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Bio-efficacy, persistence and residual toxicity of different insecticides against aphids (*Aphis gossypii* (Glover)) on sunflower

RB Dake, VK Bhamare and SH Mhaske

Abstract
An investigation was undertaken to study the bio-efficacy, persistence and residual toxicity of different newer insecticides against aphids on sunflower at research farm of department of Agril. Entomology College of agriculture Latur. The observations on total number of aphids were recorded on top, middle and bottom leaves of five randomly selected plants from each treatment at one day before and 1, 3, 7 and 14 days after first and second application of insecticides. All insecticide treatments were found significantly superior over untreated control in minimizing the incidence of aphids. On 14th DAS, the population of aphids was ranged 4.20 to 7.60 aphids/leaf and 3.40 to 6.80 aphids/leaf after first and second spray respectively. Imidacloprid 17.8 SL0.003 per cent was exhibited most effective insecticide in minimizing the aphids population (4.20 and 3.40 aphids/leaf) followed by spinosad 0.007 per cent (5.40 and 4.60 aphids/leaf), indoxacarb 0.05 per cent (5.80 and 5.00 aphids/leaf), chlorantraniliprole 0.005 per cent (6.60 and 5.80 aphids/leaf) emamectin benzoate 0.002 per cent (7.20 and 6.40 aphids/leaf), fenpropathrin 0.01 per cent (7.40 and 6.60 aphids/leaf) and flubendiamide 0.007 per cent (7.60 and 6.80 aphids/leaf) 14 days after first and second spray, respectively. Among different insecticides, imidacloprid, spinosad and indoxacarb exhibited highest efficacy against sunflower aphids.
The residual toxicity of seven label recommended insecticides *viz*., Imidacloprid 0.003 per cent, spinosad 0.007 per cent, indoxacarb 0.05 per cent, chlorantraniliprole 0.005 per cent, emamectin benzoate 0.002 per cent, fenpropathrin 0.01 per cent and flubendiamide 0.007 per cen was evaluated against aphids *Aphis gossypii* (Glover) infesting sunflower. Imidacloprid 0.003 per cent revealed the highest persistent toxicity index (PT) value of (889.63 and 877.80) and LT_{50} values 6.62 and 6.44 days against aphids *Aphis gossypii* (Glover) after first and second spray, respectively as compared to the other insecticides.

Keywords: Aphids, *Aphis gossypii*, sunflower, insecticides, management

Introduction
Sunflower (*Helianthus annuus* L.) belongs to family compositae originated in Mexico and Peru, introduced into India in the 16th century. Sunflower is one of the most important oilseed crops. The oil is used for culinary purposes, in the preparation of vanaspati ghee and in the manufacture of paints, soaps and cosmetics. The seed yield and oil content are important parameters in sunflower because sunflower oil is a good source of vegetable oil, for cooking and manufacture of margarine. Sunflower ranks third in the total area cultivated and fourth in total production. In India, during 2012-13 sunflower was cultivated in 8.22 lakh ha area with a production of 0.58 MT. In India the average yield is 705 kg/ha. Maharashtra ranks third in area and production. In Maharashtra, during 2012-2013 sunflower was grown on an area of 0.51 lakh ha with the productivity of 382 kg/ha (Anonymous, 2014) [2].
Amongst several factors responsible for low productivity of sunflower, the damage caused by insect-pests is major one. Sunflower serves as host for more than fifty insect-pests in India. However, twenty insect-pests were reported to feed on sunflower in Marathwada (Bilapate *et al*., 1994) [4]. The major insect-pests which drew the attention of both farmers and scientists are sucking pests like aphid (*Aphis gossypii* Glover). Infestation of sucking insect-pests is becoming a major concern in obtaining expected yield from sunflower crop because it's incidence start from seedling stage and prevail through the entire plant life. Both nymphs and adults of aphids suck the cell sap from leaves and stem and make the plant weak. Besides this they also secrete honey dew like substance on plant surface which attracts black sooty mould and interferes in the photosynthetic activity.
Several insecticides have been recommended against sunflower insect-pests for their effective

management. But according to several reports many of these label claimed insecticides could not gave effective results. Hence these label claimed insecticides with some new insecticides should have to be reevaluated against aphids on sunflower for effective insect-pests management.

Material and Methods

The field experiment with sunflower crop using variety LSFH-171 was conducted at Research Farm of Department of Agril. Entomology, College of Agriculture, Latur (Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani) (MS)-India during summer 2014. The experiment was conducted in a randomized block design (RBD) with three replications each replication has selected five plants. The eight treatments viz.

1. T1: Fenpropathrin 0.01 per cent.
2. T2: Indoxacarb 0.005 per cent.
3. T3: Imidacloprid 0.003 per cent.
4. T4: Spinosad 0.007 per cent.
5. T5: Flubendiamide0.007 per cent.
6. T6: Emamectin benzoate 0.002 per cent.
7. T7: Chlorantraniliprole 0.005 per cent.
8. T8: control used for investigation.

Effectiveness of insecticides was judged on the basis of level of aphids population on randomly selected five plants of sunflower. The pre-count of aphids was recorded on a day prior to application and post-counts at 1, 3, 7 and 14 days after first and second spray. The mortality was worked for 1, 3, 7 and 14 days after first and second application of insecticides. The generated data on survival of aphids was transformed into dn + 1 values and subjected for statistical analysis.

Bioassay procedure

The toxicity of different insecticides was assessed on aphid (*Aphis gossypii* Glover) on sunflower at 1, 3, 7 and 14 days after first and second application of insecticides. Due care was taken to cover the entire plants while application of insecticides. The required number of fresh flowers receiving application of insecticides was tagged for investigation on residual toxicity of insecticides. The number of test insects used for the bioassay studies was ten for each treatment in each replication. The treated leaves were brought in to the laboratory at specified intervals. The treated leaves were kept in to the plastic container. The stalk of leaves was covered with moistened cotton wool in order to retain their turgidity for 24 hours. The numbers of dead or moribund test insects were counted after 24 hours of exposure. Similarly, control mortality of test insects was also observed by releasing them on untreated substrates of sunflower plant.

Statistical treatment of data

Correction on percentage mortality

The observations on mortality of test insects were converted into percentage mortality. The average percentage mortality was calculated from the observations in 3 replications. The observations on percentage mortality thus obtained were corrected with Abbot's (1925) formula as follows.

$$P = \frac{T - C}{100 - C} \times 100$$

Whereas,

P = Corrected percentage mortality.
T = Percentage mortality in treatment.
C = Percentage mortality in control.

LT_{50} values

The values of LT_{50} (time required to give 50 per cent mortality) for different insecticides applied on sunflower plants were calculated by using software of probit analysis as suggested by Finney (1971).

PT values

The product (PT) of average residual toxicity (T) and the period (P) for which the toxicity persisted was used as an index of persistent toxicity. The values of corrected percentage mortalities at various specified periods were added. This sum was then divided by number of observations in order to obtain residual toxicity (T). The procedure followed by Saini (1959) and elaborated further by Pradhan (1967), Sarup *et al.* (1970) and Bhamare *et al.* (2015) was utilized.

Results and Discussion

Statistically non-significant difference was noted in aphids population prior to spraying. Aphids population ranged from 9.20 to 10.87and 4.30 to 11.53 aphids per leaf at one day before first and second spray, respectively. All insecticide treatments were significantly superior over untreated control in minimizing the incidence of aphids on 1, 3, 7 and 14 day after first and second spray.

The plots treated with imidacloprid 0.003 per cent observed significantly minimum population of aphid on sunflower to the extent of 2.00, 2.27, 3.07 and 4.20 per leaf at 1, 3, 7 and 14 days after first spraying, respectively and 1.07, 1.40, 2.47 and 3.40 per leaf at 1, 3, 7 and 14 days after second spraying, respectively over rest of the insecticides.

At one day after first and second spray, imidacloprid 0.003 per cent exhibited significantly lowest population of aphid to the tune of 2.00 and 1.07 per leaf, respectively. Spinosad 0.007 per cent (3.07 and 2.47 aphids per leaf) and indoxacarb 0.005 per cent (3.53 and 2.73 aphids per leaf) were found to be next effective treatments and statistically at par with each other at second spray. Chlorantraniliprole 0.005 per cent (4.33 and 3.47aphids per leaf), fenpropathrin 0.01 per cent (4.67 and 4.00 aphids per leaf), emamectin benzoate 0.002 per cent (4.87 and 4.07 aphids per leaf) and flubendiamide 0.007 per cent (5.27 and 4.47 aphids per leaf) documented lowest population of aphids after first and second spray, respectively.

At three days after first and second spray, significantly minimum population of aphid (2.27 and 1.40 per leaf) was recorded from the plots treated with imidacloprid 0.003 per cent. The next effective treatment was spinosad 0.007 per cent (3.67 and 2.53 aphids per leaf) followed by indoxacarb 0.005 per cent (3.93 and 2.93 aphids per leaf). Chlorantraniliprole 0.005 per cent (4.67 and 3.73 aphids per leaf), fenpropathrin 0.01 per cent (5.20 and 4.07 aphids per leaf), emamectin benzoate 0.002 per cent (5.27 and 4.27 aphids per leaf) and flubendiamide 0.007 per cent (5.67 and 4.67 aphids per leaf) were subsequently effective insecticides.

At seven days after first and second spray, lowest aphid population (3.07 and 2.47 per leaf) was recorded from the plots treated with imidacloprid 0.003 per cent. The next effective treatment was spinosad 0.007 per cent (4.47 and 3.87 aphids per leaf). Subsequently effective treatments in recording lowest population of aphid were indoxacarb 0.005 per cent (4.87 and 4.27 per leaf), chlorantraniliprole 0.005 per cent (5.40 and 4.80 per leaf), emamectin benzoate 0.002 per cent (6.07 and 5.47 per leaf), fenpropathrin 0.01 per cent (6.27 and 5.67 per leaf) and flubendiamide 0.007 per cent (6.47 and 5.87 per leaf).

At 14 days after first and second spray, imidacloprid 0.003 per centillustrated significantly minimum population of aphid (4.20 and 3.40 per leaf). The next effective treatment was spinosad 0.007 per cent (5.40 and 4.60 aphids per leaf) followed by indoxacarb 0.005 per cent (5.80 and 5.00 aphids per leaf). Both these treatments were statistically at bar with each other. Chlorantraniliprole 0.005 per cent (6.60 and 5.80 aphids per leaf), emamectin benzoate 0.002 per cent (7.20 and 6.40 aphids per leaf), fenpropathrin 0.01 per cent (7.40 and 6.60 aphids per leaf) and flubendiamide 0.007 per cent (7.60 and 6.80 aphids per leaf) were found to be subsequently effective treatments.

The result on the effectiveness of imidacloprid against aphids infesting sunflower in the present investigation is in accordance with the findings of Mishra (2002) [7] who proved that imidacloprid at the rate of 25 g a.i. per ha was significantly superior for the control of aphids on okra. However, Singh *et al*. (2004) [12] revealed that imidacloprid 17.8 SL at 200 ml/ha showed effective results against *Aphis gossypii* on chilli. Similarly, imidacloprid 0.004 per cent was recorded most effective treatment for the control of okra aphids by Shinde *et al*. (2011) [10]. While, El-Naggar and El-Hoda (2013) [5] registered that imidacloprid as foliar application was highly effective treatment against cotton aphids up to 14 days. According to Ghosal *et al*. (2013) [6] imidacloprid 17.8 SL at the rate of 50 g a.i. per ha was found to be most effective treatment against aphids on okra (84.54 per cent). The results observed in present studies are more or less similar with those of above scientist.

Imidacloprid 0.003 per cent (27.59 and 22.37) and spinosad 0.007 per cent (24.14 and 20.34) concentration showed comparatively high percentage mortality of aphids at 14 days after first and second spraying respectively. On the basis of PT values the descending order of persistent toxicity was imidacloprid 0.003 per cent (889.63 and 877.8) > spinosad 0.007 per cent (840.98 and 837.00) > indoxacarb 0.05 per cent (780.22 and 833.84) > chlorantraniliprole 0.005 per cent (743.50 and 776.16) > fenpropathrin 0.01 per cent (707.28 and 748.58) > emamectin benzoate 0.002 per cent (658.52 and 714.00) > flubendiamide 0.007 per cent (597.41 and 670.18) after first and second spraying respectively.

Imidacloprid 0.003 per cent showed highest LT_{50} value (6.62 and 6.44 days) against the adults of aphids on sunflower leaves receiving first and second application of insecticides respectively. The descending relative order of efficacy of insecticides in days was found to be imidacloprid 0.003 per cent (6.62 and 6.44 days) > spinosad 0.007 per cent (6.34 and 6.17) > indoxacarb 0.05 per cent (5.32 and 5.14) > chlorantraniliprole 0.005 per cent (4.74 and 4.70) > fenpropathrin 0.01 per cent (4.37 and 4.49) > emamectin benzoate 0.002 per cent (3.52 and 3.59) > flubendiamide 0.007 per cent (2.84 and 3.50) against the adults of aphids on sunflower leaves receiving first and second application of insecticides respectively. Thus, it indicates that imidacloprid 0.003 per cent followed by spinosad 0.007 per cent illustrated higher residual toxicity to aphids as compare to other insecticides.

These results are in close conformity with those obtained by Preetha *et al*. (2009) [8] who observed longest persistence of higher dose of imidacloprid up to 27 days for *Aphis gossypii* on bhendi crop. Similarly, Shinde *et al*. (2011) [11] reported highest persistent toxicity to first and third instar nymphs of *A. gossypii* in terms of PT values due to the application of imidacloprid 0.004 per cent. On the basis of LT_{50} values imidacloprid 0.004 per cent persisted longer in biologically active stage against 1st and 3rd instar nymphs of *A. gossypii*. According to Abd-Ella (2013) [1] the LT_{50} values for acetamiprid, imidacloprid, thiamethoxam and dinotefuran were 5.8, 6.2, 6.95 and 4.2 days, respectively against cowpea aphids and also indicated that neonicotinoid insecticides were highly effective against cowpea aphids under field and laboratory conditions. While, Awasthi *et al*. (2013) [3] showed the order of relative toxicity of insecticides over spinosad against cotton aphid *Aphis gossypii* was acetamiprid > acephate > imidacloprid > emamectin benzoate > indoxacarb, with their relative toxicity values being 82.28, 23.04, 16.18, 1.57 and 1.45, respectively. However, Rouhani *et al*. (2013) [9] revealed highest sensitivity of *A. punicae* to imidacloprid followed by thiacloprid, flonicamid and thiamethoxam. Thus the observations recorded in the present investigation are in close agreement with the findings of above workers.

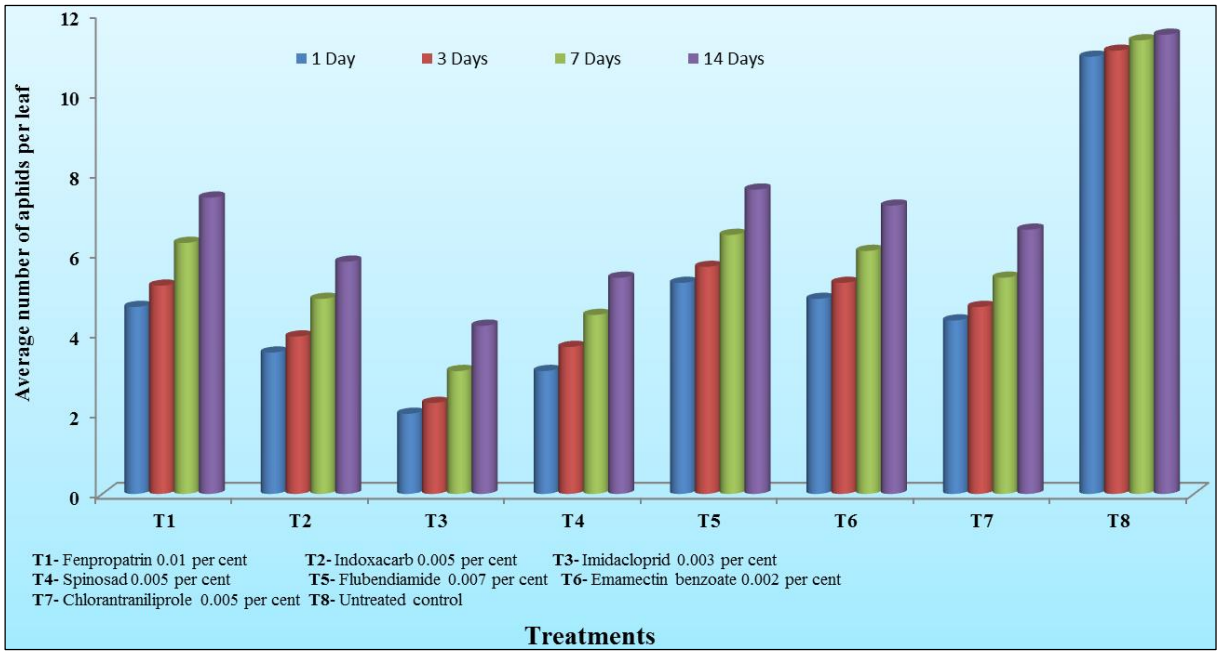

Fig 1: Effect of different insecticides on the population of sunflower aphid (first spray)

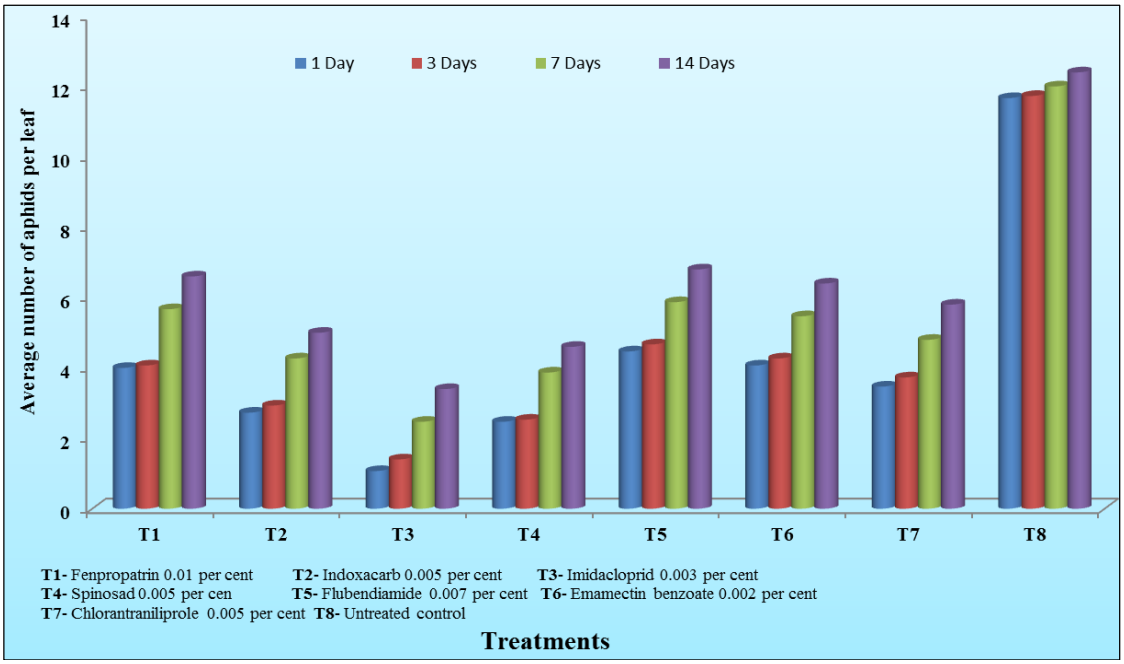

Fig 2: Effect of different insecticides on the population of sunflower aphid (second spray)

Table 1: Effect of different insecticides on the population of sunflower aphid (first spray)

Treatments	Mean number of aphids per leaf				
	1 day before treatment	Days after treatment			
		1	3	7	14
Fenpropathrin 0.001 per cent	9.20 (3.11)*	4.67 (2.73)	5.20 (2.39)	6.27 (2.59)	7.40 (2.81)
Indoxacarb 0.05 per cent	10.47 (3.31)	3.53 (2.01)	3.93 (2.10)	4.87 (2.32)	5.80 (2.51)
Imidacloprid 0.003 per cent	9.67 (3.18)	2.00 (1.58)	2.27 (1.66)	3.07 (1.88)	4.20 (2.17)
Spinosad 0.007 per cent	9.67 (3.19)	3.07 (1.88)	3.67 (2.04)	4.47 (2.23)	5.40 (2.43)
Flubendiamide 0.007 per cent	10.53 (3.32)	5.27 (2.41)	5.67 (2.49)	6.47 (2.63)	7.60 (2.85)
Emamectin benzoate 0.002 per cent	9.73 (3.20)	4.87 (2.32)	5.27 (2.39)	6.07 (2.56)	7.20 (2.78)
Chlorantraniliprole 0.005 per cent	10.00 (3.23)	4.33 (2.19)	4.67 (2.26)	5.40 (2.42)	6.60 (2.66)
Untreated Control	10.87 (3.36)	10.92 (3.38)	11.07 (3.41)	11.33 (3.44)	11.47 (3.46)
S.E. ±	0.48	0.02	0.04	0.03	0.03
C.D. at 5%	N.S.	0.05	0.11	0.08	0.09
C.V. (%)	4.03	1.24	2.53	2.00	1.93

*Figures in parentheses are square root transformed values ($\sqrt{x + 0.5}$)
N.S. - Non significant

Table 2: Effect of different insecticides on the population of sunflower aphid (second spray)

Treatments	Mean number of aphids per leaf				
	1 day before treatment	Days after treatment			
		1	3	7	14
Fenpropathrin 0.001 per cent	7.60 (2.85)*	4.00 (2.12)	4.07 (2.13)	5.67 (2.48)	6.60 (2.66)
Indoxacarb 0.05 per cent	5.90 (2.52)	2.73 (1.79)	2.93 (1.85)	4.27 (2.19)	5.00 (2.35)
Imidacloprid 0.003 per cent	4.30 (2.20)	1.07 (1.25)	1.40 (1.37)	2.47 (1.73)	3.40 (1.97)
Spinosad 0.007 per cent	5.40 (2.43)	2.47 (1.73)	2.53 (1.74)	3.87 (2.08)	4.60 (2.25)
Flubendiamide 0.007 per cent	7.60 (2.84)	4.47 (2.23)	4.67 (2.27)	5.87 (2.53)	6.80 (2.71)
Emamectin benzoate 0.002 per cent	7.27 (2.79)	4.07 (2.13)	4.27 (2.18)	5.47 (2.44)	6.40 (2.63)
Chlorantraniliprole 0.005 per cent	6.80 (2.70)	3.47 (1.98)	3.73 (2.05)	4.80 (2.30)	5.80 (2.51)
Untreated Control	11.53 (3.47)	11.67 (3.49)	11.73 (3.50)	12.00 (3.53)	12.40 (3.59)
S.E. ±	0.19	0.02	0.04	0.03	0.04
C.D. at 5%	N.S.	0.08	0.14	0.08	0.11
C.V. (%)	2.12	2.05	3.68	2.04	2.37

*Figures in parentheses are square root transformed values ($\sqrt{x + 0.5}$)
N.S. - Non significant

Table 3: Persistence of different insecticides in/on leaves of sunflower applied as first spray against aphids

Insecticides	Corrected percentage mortality after different intervals (days)				P	T	PT	R.E.	O.R.E.
	1	3	7	14					
Fenpropathrin 0.01 per cent	79.31	60.71	44.83	17.24	50.52	14	707.28	1.18	5
Indoxacarb 0.05 per cent	86.21	64.29	51.72	20.69	55.73	14	780.22	1.31	3
Imidacloprid 0.003 per cent	95.55	71.42	58.62	27.59	63.54	14	889.63	1.49	1
Spinosad 0.007 per cent	93.10	67.86	55.18	24.14	60.07	14	840.98	1.41	2
Flubendiamide 0.007 per cent	68.97	49.99	37.93	13.80	42.67	14	597.41	1.00	7
Emamectin benzoate 0.002 per cent	75.86	53.67	41.38	17.24	47.04	14	658.52	1.10	6
Chlorantraniliprole 0.005per cent	82.75	60.71	48.28	20.69	53.11	14	743.50	1.24	4

Table 4: Relative efficacy of different insecticides against aphids on sunflower applied as first spray

Insecticides	Heterogeneity		Regression Equation (y=……)	Log LT_{50} ± S.Em	LT_{50} (days)	Fiducial Limit (days)	R.E.	O.R.E.
	d.f.	χ^2						
Fenpropathrin 0.01 per cent	2	0.260	$y = 0.0279 - 1.3894x$	0.6405±0.1610	4.37	1.52 14.93	1.54	5
Indoxacarb 0.05 per cent	2	0.436	$y = 0.1040 - 1.5855x$	0.7266±0.1462	5.32	2.47 16.55	1.87	3
Imidacloprid 0.003 per cent	2	0.466	$y = 0.1452 - 2.0421x$	0.8405±0.1239	6.62	3.92 17.87	2.33	1
Spinosad 0.007 per cent	2	0.334	$y = 0.1327 - 1.8061x$	0.8026±0.1350	6.34	3.35 18.30	2.23	2
Flubendiamide0.007 per cent	2	0.235	$y = -0.1312 - 1.1988x$	0.4535±0.1936	2.84	0.15 8.67	1.00	7
Emamectin benzoate 0.002 per cent	2	0.280	$y = -0.0558 - 1.3648x$	0.5467±0.1653	3.52	0.90 10.09	1.23	6
Chlorantraniliprole 0.005per cent	2	0.330	$y = 0.0561 - 1.4656x$	0.6764±0.1544	4.74	1.91 15.60	1.67	4

Table 5: Persistence of different insecticides in/on leaves of sunflower applied as second spray against aphids

Insecticides	Corrected percentage mortality after different intervals (days)				P	T	PT	R.E.	O.R.E.
	1	3	7	14					
Fenpropathrin 0.01 per cent	77.63	67.53	54.36	14.56	53.47	14	748.58	1.12	5
Indoxacarb 0.05 per cent	87.00	72.69	59.00	19.57	59.56	14	833.84	1.24	3
Imidacloprid 0.003 per cent	93.00	74.68	61.78	22.37	62.70	14	877.8	1.31	1
Spinosad 0.007 per cent	83.00	75.68	60.12	20.34	59.78	14	837.00	1.25	2
Flubendiamide 0.007 per cent	73.00	59.00	49.50	10.00	47.87	14	670.18	1.00	7
Emamectin benzoate 0.002 per cent	75.00	63.78	52.00	13.19	51.00	14	714.00	1.06	6
Chlorantraniliprole 0.005per cent	79.68	69.87	57.00	15.31	55.44	14	776.16	1.16	4

Table 6: Relative efficacy of different insecticides against aphids on sunflower applied as second spray

Insecticides	Heterogeneity		Regression Equation (y=……)	Log LT_{50} ± S.Em	LT_{50} (days)	Fiducial Limit (days)	R.E.	O.R.E.
	d.f.	χ^2						
Fenpropathrin 0.01per cent	2	2.49	$y = 0.1425 - 1.4894x$	0.6524±0.1514	4.49	1.82 13.28	1.28	5
Indoxacarb 0.05 per cent	2	2.62	$y = 0.2145 - 1.6677x$	0.7111±0.1392	5.14	2.49 13.86	1.46	3
Imidacloprid 0.003 per cent	2	1.085	$y = 0.2069 - 1.9897x$	0.8089±0.1247	6.44	3.59 15.97	1.84	1
Spinosad 0.007 per cent	2	1.504	$y = 0.2293 - 1.6956x$	0.7907±0.1420	6.17	3.16 19.18	1.76	2
Flubendiamide 0.007 per cent	2	2.40	$y = 0.0386 - 1.4444x$	0.5444±0.1567	3.50	1.08 9.02	1.00	7
Emamectin benzoate 0.002 per cent	2	2.49	$y = 0.0593 - 1.4624x$	0.5558±0.1545	3.59	1.18 9.23	1.02	6
Chlorantraniliprole 0.005per cent	2	2.428	$y = 0.1660 - 1.5713x$	0.6725±0.2286	4.70	2.08 13.08	1.34	4

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