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Bio-efficacy of different insecticides against Aphid (*Aphis gossypii*) on Tomato, (*Lycopersicon esculentum* Mill)

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Abstract
Bio-efficacy of different insecticides was conducted against aphid on tomato at Navsari Agricultural University, Navsari, Gujarat. The results indicated that thiamethoxam 25 WG 0.008 per cent remained the most effective treatment against aphid followed by dimethoate 30 EC 0.03 per cent. Spiromesifen 22.9 SC 0.028 per cent and indoxacarb 14.5 SC 0.005 per cent were ranked third and fourth effective treatments, respectively. On the other side, Lambda cyhalothrin 5 EC at 0.003 per cent remained the least effective treatment among all the insecticide treatments evaluated in this investigation.

Keywords: Tomato, insecticides, bio-efficacy, aphid (*Aphis gossypii*)

1. Introduction
Tomato (*Lycopersicon esculentum* Mill.) is a profitable vegetable crop, cultivated in almost all the districts of South Gujarat. It is also a popular vegetable, globally ranked second in importance to potato (Mandaokar *et al*., 2000) [10]. In India, the cultivated area under tomato is 7.67 lakh hectares with production of 16385.00 MT and average productivity of 21.40 MT/ha (Anonymous, 2015) [1]. Though it is extensively grown all over the country, still productivity remains low as compared to other countries mainly due to the prevalence of various pests. Amongst various insect-pests reported in India, as many as sixteen have been observed feeding from germination to the harvesting stage which not only reduces its yield but also deteriorates the quality (Butani, 1997) [4]. The major insect pests reported on tomato in India are aphid (*Aphis gossypii*), whitefly (*Bemisia tabaci*), thrips (*Thrips tabaci*), leaf miner (*Liriomyza trifolii*), fruit borer (*Helicoverpa armigera* and red spider mite (*Tetranychus urticae*) in which, aphid (*Aphis gossypii*) is an important pest of many solanaceous as well as cruciferous crops (Anonymous, 2012) [2]. Both nymph and adult aphids suck cell sap from leaves and tender parts, thereby induce premature senescence (Pegadaraju *et al*., 2005) [13]. It also excretes honeydew on which sooty mould grows and inhibits the photosynthesis, besides transmitting over 100 plant viruses (Kennedy *et al*., 1962; Blackman and Eastop, 2000) [8-3]. Sutton (1991) [16] reported aphids, whitefly, as major pest of vegetative stages causing 20-40% yield loss. Keeping in view the importance of sucking insect pests on tomato in general and aphid in particular, the present study was undertaken to evaluate effect of various novel and modern insecticides against aphid on tomato.

2. Materials and methods
2.1 Experimental site
The studies on field screening of insecticides against aphid (*Aphis gossypii*) was carried out under field condition in the Department of Entomology, N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat during *Rabi* seasons of 2015-16 and 2016-2017. The site experienced mean annual minimum and maximum temperatures of 15 and 33 °C, respectively.

2.2 Treatment and management
The field experiments were conducted in two *Rabi* seasons: November 2015-16 and December 2016-17 taking tomato (cv. GT-2) as test crop. The experiment was laid out in Randomized Block Design (RBD) with 3m x 2m plot size using seven treatments T_1: Indoxacarb 4.5 SC 0.005%; T_2: Dimethoate 30 EC 0.03%; T_3: Lambda-cyhalothrin 5 EC

0.003%; T_4: Spiromesifen 22.9 SC 0.028%; T_5: Quinalphos 25 EC 0.05%; T_6: Thiamethoxam 25 WG 0.008% and T_7: Control (no pesticide, only normal water) wherein each treatment was replicated four times. Each plot was separated by a gap of 1 m so that drifting of insecticides during spraying could be minimized. The experimental field was thoroughly prepared by ploughing followed by repeated harrowing. The field was subsequently cleaned by the removal of stubbles of the previous crop. Healthy disease free 25 days old seedlings of tomato (GT-2) were planted at a spacing of 60 cm × 45 cm. Gap filling was done after 10 days. The application of insecticides was done based on Economic Threshold Level (ETL) of the insect-pests. For all the treatments, the crop was grown with NPK doze as per the State recommendation of 180:60:60 kg N:P:K Kg/ha, respectively. Full quantity of P and K fertilizers were applied at transplanting while, half doze of nitrogenous fertilizer was applied at thirty days after transplanting and the remaining half was applied 15 days after the first application of nitrogenous fertilizer.

2.3 Data collection

The aphid population consisting of nymphs and adults was counted before spray (1 day before) as well as after spray (1, 7 and 15 days after spraying) during early morning on selected leaf in top, middle and bottom canopy of the ear marked plant and was expressed as total aphid population of plant which was later converted to aphid infestation index as given by Pradhan *et al.* (1960) [14] and Prasad (1978) [15].

Grade 0: Plants completely free from aphid.
Grade 1: Inflorescence showing up to 15 aphids but do not show any sign of injury.
Grade 2: Aphid colonies scattered on leaves and inflorescence.
Grade 3: Leaves, stems, inflorescence and fruits densely populated by aphids, curling and yellowing of the leaves and fruits are more evident.
Grade 4: Very heavy population of aphids on plants, leaves, inflorescence and fruits showing symptoms of drying.
Grade 5: Completely drying of plants due to heavy infestation of aphids

2.4 Statistical analysis

The average aphid grade index based on adult and nymph population was statistically analysed at different intervals before as well as after spraying. Overall, aphid grade index of post spray interval was thus assessed. The analysis of data was done in the Department of Statistics, N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat.

3. Results and discussion

3.1 First year (2015-16)

The results indicated in Table-1 revealed that all the insecticides (except lamdacyhalothrin 5 EC 0.003%) evaluated in this investigation proved their significant superiority over untreated control during first year of experimentation. The results obtained after first spray irrespective of post spray intervals indicated lowest aphid population in thiamethoxam 25 WG 0.008 per cent (0.32 aphid grade/plant). Next in the order of effectiveness was dimethoate 30 EC 0.03 per cent (0.66) which was significantly superior over remaining insecticide treatments. The next effective treatment was spiromesifen 22.9 SC 0.028 per cent (1.42 aphid grade/plant) which was at par with indoxacarb 14.5 SC 0.005 per cent (1.63). Plots treated with quinalphos 25 EC 0.05 per cent indicated 2.32 aphid grade per plant which was followed by lambda cyhalothrin 5 EC 0.003 per cent (3.09), the later was at par with untreated control indicating highest aphids (3.46) (Table 1).

Insecticide effectiveness (irrespective of post spray intervals) after second spray during first year of the trial showed similarity with respect to the order of effectiveness of treatments obtained after first spray which in turn indicated lowest aphid population in thiamethoxam 25 WG 0.008 per cent treated plots (0.40 aphid grade/plant) followed by dimethoate 30 EC 0.03 per cent (0.72) which was at par with it. Next in the order of effectiveness was spiromesifen 22.9 SC 0.028 per cent (1.23) which was at par with indoxacarb 14.5 SC 0.005 per cent (1.66). Plot treated with quinalphos 25 EC 0.05 per cent indicated 2.52 aphids grade per plant followed by lambda cyhalothrin 5 EC 0.003 per cent (3.37) and were at par with untreated control showing highest aphids (3.74) (Table 1).

The pooled aphid population grade over periods and spray interval during first year indicated non-significant interaction between treatment and spray interval indicating lowest aphids in thiamethoxam 25 WG 0.008 per cent (0.36 aphid grade/plant) which was significantly lower to the remaining treatments. Next in the order of effectiveness were dimethoate 30 EC 0.03 per cent (0.69), spiromesifen 22.9 SC 0.028 per cent (1.33), indoxacarb 14.5 SC 0.005 per cent (1.65) and quinalphos 25 EC 0.05 per cent (2.42) which were significantly different from each other. On the other hand, least effective treatment lambda cyhalothrin 5 EC 0.003 per cent (3.22) was at par with the untreated control which in turn indicated highest aphids to the tune of 3.60 aphid grade/plant (Table 1).

3.2 Second year (2016-17)

All the insecticide treatments (irrespective of post spray intervals) after first spray during second year of experimentation were found significantly superior over untreated control wherein there was similarity in the effectiveness of treatments at various intervals after spraying which was proved by non-significant interaction between treatment and days after spraying. The lowest aphid population was observed in thiamethoxam 25 WG 0.008 per cent (0.39 aphid grade/plant) followed by dimethoate 30 EC 0.03 per cent (0.66) which was at par with it. Next in the effectiveness was spiromesifen 22.9 SC 0.028 per cent (1.36) which was at par with indoxacarb 14.5 SC 0.005 per cent (1.56). Least effective insecticide treatment was lambda cyhalothrin 5 EC 0.003 per cent showing 3.08 aphid grade which was at par with control plot indicating highest aphids (3.61) (Table 1).

On the other hand, lowest aphid population was recorded in thiamethoxam 25 WG 0.008 per cent (0.32 aphid grade/plant) during second spray in the second year of experimentation followed by dimethoate 30 EC 0.03 per cent (0.85) which was significantly different from it although, it was superior to the remaining insecticide treatments. The next superior treatment was spiromesifen 22.9 SC 0.028 per cent (1.46 aphids) which was at par with indoxacarb 14.5 SC 0.005 per cent (1.65). Plot treated with quinalphos 25 EC 0.05 per cent indicated aphid population of 2.32 grades per plant followed by 3.21 in lambda cyhalothrin 5 EC 0.003 per cent, but it was at par with control plot which had highest aphids (3.58) (Table 1).

The pooled results of two sprays during second year of

experimentation indicated lowest aphids in thiamethoxam 25 WG 0.008 per cent (0.36 aphid grade/plant). Next effective group consisted of dimethoate 30 EC 0.03 per cent (0.75) and spiromesifen 22.9 SC 0.028 per cent (1.41) which was at par with indoxacarb 14.5 SC 0.005 per cent (1.61). Plot treated with quinalphos 25 EC 0.05 per cent recorded 2.44 aphid grade followed by lambda cyhalothrin 5 EC 0.003 per cent (3.14), though later did not differ significantly with control indicating highest aphids (3.60) (Table 1).

Table 1: Efficacy of various insecticides against aphid on tomato during 2015-17

S. No.	Treatment with concentration	Aphid: Grade/plant* (2015-16)											Aphid: Grade/plant* (2016-17)									
		First spray					Second spray					Pooled over spray	First spray					Second spray				Pooled over spray
		Pre-treat	Post treatment observation at			Mean over DAS	Pre-treat	Post treatment observation at			Mean over DAS		Pre-treat	Post treatment observation at			Mean over DAS	Pre-treat	Post treatment observation at			Mean over DAS	
			1 DAS	7 DAS	15 DAS			1 DAS	7 DAS	15 DAS				1 DAS	7 DAS	15 DAS			1 DAS	7 DAS	15 DAS	
1.	Indoxacarb 14.5 SC 0.005%	1.61 (2.09)	1.57 (1.98)	1.21 (0.96)	1.59 (2.04)	1.46 (1.63)	1.91 (3.14)	1.58 (1.98)	1.20 (0.94)	1.64 (2.18)	1.47 (1.66)	1.47 (1.65)	1.88 (3.03)	1.56 (1.94)	1.19 (0.92)	1.55 (1.91)	1.44 (1.56)	1.96 (3.35)	1.60 (2.05)	1.21 (0.97)	1.59 (2.04)	1.47 (1.65)	1.45 (1.61)
2.	Dimethoate 30 EC 0.03%	1.98 (3.44)	1.09 (0.68)	0.94 (0.39)	1.21 (0.96)	1.08 (0.66)	1.73 (2.50)	1.02 (0.53)	0.97 (0.44)	1.32 (1.24)	1.10 (0.72)	1.09 (0.69)	2.04 (3.65)	1.06 (0.62)	0.89 (0.29)	1.27 (1.12)	1.08 (0.66)	2.04 (3.65)	1.09 (0.69)	1.07 (0.65)	1.33 (1.28)	1.16 (0.85)	1.12 (0.75)
3.	Lambdacyhalothrin 5 EC 0.003%	1.91 (3.16)	1.85 (2.93)	1.87 (3.00)	1.96 (3.34)	1.89 (3.09)	2.04 (3.66)	1.95 (3.32)	1.97 (3.37)	1.98 (3.41)	1.97 (3.37)	1.93 (3.22)	1.89 (3.06)	1.85 (2.92)	1.91 (3.14)	1.92 (3.17)	1.89 (3.08)	1.92 (3.19)	1.88 (3.05)	1.93 (3.22)	1.96 (3.36)	1.93 (3.21)	1.91 (3.14)
4.	Spiromesifen 22.9 SC 0.028%	1.80 (2.75)	1.50 (1.74)	1.18 (0.90)	1.48 (1.69)	1.39 (1.42)	1.81 (2.78)	1.27 (1.10)	1.22 (0.98)	1.47 (1.65)	1.32 (1.23)	1.35 (1.33)	1.94 (3.25)	1.38 (1.40)	1.22 (1.00)	1.49 (1.73)	1.37 (1.36)	1.83 (2.84)	1.49 (1.72)	1.22 (1.00)	1.49 (1.71)	1.40 (1.46)	1.38 (1.41)
5.	Quinalphos 25 EC 0.05%	2.03 (3.61)	1.88 (3.03)	1.47 (1.67)	1.69 (2.35)	1.68 (2.32)	1.95 (3.29)	1.92 (3.20)	1.47 (1.65)	1.83 (2.83)	1.74 (2.52)	1.71 (2.42)	1.95 (3.29)	1.89 (3.08)	1.58 (2.00)	1.78 (2.66)	1.75 (2.56)	1.83 (2.83)	1.71 (2.44)	1.44 (1.57)	1.88 (3.04)	1.68 (2.32)	1.71 (2.44)
6.	Thiamethoxam 25 WG 0.008%	1.98 (3.40)	0.86 (0.23)	0.71 (0.00)	1.16 (0.83)	0.91 (0.32)	1.90 (3.11)	0.99 (0.48)	0.71 (0.00)	1.16 (0.83)	0.95 (0.40)	0.93 (0.36)	1.90 (3.11)	0.92 (0.34)	0.71 (0.00)	1.20 (0.95)	0.94 (0.39)	1.91 (3.13)	0.90 (0.31)	0.71 (0.00)	1.11 (0.73)	0.91 (0.32)	0.93 (0.36)
7.	Control	1.92 (3.17)	1.95 (3.30)	1.97 (3.39)	2.05 (3.69)	1.99 (3.46)	2.02 (3.59)	2.05 (3.69)	2.06 (3.74)	2.07 (3.80)	2.06 (3.74)	2.03 (3.60)	1.88 (3.05)	2.00 (3.50)	2.03 (3.63)	2.05 (3.70)	2.03 (3.61)	1.93 (3.21)	2.00 (3.50)	2.02 (3.60)	2.04 (3.65)	2.02 (3.58)	2.02 (3.60)
SEm+ (T)		0.09	0.09	0.07	0.08	0.05	0.09	0.08	0.07	0.08	0.06	0.03	0.11	0.10	0.07	0.08	0.06	0.09	0.09	0.06	0.07	0.05	0.04
CD at 5% (T)		NS	0.28	0.22	0.25	0.16	NS	0.26	0.23	0.24	0.18	0.11	NS	0.32	0.21	0.26	0.18	NS	0.29	0.19	0.22	0.17	0.11
SEm+ (T x D)		-	-	-	-	0.07	-	-	-	-	0.06	0.05	-	-	-	-	0.08	-	-	-	-	0.07	0.05
CD at 5% (Tx D)		-	-	-	-	NS	-	-	-	-	0.19	0.14	-	-	-	-	NS	-	-	-	-	NS	0.15
SEm+ (T x S)		-	-	-	-	-	-	-	-	-	-	0.07	-	-	-	-	-	-	-	-	-	-	0.08
CD at 5% (Tx S)		-	-	-	-	-	-	-	-	-	-	NS	-	-	-	-	-	-	-	-	-	-	NS
CV (%) (T)		10.08	12.69	11.28	10.79	13.05	10.44	11.62	11.37	10.10	14.07	13.58	11.62	14.26	10.42	11.17	14.40	10.38	12.87	9.68	9.13	13.40	13.91
CV (%) (T x P)		-	-	-	-	10.60	-	-	-	-	8.91	9.78	-	-	-	-	11.68	-	-	-	-	10.44	11.07

*Total of top, middle and bottom leaves/plant

Figures mentioned in parenthesis are re-transformed values and those outside are √x + 0.5 value

Table 2: Overall efficacy of various insecticides against aphid of tomato during 2015-17.

S. No.	Treatment with concentration	Aphid: Grade/plant*			
		Pre-treat	Post treatment observation (Pooled over sprays)		
			2015-16	2016-17	Overall pooled
1.	Indoxacarb 14.5 SC 0.005%	1.84 (2.89)	1.47 (1.65)	1.45 (1.61)	1.46^{cd} (1.63)
2.	Dimethoate 30 EC 0.03%	1.95 (3.29)	1.09 (0.69)	1.12 (0.75)	1.11^{b} (0.72)
3.	Lambdacyhalothrin 5 EC 0.003%	1.94 (3.26)	1.93 (3.22)	1.91 (3.14)	1.92^{f} (3.18)
4.	Spiromesifen 22.9 SC 0.028%	1.84 (2.9)	1.35 (1.33)	1.38 (1.41)	1.37^{c} (1.37)
5.	Quinalphos 25 EC 0.05%	1.94 (3.25)	1.71 (2.42)	1.71 (2.44)	1.71^{e} (2.43)
6.	Thiamethoxam 25 WG 0.008%	1.92 (3.18)	0.93 (0.36)	0.93 (0.36)	0.93^{a} (0.36)
7.	Control	1.94 (3.25)	2.03 (3.60)	2.02 (3.60)	2.02^{g} (3.60)
SEm+ (T)		0.05	0.03	0.05	0.04
CD at 5% (T)		NS	0.11	0.17	0.11
SEm+ (T x S)		-	0.07	0.08	0.03
CD at 5% (Tx S)		-	NS	NS	0.10
SEm+ (YxTx S)		-	-	-	0.07
CD at 5% (YxTx S)		-	-	-	NS
CV (%) (T)		10.65	13.58	13.91	13.74
CV (%) (T x P)		-	9.78	11.07	10.45

*Total of top, middle and bottom leaves/plant

Figures mentioned in parenthesis are re-transformed values and those outsides are √x +0.5 values

*Treatment ranking as per DMRT

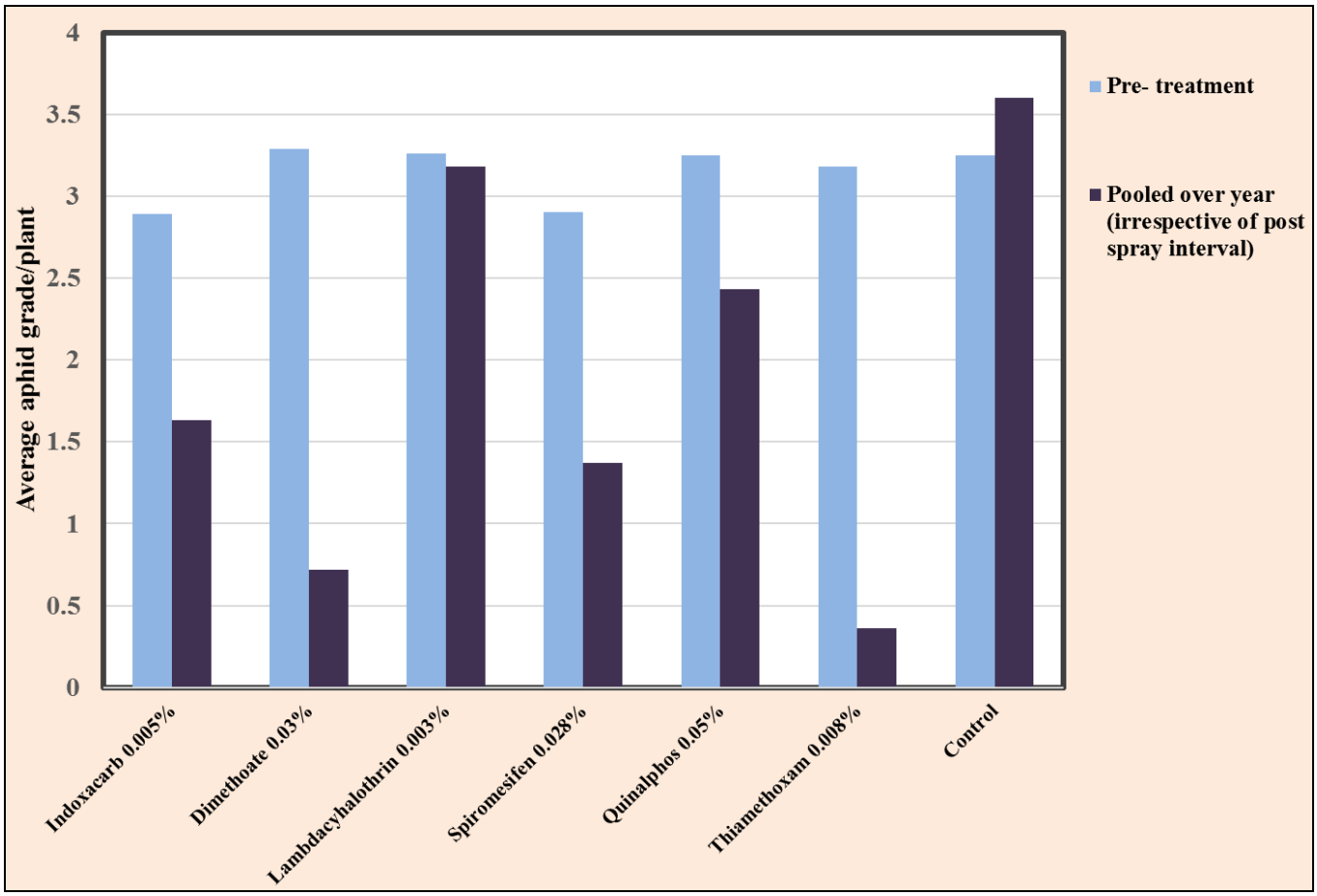

Fig 1: Bioefficacy of various insecticides against aphid on tomato

3.3 Pooled over years (2015-2017)

The pooled results obtained after two years of experimentation showed almost the same or similar order of effectiveness which is evident from the non-significant interaction of between treatment, spray and year. All the treatments were also found superior over untreated control. Lowest aphid population was observed in thiamethoxam 25 WG 0.008 per cent (0.36 aphid grade/plant). Next effective treatment was dimethoate 30 EC 0.03 per cent (0.72) which was superior to the remaining insecticides. The treatment of spiromesifen 22.9 SC 0.028 per cent recorded 1.37 aphids and was at par with indoxacarb 14.5 SC 0.005 per cent (1.63). Plot treated with quinalphos 25 EC 0.05 per cent indicated aphid population of 2.43 aphids and was superior over lambda cyhalothrin 5 EC 0.003 per cent (3.18) wherein, the later was at par with untreated control plot recording highest aphids (3.60) (Table 2 and Fig. 1). Overall, the order of effectiveness of various treatments against aphid on tomato was: thiamethoxam 25 WG at 0.008 per cent > dimethoate 30 EC 0.03 per cent > spiromesifen 22.9 SC 0.028 per cent > indoxacarb 14.5 SC 0.005 per cent > quinalphos 25 EC 0.05 per cent > lambda cyhalothrin 5 EC 0.003 per cent > control.

Muzemu *et al.* (2011) [12] revealed that dimethoate was most effective against aphid which is also indicated in the results obtained in the current investigation proving superiority of dimethoate next to thiamethoxam 25 WG.

Similarly, Gaikwad *et al.* (2014) [6] reported superior efficacy of dimethoate 30 EC 0.03 per cent and imidacloprid 17.8 SL 0.004 per cent for the control of safflower aphid (*Uroleucon compositae* Theobald).

Kaur and Singh (2014) [7] indicated that thiamethoxam (Actara) 25 WG and imidacloprid 17.8 SL significantly reduced aphid population. Similarly, Maurya *et al.* (2015) [11] revealed that seed treatment with thiamethoxam protected tomato seedlings from aphids and thrips in the early season from the onset of seed planting. Chinniah *et al.* (2016) [5] revealed that thiomethoxam 25 WG @ 100 gm/ha was found effective in chilli reducing aphid population. Similarly, Khaja and Patil (2016) [9] opined that thiamethoxam 25 WG was effective against leafhoppers, aphids, whiteflies and thrips in okra.

In the current investigation, thiamethoxam and dimethoate were proved most effective treatments against aphid on tomato which is also indicated in the results of earlier workers thus it can be inferred that the results obtained in this investigation are said to be in agreement to earlier reports.

4. Conclusion

It may be summarized on the basis of two-years of investigation (2015-2017) that thiamethoxam 25 WG at 0.008 per cent remained the most effective treatment against aphid in tomato followed by dimethoate 30 EC 0.03 per cent. In contrast, lambda cyhalothrin 5 EC at 0.003 per cent was not found effective and remained the least effective treatment in this investigation at all the intervals after spraying.

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