanii</i> 1.15WP (4g lit. ⁻¹)	123	101	264	174
4.	Acetamiprid 20SP (20g a.i. ha ⁻¹) followed by Thiachloprid 21.7SC (25g a.i. ha ⁻¹)	120	89	248	162
5.	Acetamiprid 20SP (20g a.i. ha ⁻¹) followed by Clothianidin 50WDG (20g a.i. ha ⁻¹)	109	64	239	145
6.	Acetamiprid 20SP (20g a.i. ha ⁻¹) followed by <i>Lecanicillium lecanii</i> 1.15WP (4g lit. ⁻¹)	106	47	230	133
7.	Carbosulfan 25EC (250g a.i. ha ⁻¹) followed by Thiachloprid 21.7SC (25g a.i. ha ⁻¹)	102	47	210	125
8.	Carbosulfan 25EC (250g a.i. ha ⁻¹) followed by Clothianidin 50WDG (20g a.i. ha ⁻¹)	90	33	204	113
9.	Carbosulfan 25EC (250g a.i. ha ⁻¹) followed by <i>Lecanicillium lecanii</i> 1.15WP (4g lit. ⁻¹)	81	24	166	93
10.	Untreated control	69	21	148	82
	S.Em.±	6	10	18	9
	C.D.at 5%	17	30	52	29
	C.V.%	9.23	19.42	13.23	14.73
	YXT				34

* $\sqrt{X + 0.5}$ transformed values

Figures in parenthesis are retransformed values

Table 10. Seed yield of cumin in different treatments.

Treat. No.	Qty. of insecticide (L/kg ha ⁻¹)	Price of insecticide (₹ ha ⁻¹)	Labour cost (₹)	Total cost of treatment (₹ ha ⁻¹)	Yield (kg ha ⁻¹)	Gross realization (₹ ha ⁻¹)	Net realization over control (₹ ha ⁻¹)	Net gain (₹ ha ⁻¹)	PCBR
1.	100g + 115ml	384	800	1184	216	43200	26800	25616	21.64
2.	100g + 40g	450	800	1250	184	36800	20400	19150	15.32
3.	100g + 1.600kg	488	800	1288	174	34800	18400	17112	13.29
4.	100g + 230ml	314	800	1114	162	32400	16000	14886	13.36
5.	100g + 40g	380	800	1180	145	29000	12600	11420	9.68
6.	100g + 1.600kg	418	800	1218	133	26600	10200	8982	7.37
7.	1.000lit. + 230ml	634	800	1434	125	25000	8600	7166	5.00
8.	1.000lit. + 40g	700	800	1500	113	22600	6200	4700	3.13
9.	1.000lit. + 1.600kg	738	800	1538	93	18600	2200	662	0.43
10.	-	-	-	-	82	16400	-	-	-

Price of cumin: ₹ 200 kg⁻¹; Carbosulfan 25EC: ₹ 450 lit.⁻¹; Acetamiprid 20SP: ₹ 1,300 kg⁻¹; Clothianidin 50WDG : ₹ 12,500 kg⁻¹; Thiamethoxam 25WG: ₹ 2,000 kg⁻¹; Thiachloprid 21.7SC: ₹ 1,600 lit.⁻¹; *Lecanicillium lecanii* 1.15WP: ₹ 180 kg⁻¹; Labour cost: ₹ 200 day⁻¹

Patel *et al.*, (2002) observed that carbosulfan 25EC (0.05%) was found effective in controlling cummin aphid under north Gujarat conditions. More or less similar observations on effectiveness of carbosulfan 25EC against aphid were also reported by Patil and Patel (2013) in Isabgol crop. Thus, the present findings corroborate the earlier reports. Overall, thiamethoxam 25WG (25g a.i. ha⁻¹) followed by thiacloprid 21.7SC (25g a.i. ha⁻¹) treated cummin plots had registered least population of aphid at both of the sprays. It also explicated that the highest seed yield of cummin as well as maximum profit had recorded in the treatment of thiamethoxam 25WG (25g a.i. ha⁻¹) followed by thiacloprid 21.7SC (25g a.i. ha⁻¹). From the present investigation it can be concluded that for effective and economical management of cummin aphid, first foliar spray of thiamethoxam 25WG (25g a.i. ha⁻¹) (25g a.i. ha⁻¹ ; 2.5g 10lit.⁻¹water) should be done at 10%

umbels aphid infestation and second spray of thiacloprid 21.7SC (25g a.i. ha⁻¹; 2.88g 10lit.⁻¹ water) should be made after 10days of the first spray.

References

- Pachundkar, N. N., Borad, P. K. and Patil, P. A. 2013. Evaluation of various synthetic insecticides against sucking insect pests of cluster bean. *Int. J Scientific and Research, Publications* 3(8):1-6.
- Patel, G. M., Patel, B. R., Patel, I. S., Patel, R. K. and Patel, S. R. 2002. Testing of Marshal 25 EC for the control of sucking pest like aphids in cummin crop. *Report of Ad-hoc Research Project.*
- Patil, S. J. and Patel, B. R. 2013. Evaluation of different synthetic and botanical insecticides against aphid, *Aphis gossypii* Glover infesting Isabgol crop. *The Bioscan* 8(2):705-707.

Received : October 2018; Revised : November 2018;
Accepted : December 2018.