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RB Dake
Department of Agricultural Entomology, College of Agriculture, Latur, Maharashtra, India

VK Bhamare
Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Correspondence
RB Dake
Department of Agricultural Entomology, College of Agriculture, Latur, Maharashtra, India

Bio-efficacy, persistence and residual toxicity of different insecticides against jassids (*Amrasca biguttula biguttula* Ishida) 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 jassid on sunflower at research farm of department of Agril. Entomology College of agriculture Latur. The observations on total number of jassids 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 jassids. On 14th DAS, the population of jassids was ranged 4.20 to7.60 jassids/leaf and 3.40 to 6.80 jassids/leaf after first and second spray respectively. Imidacloprid 17.8 SL 0.003 per cent was exhibited most effective insecticide in minimizing the jassids population (4.20 and 3.40 jassids/leaf) followed by spinosad 0.007 per cent (5.40 and 4.60 jassids/leaf), indoxacarb 0.05 per cent (5.80 and 5.00 jassids/leaf), chlorantraniliprole 0.005 per cent (6.60 and 5.80 jassids/leaf) emamectin benzoate 0.002 per cent (7.20 and 6.40 jassids/leaf), fenpropathrin 0.01 per cent (7.40 and 6.60 jassids/leaf) and flubendiamide 0.007 per cent (7.60 and 6.80 jassids/leaf) after first and second spray, respectively. Among different insecticides, imidacloprid, spinosad and indoxacarb exhibited highest efficacy against sunflower jassids.
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 jassids infesting sunflower. Imidacloprid 0.003 per cent revealed the highest persistent toxicity index (PT) value of (804.3 and 843.08) and LT_{50} values 5.75 and 5.91 days against jassids 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: Jassids, *Amrasca biguttula biguttula*, 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) [6]. The major insect-pests which drew the attention of both farmers and scientists are sucking pests like jassids (*Amrasca biguttula biguttula* Ishida). 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 jassids desap the plant and shows symptoms like stunted growth, burning of leaf margins, cupped and crinkled leaves.

In severe case if infestation occurs, characteristic "hopper burn" symptoms are noticed

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 jassids 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: Flubendiamide 0.007 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 jassid population on randomly selected five plants of sunflower. The pre-count of jassid 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 jassid was transformed into dn+1values and subjected for statistical analysis.

Bioassay procedure

The toxicity of different insecticides was assessed on Jassid (*Amrasca biguttula biguttula*) 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.

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

Where as, 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) [13] and Bhamare *et al.* (2015) was utilized.

Results and Discussion

Statistically non significant difference was noted in jassid population prior to spraying. Jassid population ranged from 3.69 to 4.24 and 1.93 to 4.13 jassids 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 jassids 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 jassids on sunflower to the extent of 0.71, 0.81, 0.88 and 1.32 per leaf at 1, 3, 7 and 14 days after first spraying, respectively and 0.31, 0.53, 0.83 and 1.22 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 jassids to the tune of 0.71 and 0.31 per leaf, respectively. Spinosad 0.007 per cent (0.87 and 0.47 jassids per leaf) and indoxacarb 0.005 per cent (1.13 and 0.82 jassids per leaf) were found to be next effective treatments. Chlorantraniliprole 0.005 per cent (1.23 jassids per leaf), emamectin benzoate 0.002 per cent (1.42 jassids per leaf), fenpropathrin 0.01 per cent (1.43 jassids per leaf) and flubendiamide 0.007 per cent (1.47 jassids per leaf) documented lowest population of jassids after first spray. Chlorantraniliprole 0.005 per cent (0.93 jassids per leaf), emamectin benzoate 0.002 per cent (1.02 jassids per leaf), flubendiamide 0.007 per cent (1.07 jassids per leaf) and fenpropathrin 0.01 per cent (1.32 jassids per leaf) documented lowest population of jassids after second spray.

At three days after first and second spray, significantly minimum population of jassids (0.87 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 (0.97 and 2.53 jassids per leaf) followed by indoxacarb 0.005 per cent (1.23 and 2.93 jassids per leaf). Chlorantraniliprole 0.005 per cent (1.33 and 3.73 jassids per leaf), emamectin benzoate 0.002 per cent (1.52 and 4.27 jassids per leaf), fenpropathrin 0.01 per cent (1.53 and 4.07 jassids per leaf), and flubendiamide 0.007 per cent (1.57 and 4.67 jassids 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 jassids 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 cent illustrated 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 jassids per leaf) followed by indoxacarb 0.005 per cent (5.80 and 5.00 jassids per leaf). Both these treatments were statistically at bar with each other. Chlorantraniliprole 0.005 per cent (6.60 and 5.80 jassids per leaf), emamectin benzoate 0.002 per cent (7.20 and 6.40 jassids per leaf), fenpropathrin 0.01 per cent (7.40 and 6.60 jassids per leaf) and flubendiamide 0.007 per cent (7.60 and 6.80 jassids per leaf) were found to be subsequently effective treatments.

The trends of results found in the present investigation coincides with Kencharaddi (2011) [10] who reported lowest incidence of leafhopper in sunflower with imidacloprid 600 FS (at the rate of 10 ml/kg seeds) followed by imidacloprid 70 WS (at the rate of 5 g/kg seeds).

Similar trends of results were also pointed out by many authors in different crops as discussed below. Aslam *et al.* (2004) [4] reported that imidacloprid at the rate of 80 to 250 ml per ha was effective against jassids infesting cotton up to 7 days. Similarly, Asi *et al.* (2008) [3] indicated imidacloprid 200 SL (confidor) and diafenthiuron 500 SC (polo) were highly effective against sucking insect-pests of cotton. While, Preetha *et al.* (2009) [12] documented imidacloprid 17.8 SL at 25 g a.i. per ha effective against jassids on okra. In the same way, Shinde *et al.* (2011) observed imidacloprid 0.004 per cent most effective treatment for the control of okra jassids. However, Das and Islam (2014) [7] reported that imidacloprid 70 WG proved to be superior and significantly increased the mortality of brinjal jassids. While, Kolhe (2014) [11] exhibited highest efficacy of imidacloprid 0.003 per cent against groundnut jassids. Thus, 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 jassids (25.00, 21.43 and 17.85 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 (804.3 and 843.08) > spinosad 0.007 per cent (766.85 and 806.05) > indoxacarb 0.05 per cent (729.71 and 756.45) > chlorantraniliprole 0.005 per cent (692.65 and 706.86) > fenpropathrin 0.01 per cent (630.98 and 656.84) > emamectin benzoate 0.002 per cent (563.91 and 619.78) > flubendiamide 0.007 per cent (544.35 and 570.22) after first and second spraying respectively.

Imidacloprid 0.003 per cent showed highest LT_{50} value (5.75 days and 5.91) against the jassid 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 (5.75 and 5.91) > spinosad 0.007 per cent (5.36 and 5.53) > indoxacarb 0.05 per cent (4.74 and 4.93) > chlorantraniliprole 0.005 per cent (4.19 and 4.38) > fenpropathrin 0.01 per cent (3.84 and 3.68) > emamectin benzoate 0.002 per cent (3.00 and 3.21) > flubendiamide 0.007 per cent (2.56 and 2.86) against the nymph of jassid 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.

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

Treatments	Mean number of jassids per leaf				
	1 day before treatment	Days after treatment			
		1	3	7	14
Fenpropathrin 0.01 per cent	3.69 (2.04)*	1.43 (1.38)	1.53 (1.45)	1.66 (1.46)	2.00 (1.58)
Indoxacarb 0.005 per cent	3.91 (2.10)	1.13 (1.27)	1.23 (1.35)	1.30 (1.33)	1.77 (1.50)
Imidacloprid 0.003 per cent	3.93 (2.11)	0.71 (1.10)	0.81 (1.18)	0.88 (1.18)	1.32 (1.35)
Spinosad 0.005 per cent	3.80 (2.07)	0.87 (1.17)	0.97 (1.25)	1.03 (1.24)	1.61 (1.46)
Flubendiamide 0.007 per cent	4.24 (2.18)	1.47 (1.41)	1.57 (1.47)	1.63 (1.46)	2.17 (1.64)
Emamectin benzoate 0.002 per cent	3.71 (2.06)	1.42 (1.39)	1.52 (1.45)	1.59 (1.45)	2.08 (1.61)
Chlorantraniliprole 0.005 per cent	3.80 (2.07)	1.23 (1.31)	1.33 (1.38)	1.40 (1.38)	1.97 (1.57)
Untreated Control	3.78 (2.12)	3.80 (2.07)	3.90 (2.12)	3.97 (2.12)	4.07 (2.13)
S.E. $\pm$	0.14	0.03	0.03	0.03	0.04
C.D. at 5%	N.S.	0.10	0.09	0.09	0.11
C.V. (%)	2.81	3.92	3.53	3.38	4.35

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

Treatments	Mean number of jassids per leaf				
	1 day before treatment	Days after treatment			
		1	3	7	14
Fenpropathrin 0.01 per cent	2.09 (1.60)*	1.32 (1.35)	1.37 (1.36)	1.57 (1.44)	1.90 (1.55)
Indoxacarb 0.005 per cent	2.11 (1.62)	0.82 (1.14)	0.97 (1.21)	1.30 (1.34)	1.67 (1.48)
Imidacloprid 0.003 per cent	1.93 (1.56)	0.31 (0.90)	0.53 (1.01)	0.83 (1.16)	1.22 (1.32)
Spinosad 0.007 per cent	2.00 (1.58)	0.47 (0.98)	0.74 (1.12)	1.03 (1.23)	1.51 (1.42)
Flubendiamide 0.007 per cent	2.44 (1.71)	1.07 (1.25)	1.27 (1.33)	1.67 (1.47)	2.07 (1.61)
Emamectin benzoate 0.002 per cent	2.07 (1.61)	1.02 (1.23)	1.27 (1.33)	1.62 (1.46)	1.98 (1.57)
Chlorantraniliprole 0.005 per cent	2.00 (1.59)	0.93 (1.19)	1.17 (1.29)	1.47 (1.40)	1.87 (1.53)
Untreated Control	4.13 (2.15)	4.20 (2.17)	4.47 (2.23)	4.73 (2.28)	5.07 (2.36)
S.E. $\pm$	0.08	0.02	0.03	0.03	0.03
C.D. at 5%	N.S.	0.07	0.08	0.10	0.10
C.V. (%)	2.57	3.37	3.18	3.71	3.63

*Figures in parentheses are square root transformed values (x + 0.5)

N.S.- Non significant

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

Insecticides	Corrected percentage mortality after different intervals (days)				P		PT	R.E.	O.R.E.
	1	3	7	14					
Fenpropathrin 0.01 per cent	75.00	51.72	39.28	14.28	45.07	14	630.98	1.16	5
Indoxacarb 0.05 per cent	82.14	62.07	46.43	17.85	52.12	14	729.71	1.34	3
Imidacloprid 0.003 per cent	89.29	65.52	49.99	25.00	57.42	14	804.3	1.48	1
Spinosad 0.007 per cent	85.72	65.52	46.43	21.43	54.77	14	766.85	1.41	2
Flubendiamide 0.007 per cent	67.86	44.83	35.71	07.13	38.88	14	544.35	1.00	7
Emamectin benzoate 0.002 per cent	71.42	48.28	39.28	10.71	42.42	14	593.91	1.09	6
Chlorantraniliprole 0.005per cent	78.57	58.62	42.86	17.85	49.47	14	692.65	1.27	4

Table 4: Relative efficacy of different insecticides against jassids 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 0.01per cent	2	0.167	$y = -0.0769 - 1.2686x$	0.5419±0.1766	3.84	0.62 11.58	1.50	5
Indoxacarb 0.05 per cent	2	0.330	$y = 0.0561 - 1.4656x$	0.6764±0.1544	4.74	1.91 15.60	1.85	3
Imidacloprid 0.003 per cent	2	0.237	$y = 0.1022 - 1.6399x$	0.7600±0.1438	5.75	2.80 18.12	2.25	1
Spinosad 0.007 per cent	2	0.124	$y = 0.0852 - 1.5362x$	0.7293±0.1504	5.36	2.41 18.10	2.09	2
Flubendiamide 0.007 per cent	2	0.258	$y = -0.1818 - 1.1721x$	0.4083±0.2044	2.56	0.04 7.48	1.00	7
Emamectin benzoate 0.002 per cent	2	0.371	$y = -0.1197 - 1.2359x$	0.4785±0.1858	3.00	0.29 9.10	1.17	6
Chlorantraniliprole 0.005 per cent	2	0.229	$y = -0.0042 - 1.3688x$	0.6223±0.1630	4.19	1.34 14.20	1.64	4

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

Insecticides	Corrected percentage mortality after different intervals (days)				P		PT	R.E.	O.R.E.
	1	3	7	14					
Fenpropathrin 0.01 per cent	78.57	49.99	44.83	14.28	46.92	14	656.84	1.15	5
Indoxacarb 0.05 per cent	85.71	60.71	48.28	21.43	54.03	14	756.45	1.33	3
Imidacloprid 0.003 per cent	92.85	64.29	55.18	28.56	60.22	14	843.08	1.48	1
Spinosad 0.007 per cent	89.29	64.29	51.72	25.00	57.57	14	806.05	1.41	2
Flubendiamide 0.007 per cent	71.42	42.86	37.93	10.71	40.73	14	570.22	1.00	7
Emamectin benzoate 0.002 per cent	75.00	46.43	41.38	14.28	44.27	14	619.78	1.09	6
Chlorantraniliprole 0.005per cent	82.14	54.14	44.83	17.85	50.49	14	706.86	1.24	4

Table 6: Relative efficacy of different insecticides against jassids 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	0.186	$y = -0.0691 - 1.3663x$	0.5660±0.1646	3.68	0.98 10.98	1.29	5
Indoxacarb 0.05 per cent	2	0.280	$y = 0.0544 - 1.5895x$	0.6928±0.1446	4.93	2.21 14.18	1.72	3
Imidacloprid 0.003 per cent	2	0.293	$y = 0.0827 - 1.7952x$	0.7715±0.1337	5.91	3.06 16.13	2.07	1
Spinosad 0.007 per cent	2	0.104	$y = 0.0752 - 1.6714x$	0.7425±0.1406	5.53	2.69 16.08	1.93	2
Flubendiamide 0.007 per cent	2	0.469	$y = -0.1452 - 1.2215x$	0.4569±0.1904	2.86	0.19 8.49	1.00	7
Emamectin benzoate 0.002 per cent	2	0.372	$y = -0.1072 - 1.3317x$	0.5070±0.1716	3.21	0.61 8.96	1.12	6
Chlorantraniliprole 0.005 per cent	2	0.192	$y = 0.0080 - 1.4766x$	0.6414±0.1529	4.38	1.67 13.08	1.53	4

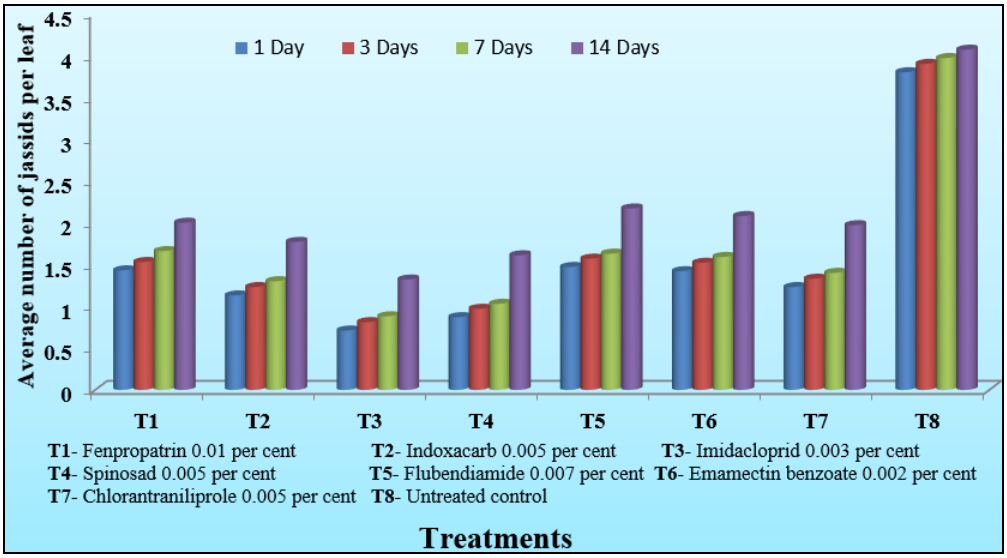

Fig 1: Effect of different insecticides on the population of sunflower jassid (first spray)

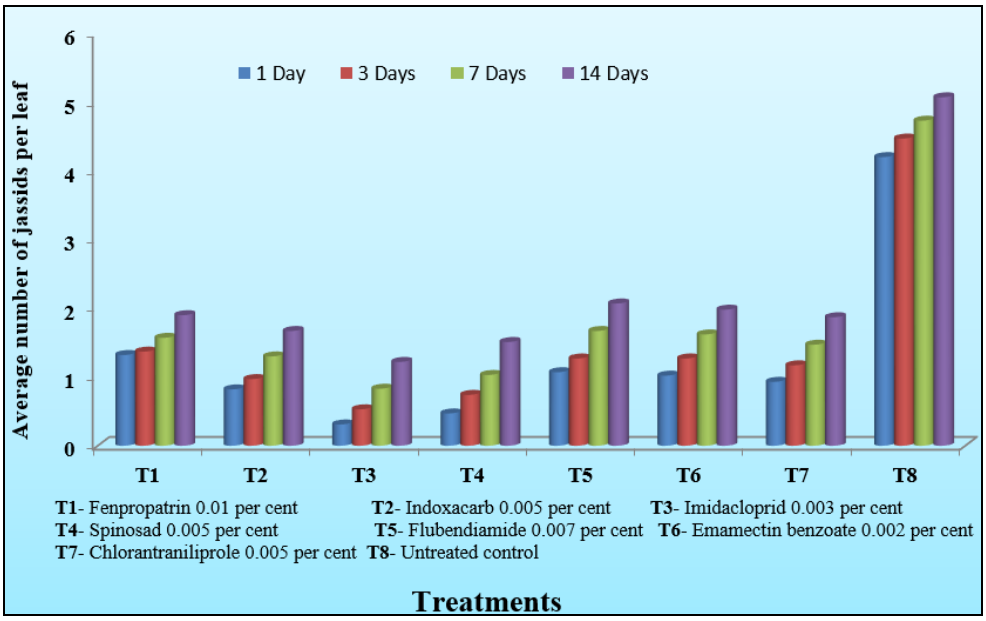

Fig 2: Effect of different insecticides on the population of sunflower jassid (second spray)

These results are parallel to the findings of Preetha *et al.* (2009) [12] who documented that higher dose of imidacloprid showed longest persistence up to 29 days for *Amrasca biguttula biguttula* on bhendi crop. Whereas, Shinde and Shetgar (2010) [14] evidenced highest PT values (431.5 and 367.3) and LT_{50} values (2.73 and 1.67 days) in imidacloprid 0.004 per cent against first and third instars nymphs of *A. biguttula biguttula*, respectively. Amongst various neonicotinoids, imidacloprid showed 90 per cent and 93 per cent reduction of jassid population at one day and eight days after application (Venkanna *et al.*, 2010) [16]. According to Ghadage *et al.* (2012) [9] imidacloprid 0.005 per cent proved effective and gave 80.79 to 90.01 per cent jassid mortality. Similarly, imidacloprid 17.8 per cent SL registered 46.67, 80.00, 97.33 and 100.00 per cent nymphal mortality of *A. biguttula biguttula* at 24, 48, 72 and 96 hours after treatment, respectively (Shreevani *et al.*, 2012) [15]. While, Bharati (2013) [5] reported highest persistent toxicity in imidacloprid 0.004 per cent against jassids in terms of PT values 934.50 and 940.84 and; LT_{50} values 7.92 and 7.91 days after first and second spray, respectively. According to Kolhe (2014) [11] highest persistent toxicity in terms of PT values (1459.63, 1431.49 and 1382.47, 1283.94) and highest LT_{50} values (9.26, 8.77 and 6.83, 9.73 days) were observed due to the application of imidacloprid 0.003 per cent against nymphs and adults of *E. kerri* after first and second sprays. Thus the present findings are in line with these 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) [10] 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.

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