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Bio-efficacy, persistence and residual toxicity of different insecticides against whitefly (*Bemisia tabaci* (Gennadius)) on sunflower

RB Dake and VK Bhamare

Abstract
An investigation was undertaken to study the bio-efficacy, persistence and residual toxicity of different newer insecticides against whitefly on sunflower at research farm of department of Agril. Entomology College of agriculture Latur. The observations on total number of whiteflies 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 whiteflies. On 14th DAS, the population of whiteflies was ranged 0.64 to 1.43 whiteflies/leaf and 0.87 to 1.42 whiteflies/leaf after first and second spray respectively. Imidacloprid 0.003 per cent exhibited significantly lowest population of whitefly (0.64 and 0.87 per leaf). However, spinosad 0.007 per cent (1.02 and 1.07 whiteflies per leaf), indoxacarb 0.005 per cent (1.07 and 1.10 whiteflies per leaf) and chlorantraniliprole 0.005 per cent (1.20 and 1.30 whiteflies per leaf) were found to be next effective treatments and statistically on par with each other. Fenpropathrin 0.01 per cent (1.31 and 1.42 whiteflies per leaf), emamectin benzoate 0.002 per cent (1.36 and 1.29 whiteflies per leaf) and flubendiamide 0.007 per cent (1.43 and 1.20 whiteflies per leaf) were found to be subsequently effective treatments at 14 days after first and second spray, respectively. Among different insecticides, imidacloprid, spinosad and indoxacarb exhibited highest efficacy against sunflower whiteflies.
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 whitefly *Bemisia tabaci* (Gennadius) infesting sunflower. Imidacloprid 0.003 per cent revealed the highest persistent toxicity index (PT) value of (921.48 and 944.79) and LT_{50} values 7.80 and 7.99 days against whitefly *Bemisia tabaci* (Gennadius) after first and second spray, respectively as compared to the other insecticides.
Among all the treatments, highest incremental cost benefit ratio (1:17.66) was attained by imidacloprid 0.003 per cent.

Keywords: Whitefly, *Bemisia tabaci*, 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) [5]. The major insect-pests which drew the attention of both farmers and scientists are sucking pests like whitefly (*Bemisia tabaci* (Gennadius)). 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 whitefly suck the cell sap from leaves desap the plant and shows symptoms like stunted growth and yellowing of leaves. Besides these sucking insect-pests are known as vector for carrying different diseases. 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 whiteflies 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. T1: Fenpropathrin 0.01 per cent, T2: Indoxacarb 0.005 per cent, T3: Imidacloprid 0.003 per cent, T4: Spinosad 0.007 per cent, T5: Flubendiamide0.007 per cent, T6: Emamectin benzoate 0.002 per cent, T7: Chlorantraniliprole 0.005 per cent and T8: control used for investigation. Effectiveness of insecticides was judged on the basis of level of whitefly population on randomly selected five plants of sunflower. The pre-count of whitefly 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 whitefly was transformed into dn+1values and subjected for statistical analysis.

Bioassay procedure

The toxicity of different insecticides was assessed on whitefly (*Bemisia tabaci* (Gennadius)) 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 leaves 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) [8].

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 whitefly population prior to spraying. Whitefly population ranged from 1.12 to 1.49 and 1.16 to 2.13 whiteflies 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 whiteflies 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 whitefly on sunflower to the extent of 0.13, 0.33, 0.31 and 0.64 per leaf at 1, 3, 7 and 14 days after first spraying, respectively and 0.24, 0.42, 0.53 and 0.87 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, significantly minimum population of whitefly (0.13 and 0.24 per leaf) was registered from the plots treated with imidacloprid 0.003 per cent followed by spinosad 0.007 per cent (0.27 and 0.38 per leaf). Both these treatments were found to be equally effective in reducing whitefly population. Subsequently effective treatments were indoxacarb 0.005 per cent (0.40 and 0.56 whitefly per leaf), fenpropathrin 0.01 per cent (0.56 and 0.76 whitefly per leaf), chlorantraniliprole 0.005 per cent (0.62 and 0.76 whitefly per leaf), emamectin benzoate 0.002 per cent (0.62 and 0.84 whitefly per leaf), and flubendiamide 0.007 per cent (0.76 and 0.96 whitefly per leaf).

Imidacloprid 0.003 per cent registered significantly lowest population of whitefly to the tune of 0.31 and 0.42 per leaf. Spinosad 0.007 per cent (0.49 and 0.62 whitefly per leaf) and indoxacarb 0.005 per cent (0.53 and 0.73 whitefly per leaf) were found to be next effective treatments and statistically on par with each other. However, fenpropathrin 0.01 per cent, emamectin benzoate 0.002 per cent, chlorantraniliprole 0.005 per cent and flubendiamide 0.007 per cent were observed to be the next effective treatments noted 0.67, 0.69, 0.78, 0.87 and 0.93, 0.96, 0.87, 1.07 whitefly per leaf, at three days after first and second spray respectively.

At seven days after first and second spray, significantly least population of whitefly (0.33 and 0.53 per leaf) was evidenced from the plots treated with imidacloprid 0.003 per cent. The next effective treatment was spinosad 0.007 per cent (0.58 and 0.78 whitefly per leaf) followed by indoxacarb 0.005 per cent (0.69 and 0.82 whitefly per leaf) and emamectin benzoate 0.002 per cent (0.78 and 0.98 whitefly per leaf). All

these treatments were statistically at par with each other. Subsequently effective treatments in reducing population of sunflower whitefly were chlorantraniliprole 0.005 per cent (0.84 and 0.93 whitefly per leaf), fenpropathrin 0.01 per cent (0.91 and 1.11 whitefly per leaf) and flubendiamide 0.007 per cent (1.02 and 1.13 whitefly per leaf).

At 14 days after first and second spray, imidacloprid 0.003 per cent exhibited significantly lowest population of whitefly (0.64 and 0.87 per leaf). However, spinosad 0.007 per cent (1.02 and 1.07 whiteflies per leaf), indoxacarb 0.005 per cent (1.07 and 1.10 whiteflies per leaf) and chlorantraniliprole 0.005 per cent (1.20 and 1.30 whiteflies per leaf) were found to be next effective treatments and statistically on par with each other. Fenpropathrin 0.01 per cent (1.31 and 1.42 whiteflies per leaf), emamectin benzoate 0.002 per cent (1.36 and 1.29 whiteflies per leaf) and flubendiamide 0.007 per cent (1.43 and 1.20 whiteflies per leaf) were found to be subsequently effective treatments at 14 days after first spray.

The present findings are in close agreement with the earlier reports of Rathod *et al.* (2010) [13] who documented that imidacloprid 70 WS at the rate of 5 g/kg seed was the most effective treatment followed by imidacloprid 200 SL at the rate of 0.5 ml/l at 20 and 30 days after emergence in minimizing average population of whiteflies in sunflower. Analogously, lowest incidence of sunflower whitefly was recorded in imidacloprid 600 FS (at the rate of 10 ml/kg seeds) followed by imidacloprid 70 WS (at the rate of 5 g/kg seeds) by Kencharaddi (2011) [11].

The results observed in present studies are more or less similar with the findings of Sing *et al.* (2004) [14] who noticed that imidacloprid 17.8 SL was significantly superior over untreated check in reducing per cent population of whiteflies on chilli. However, Asi *et al.* (2008) [3] reported imidacloprid 200 SL (confidor) and diafenthiuron 500 SC (polo) were highly effective treatments against cotton whitefly. Studies of Preetha *et al.* (2009) reported imidacloprid 17.8 SL at 25 g a.i. per ha was effective treatment against whiteflies on okra. According to Bokan (2012) [6] spinosad 45 EC @ 135 g/ha and imidacloprid 17.8 SP @ 10 g/ha exhibited most effective treatments in reducing white fly population on chilli. Similarly, imidacloprid was found to be most effective insecticide for the control of whitefly, *Bemisia tabaci* (Genn.) on coriander (Ghadage *et al.*, 2012b) [9] and on brinjal (Omprakash and Raju, 2013 and; Das and Islam, 2014) [12, 7]. However, Afzal *et al.* (2014) [1] noted that imidacloprid was most effective insecticide against whitefly up to seven days after application in cotton. These results endorse the results of the present findings.

Imidacloprid 0.003 per cent, spinosad 0.007 per cent and indoxacarb 0.05 per cent concentration showed comparatively high percentage mortality of whiteflies (27.59, 24.14 and 24.14 per cent) and (28.56, 25.00 and 21.43) 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 (921.48 and 944.79) > spinosad 0.007 per cent (872.34 and 888.72) > indoxacarb 0.05 per cent (835.38 and 846.58) > chlorantraniliprole 0.005 per cent (774.06 and 784.87) > fenpropathrin 0.01 per cent (736.96 and 748.30) > emamectin benzoate 0.002 per cent (651.17 and 661.64) > flubendiamide 0.007 per cent (615.02 and 624.57) after first and second spraying respectively.

Imidacloprid 0.003 per cent showed highest LT_{50} value (7.80 days and 7.99) against the whitefly on sunflower leaves receiving first application of insecticides. The descending relative order of efficacy of insecticides in days was found to be imidacloprid 0.003 per cent (7.80 and 7.99) > spinosad 0.007 per cent (6.93 and 7.13) > indoxacarb 0.05 per cent (6.34 and 6.25) > chlorantraniliprole 0.005 per cent (5.32 and 5.52) > fenpropathrin 0.01 per cent (4.74 and 4.94) > emamectin benzoate 0.002 per cent (3.42 and 3.60) > flubendiamide 0.007 per cent (3.06 and 3.23) against the nymphs of whitefly 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 whitefly as compare to other insecticides.

These findings are supported with the work of Horowitz *et al.* (1998) [10] who recorded slightly more sensitivity of adult whiteflies to imidacloprid and noted 76, 56 and 25 per cent mortality on three, ten and seventeen days, respectively. According to Ghadage *et al.* (2012 b) [9] imidacloprid 0.005 per cent was found to be effective against whitefly, *Bemisia tabaci* (Genn.) on coriander and registered 87.76 to 91.88 per cent mortality. Analogously, Bharati (2013) [4] noted highest persistent toxicity in terms of PT values to the extent of 941.36, 966.70 and 978.46 against whitefly after second, third and fourth spray, respectively due to the application of imidacloprid 0.004 per cent while, LT_{50} values of imidacloprid 0.004 per cent persisted to the highest extent of 8.05, 8.11 and 8.26 days against whitefly after second, third and fourth spray, respectively. Thus, these results endorse the results of the present findings.

Among all the treatments, highest incremental cost benefit ratio (1:17.66) was attained by imidacloprid 0.003 per cent which was followed by fenpropathrin 0.01 per cent (1:7.03), spinosad 0.005 per cent (1:4.03), indoxacarb 0.005 per cent (1:3.53), emamectin benzoate 0.002 per cent (1:2.32), flubendiamide 0.007 per cent (1:2.11) and chlorantraniliprole 0.005 per cent (1:2.08). These results are analogous to the findings of Kencharaddi (2011) [11] who documented higher cost benefit ratio (2.63) in imidacloprid 600 FS (at the rate of 10 ml /kg seeds treatment) followed by imidacloprid 70 WS (at the rate of 5 g/kg seeds) in sunflower.

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

Treatments	Mean number of whiteflies per leaf				
	1 day before	Days after treatment			
		1	3	7	14
Fenpropathrin 0.01per cent	1.40 (1.37)*	0.56 (1.00)	0.67 (1.07)	0.91 (1.19)	1.31 (1.35)
Indoxacarb 0.005 per cent	1.12 (1.26)	0.40 (0.95)	0.53 (1.01)	0.69 (1.09)	1.07 (1.25)
Imidacloprid 0.003 per cent	1.12 (1.26)	0.13 (0.78)	0.33 (0.89)	0.31 (0.89)	0.64 (1.06)
Spinosad 0.007 per cent	1.46 (1.40)	0.27 (0.86)	0.49 (1.00)	0.58 (1.04)	1.02 (1.23)

Flubendiamide 0.007 per cent	1.49 (1.40)	0.76 (1.11)	0.87 (1.16)	1.02 (1.22)	1.43 (1.39)
Emamectin benzoate 0.002 per cent	1.44 (1.38)	0.62 (1.06)	0.69 (1.03)	0.78 (1.12)	1.36 (1.36)
Chlorantraniliprole 0.005 per cent	1.30 (1.33)	0.62 (1.06)	0.78 (1.11)	0.84 (1.16)	1.20 (1.30)
Untreated Control	1.34 (1.36)	1.36 (1.36)	1.47 (1.40)	1.64 (1.46)	2.09 (1.60)
S.E. $\pm$	0.15	0.04	0.02	0.03	0.03
C.D. at 5%	N.S.	0.11	0.07	0.09	0.09
C.V. (%)	7.24	5.68	4.09	4.75	4.08

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

Treatments	**Mean number of whiteflies per leaf**				
	1 day before	**Days after treatment**			
		1	**3**	**7**	**14**
Fenpropathrin 0.01 per cent	1.40 (1.30)*	0.76 (1.12)	0.93 (1.19)	1.11 (1.26)	1.42 (1.44)
Indoxacarb 0.005 per cent	1.16 (1.28)	0.56 (1.03)	0.73 (1.11)	0.82 (1.15)	1.10 (1.26)
Imidacloprid 0.003 per cent	1.33 (1.35)	0.24 (0.86)	0.42 (0.95)	0.53 (1.02)	0.87 (1.17)
Spinosad 0.007 per cent	1.24 (1.31)	0.38 (0.93)	0.62 (1.05)	0.78 (1.12)	1.07 (1.25)
Flubendiamide 0.007 per cent	1.31 (1.34)	0.96 (1.19)	1.07 (1.24)	1.13 (1.28)	1.20 (1.30)
Emamectin benzoate 0.002 per cent	1.36 (1.36)	0.84 (1.16)	0.96 (1.19)	0.98 (1.21)	1.29 (1.45)
Chlorantraniliprole 0.005 per cent	1.36 (1.36)	0.76 (1.11)	0.87 (1.16)	0.93 (1.20)	1.30 (1.34)
Untreated Control	2.13 (1.42)	2.17 (1.64)	2.27 (1.66)	2.40 (1.70)	2.70 (1.77)
S.E. $\pm$	0.10	0.02	0.03	0.03	0.03
C.D. at 5%	N.S.	0.05	0.08	0.08	0.10
C.V. (%)	4.21	2.40	3.79	3.62	4.27

*Figures in parentheses are square root transformed values (Ö x + 0.5)
N.S- Non significant

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

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	82.75	60.70	46.43	20.68	52.64	14	736.96	1.20	5
Indoxacarb 0.05 per cent	93.10	67.86	53.57	24.14	59.67	14	835.38	1.36	3
Imidacloprid 0.003 per cent	100	75.00	60.71	27.59	65.82	14	921.48	1.50	1
Spinosad 0.007 per cent	96.55	71.42	57.14	24.14	62.31	14	872.34	1.42	2
Flubendiamide 0.007 per cent	65.52	57.14	39.28	13.80	43.93	14	615.02	1.00	7
Emamectin benzoate 0.002 per cent	68.97	57.14	42.86	17.24	46.55	14	651.17	1.06	6
Chlorantraniliprole 0.005per cent	86.21	64.29	49.99	20.68	55.29	14	774.06	1.26	4

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

Insecticides	**Heterogeneity**		**Regression Equation (y=……)**	**Log LT_{50} $\pm$ S.Em**	**LT_{50} (days)**	**Fiducial Limit (days)**	**R.E.**	**O.R.E.**
	d.f.	**χ^2**						
Fenpropathrin 0.01 per cent	2	0.330	$y = 0.0561 - 1.4656x$	0.6764±0.1544	4.74	1.91 15.60	1.55	5
Indoxacarb 0.05 per cent	2	0.334	$y = 0.1327 - 1.8061x$	0.8026±0.1350	6.34	3.35 18.30	1.76	3
Imidacloprid 0.003 per cent	2	0.924	$y = 0.2810 - 2.2998x$	0.8921±0.1154	7.80	4.65 19.63	2.55	1
Spinosad 0.007 per cent	2	0.466	$y = 0.1452 - 2.0421x$	0.8405±0.1239	6.93	3.92 17.87	2.26	2
Flubendiamide 0.007 per cent	2	0.734	$y = -0.0801 - 1.1043x$	0.4860±0.2043	3.06	0.04 13.07	1.00	7
Emamectin benzoate 0.002 per cent	2	0.760	$y = -0.0392 - 1.1554x$	0.5343±0.1921	3.42	0.28 14.93	1.12	6

Chlorantraniliprole 0.005per cent	2	0.436	$y = 0.1040 - 1.5855x$	0.7266±0.1462	5.32	2.47 16.55	1.74	4

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

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	82.14	65.52	48.28	17.85		53.45	14	748.30	1.20	5
Indoxacarb 0.05 per cent	92.85	72.41	55.18	21.43		60.47	14	846.58	1.35	3
Imidacloprid 0.003 per cent	100	79.31	62.07	28.56		67.48	14	944.79	1.51	1
Spinosad 0.007 per cent	94.43	75.87	58.62	25.00		63.48	14	888.72	1.42	2
Flubendiamide 0.007 per cent	64.29	62.07	41.38	10.71		44.61	14	624.57	1.00	7
Emamectin benzoate 0.002 per cent	67.86	62.07	44.83	14.28		47.26	14	661.64	1.06	6
Chlorantraniliprole 0.005 per cent	85.71	68.97	51.72	17.85		56.06	14	784.87	1.26	4

Table 6: Relative efficacy of different insecticides against whiteflies 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 0.01 per cent	2	0.361	$y = 0.0800 - 1.4908x$	0.6937±0.1528	4.94	2.09 16.25	1.53	5
Indoxacarb 0.05 per cent	2	0.409	$y = 0.1449 - 1.9413x$	0.7962±0.1266	6.25	3.43 15.76	1.93	3
Imidacloprid 0.003 per cent	2	0.645	$y = 0.2994 - 2.4126x$	0.9026±0.1116	7.99	4.83 19.42	2.47	1
Spinosad 0.007 per cent	2	0.314	$y = 0.1603 - 2.1108x$	0.8531±0.1214	7.13	4.11 17.98	2.21	2
Flubendiamide 0.007 per cent	2	0.958	$y = -0.0562 - 1.1190x$	0.5090±0.1995	3.23	0.12 14.44	1.00	7
Emamectin benzoate 0.002 per cent	2	0.928	$y = -0.0153 - 1.1714x$	0.5559±0.1884	3.60	0.44 16.24	1.21	6
Chlorantraniliprole 0.005per cent	2	0.457	$y = 0.1263 - 1.6153x$	0.7421±0.1448	5.52	2.64 17.05	1.71	4

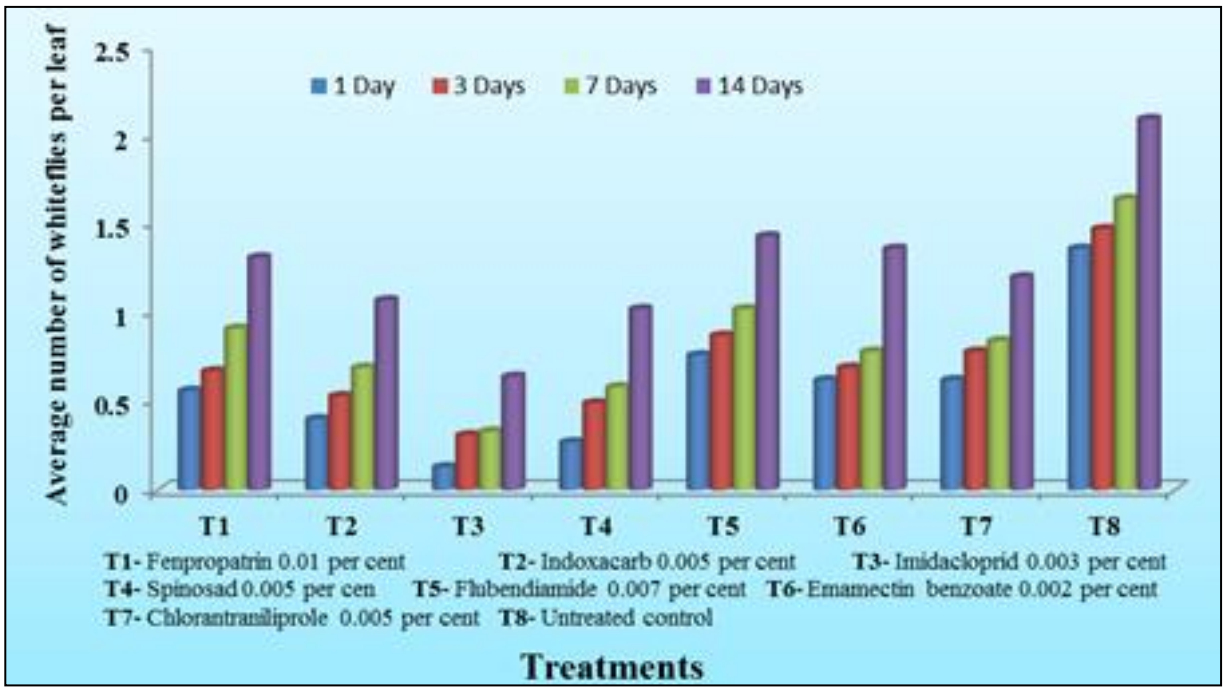

Fig 1: Effect of different insecticides on the population of sunflower whitefly (first spray)

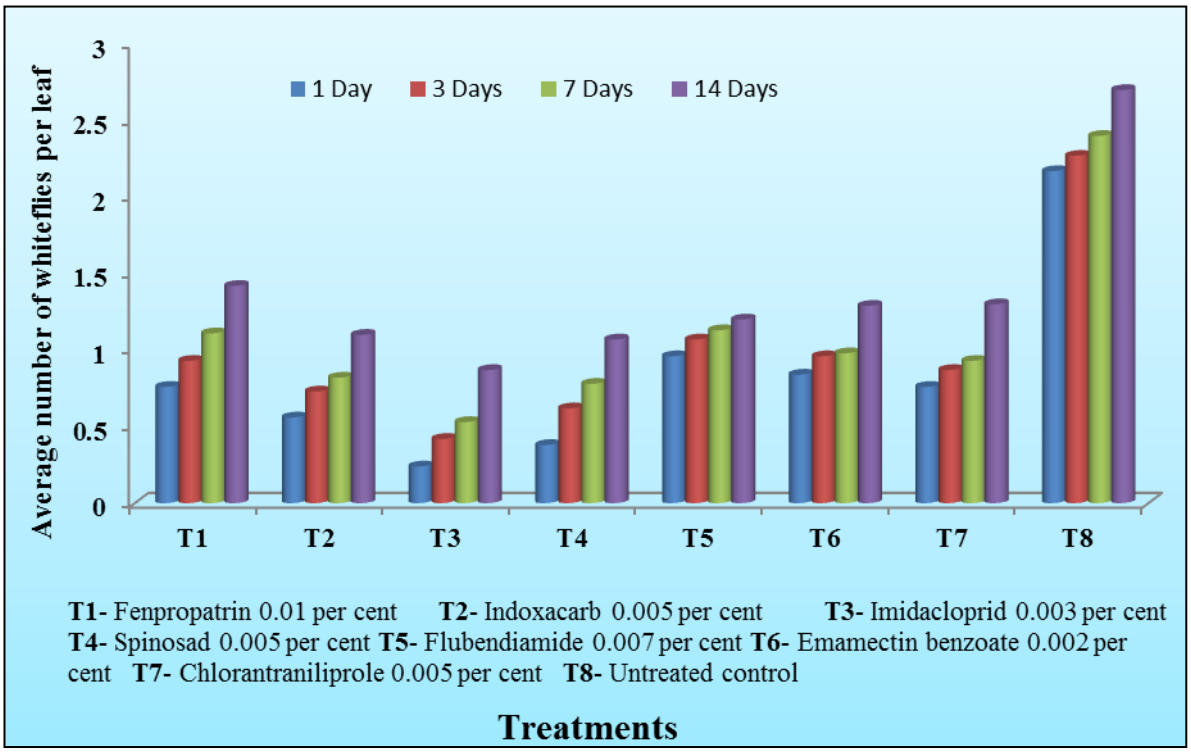

Fig 2: Effect of different insecticides on the population of sunflower whitefly (second spray)

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