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To evaluate the bio-efficacy of different modern insecticides and biopesticides against aphids on French bean

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Abstract
The present investigation entitled Studies on major insect pests of french bean (*Phaseolus vulgaris* L.) and bio-efficacy evaluation of newer insecticides was carried out at Research cum Instructional Farm, Raipur, Under College of Agriculture Raipur(C.G.) during Rabi 2022-23.The results of the experiment revealed that lowest percentage of Aphid population 12.84% was recorded from the (T_4) treatments of Sulfoxaflor 12% SC @ 33.75 g a.i./ha in 1 to 15 days after spraying which was found to be at par with other three doses of Sulfoxaflor 12% SC @ 21, 24, 27 g a.i./ha respectively against the Aphid the Sulfoxaflor 12% SC with 33.75 g a.i./ha was found most effective against Aphid as it was recorded lowest pest population (2.84 Aphid/plant) and *Lecanicillium lecanii* 10% 1x108 CFU declared least effective among all treatments.

Keywords: Aphid, Sulfoxaflor, *Lecanicillium lecanii*, CFU

Introduction
The French bean (*Phaseolus vulgaris* L.) is an annual, diploid (2n=2x=22), herbaceous plant belonging to the Fabaceae family and the Phaseolus genus. Common bean (*Phaseolus vulgaris* L.; Fabaceae) is a legume of importance, and it is also known as French bean, kidney bean, snap bean, runner bean and string bean (Onder *et al.*, 2006) [6]. Today, the common bean is considered one of the most important legumes globally. In India, dry seed varieties are commonly referred to as "French beans." The yield losses due to insect pests alone have been estimated to the tune of 35 to 100%.

Both biotic and abiotic factors impact crop production. French beans are affected by around 30 insect pests, including common sucking pests such as aphids (*Aphis craccivora*), leafhoppers (*Empoasca dolichi*), thrips (*Megalurothrips sjostedti*), whiteflies (*Bemisia tabaci*), and mites (*Tetranychus urticae*) (Srivastava and Butani, 1998) [8].

Leguminous plant species are susceptible to many biotic stresses, including attacks by many different insect pests and diseases. Pest and disease problems are the major constraints to agricultural productivity of the common bean, particularly in the tropics (Graham and Vance, 2003) [2]. Worldwide, yield losses due to insect pests alone have been estimated to the tune of 35% to 100% annually (Singh and Schwartz, 2011) [7]. The pods are also rich in minerals and vitamins. Additionally, French beans have medicinal benefits, such as helping control diabetes, heart problems, and bladder issues. They also have properties that can help with constipation and diarrhea.

Materials and Methods
Efficacy of botanical and chemical insecticides were evaluated against insect pests of French bean at Research cum Instructional Farm, College of Agriculture Raipur, Chhattisgarh during Rabi 2022-23 with Randomized Block Design (RBD).

Particulars		Details
Season	:	*Rabi*-2022
Crop	:	French bean
Name of variety	:	Falguni bean
Design	:	Randomized Block Design
Plot size	:	3×2.2 m^2 (6.6 m^2)
Plant Spacing	:	50 x 40 cm
Number of Treatments	:	8
Replication	:	3
Date of sowing	:	11/11/2022
1st spray	:	13/01/2023
2nd spray	:	29/01/2023

Treatment details

The experiment was conducted in a randomized block design with 3 replications.

The experiment consists of 8 different treatments.

Treatment	Name of Treatment	Dose (G a.i./ha)	Formulation (ml or g/ha)
T_1	Sulfoxaflor 12% SC w/v	21	175
T_2	Sulfoxaflor 12% SC w/v	24	200
T_3	Sulfoxaflor 12% SC w/v	27	225
T_4	Sulfoxaflor 12% SC w/v	33.75	285
T_5	Chlorpyrifos 20 EC	200	1000
T_6	Imidacloprid 17.8% SL	25.0	125
T_7	*Lecanicillium lecanii*	10% (1x10^8) CFU/ml	10 ml
T_8	Untreated Control	-	-

Preparation of pesticide solution

The insecticides and biopesticides of the required concentration were prepared in water and sprayed after the proper stirring of the solution. The knapsack sprayer fitted with a flat cone nozzle was used to spray the material.

The insecticidal solution was prepared using the following formula:

Formula = C1V1 = C2V2

Where,

C1 = Concentration of given formulation (%)

V1 = Volume/amount of formulation required (ml or g)

C2 = Concentration of spray fluid required (%)

V2 = Volume/amount of spray fluid required.

Method of application of insecticides

Treatment wise applications of insecticides were given after the appearance of the pests by using high volume sprayer with required concentration. The subsequent second spray was made after 15 days of first spray.

Spray schedule of insecticidal solution

All the insecticides were applied as foliar spray in morning or evening hours on the crop using pre-calibrated knapsack sprayer when the pest population built up sufficiently on 13th January, 2023 and second was repeated after 15th days of the first spray when pest populations again built up. An untreated check was maintained for comparison.

Observation methods

The data on population of french bean aphid *A. craccivora* three shoots were observed on each selected plant and the population of aphids was counted from 10 cm length of each shoot. The pre-treatment observation was recorded at one day before 1st spray and post treatment observations were recorded at 1, 3, 7, 10 and 14th days after each spray.

Interpretation of data

The data obtained just before treatment and one, three, seven, ten and fourteen days after the spray were taken into consideration to find out the percent reduction in the population which was determined using the Henderson and Tilton (1955) [5] equation:

$$\text{Percent reduction in pest populatio} = 1 - \frac{\text{Ta x Cb}}{\text{Tb x Ca}} X100$$

Where,

Ta = Population in treated plots after treatment

Tb = Population in treated plots before treatment

Ca = Population in untreated plots after treatment

Cb = Population in untreated plots before treatment.

Statistical analysis

The data obtained were analysed statistically after using appropriate transformation. Square-root transformation is appropriate for data consisting of small whole numbers, for example, data obtained in counting rare events, such as the number of infested plants in a plot, the number of insects caught in traps, or the number of weeds per plot. The square-root transformation is also appropriate for percentage data where the range is between 0 and 30% or between 70 and 100%. For other ranges of percentage data use the arc sine transformation. If most of the values in the data set are small (e.g., less than 10), especially with zeroes present, √(X + 0.5)/1/2 should be used instead of X1/2, where X is the original data. All percentage data of experiments were processed under square-root transformation before statistical analysis.

This transformed data was then analyzed by the method of analysis of variance. The "F" test was used at 5 percent level of significance. Critical difference (CD) values were analysed at 5 percent level of significance (Gomez and Gomez, 1984; Draper and Smith, 1998) [4, 1]. CD = SEd (Standard error of deviation) x Table t-value at 5% of significance.

Result and Discussion

A) Efficacy of insecticide and biopesticides against Aphid: first spray

On evaluation of the bio-efficacy of different modern insecticide and biopesticides against aphids on french bean revealed that the pre-treatments observations were non-significant to each other with incidence ranged from 12.11 to 19.82 percent during Rabi 2022-23. After first spray, at 1 days the lowest infestation (2.95%) of Aphid was recorded in T_5-Chlorpyrifos 20 EC @ 200 g a.i./ha (2.95%). followed by T_4-Sulfoxaflor 12% SC @ 33.75 g a.i./ha (2.98%)., T_3-Sulfoxaflor 12% SC @ 27 g a.i/ha (3.04%), T_2-Sulfoxaflor 12% SC @ 24 g a.i./ha (3.10%). T_1-Sulfoxaflor 12% SC @ 21 g a.i./ha (3.17%), and T_6 Imidacloprid @ 25.00 g a.i./ha (5.40%) The least effective treatment was T_7-*Lecanicillium lecanii* @ 10% (1x108) CFU/ml (10.55%) percent infestation of aphids but it was significantly superior over untreated control recorded 18.30 percent Aphids/plant.

After 3 days of first spray, different chemical insecticides and biopesticides were significantly superior to untreated control. Among the different treatments, lowest (3.08%)

aphids were found in T_3-Sulfoxaflor 12% SC @ 27 g a.i./ha which was significantly superior over untreated control with 24.70 percent infestation followed by T_4-Sulfoxaflor 12% SC @ 33.75 g a.i./ha (3.22%), T_2-Sulfoxaflor 12% SC @ 24 g a.i./ha (3.26%), T_1-Sulfoxaflor 12% SC @ 21 g a.i./ha (3.37%), T_5-Chlorpyrifos 20 EC @ 200 g a.i./ha. (3.40%), T_6 Imidacloprid @ 25.00 g a.i./ha (5.88%) and the least effective treatment was T_7-*Lecanicillium lecanii* @ 10% (1x108) CFU/ml (8.08%) which was significantly superior over untreated control with 20.84 percent infestation.

After 7 days of first spray, different chemical insecticides and biopesticides were significantly superior to untreated control. Among the treatments, lowest (3.02%%) aphids were found in T_4-Sulfoxaflor 12% SC @ 33.75 g a.i./ha (3.02%), which was significantly superior over untreated control with 23.79 percent infestation followed by T_3-Sulfoxaflor 12% SC @ 27 g a.i./ha (3.18%), T_2-Sulfoxaflor 12% SC @ 24 g a.i./ha (3.39%), T_1-Sulfoxaflor 12% SC @ 21 g a.i./ha (3.54%), T_5-Chlorpyrifos 20 EC @ 200 g a.i./ha. (4.78%), T_6 Imidacloprid @ 25.00 g a.i./ha (6.50%) and the least effective treatment was T_7-*Lecanicillium lecanii* @ 10% (1x108) CFU/ml (6.68%).

After 10 days of first spray, different chemical insecticides and biopesticides were significantly superior to untreated control. Among the treatments, lowest (3.66%) aphids were found in T_4-Sulfoxaflor 12% SC @ 33.75 g a.i./ha (3.66%), which was significantly superior over untreated control with 24.15 percent infestation followed by T_3-Sulfoxaflor 12% SC @ 27 g a.i./ha (4.19%), T_2-Sulfoxaflor 12% SC @ 24 g a.i./ha (4.41%), T_1-Sulfoxaflor 12% SC @ 21 g a.i./ha (4.74%), T_5-Chlorpyrifos 20 EC @ 200 g a.i./ha. (5.72%), T_6 Imidacloprid @ 25.00 g a.i./ha (6.96%) and the least effective treatment was T_7-*Lecanicillium lecanii* @ 10% (1x108) CFU/ml (8.35%).

After 14 days of first spray, different chemical insecticides and biopesticides were significantly superior to untreated control. Among the treatments, lowest (4.02%) aphids were found in T_4-Sulfoxaflor 12% SC @ 33.75 g a.i./ha (4.02%), which was significantly superior over untreated control with 26.73 percent infestation followed by T_3-Sulfoxaflor 12% SC @ 27 g a.i./ha (4.91%), T_2-Sulfoxaflor 12% SC @ 24 g a.i./ha (5.52%), T_5-Chlorpyrifos 20 EC @ 200 g a.i./ha. (6.06%), T_1-Sulfoxaflor 12% SC @ 21 g a.i./ha (6.73%), T_6 Imidacloprid @ 25.00 g a.i./ha (7.70%) and the least effective treatment was T_7-*Lecanicillium lecanii* @ 10% (1x108) CFU/ml (9.01%).

B) Efficacy of insecticide and biopesticides against Aphid: Second spray

On evaluation of the bio-efficacy of different modern insecticide and biopesticides against aphid on french bean revealed that after second spray, at 1 days T_5-Chlorpyrifos 20 EC @ 200 g a.i./ha. (2.02%) was most effective with 2.02 percent infestation which was significantly superior over untreated control with 19.42 percent infestation, followed by T_3-Sulfoxaflor 12% SC @ 27 g a.i./ha (2.16%), T_2-Sulfoxaflor 12% SC @ 24 g a.i./ha (2.22%), T_1-Sulfoxaflor 12% SC @ 21 g a.i./ha (2.36%), T_4-Sulfoxaflor 12% SC @ 33.75 g a.i./ha (2.75%), T_6 Imidacloprid @ 25.00 g a.i./ha (3.40%) and the least effective treatment was T_7-*Lecanicillium lecanii* @ 10% (1x108) CFU/ml (8.42%).

After 3 days of second spray, different chemical insecticides and biopesticides were significantly superior to untreated control. Among the treatments, lowest (3.08%) aphids were found in T_3-Sulfoxaflor 12% SC @ 27 g a.i./ha which was significantly superior over untreated control with 24.70 percent infestation followed by T_4-Sulfoxaflor 12% SC @ 33.75 g a.i./ha (3.22%), T_2-Sulfoxaflor 12% SC @ 24 g a.i./ha (3.26%), T_1-Sulfoxaflor 12% SC @ 21 g a.i./ha (3.37%), T_5-Chlorpyrifos 20 EC @ 200 g a.i./ha. (3.40%), T_6 Imidacloprid @ 25.00 g a.i./ha (5.88%) and the least effective treatment was T_7-*Lecanicillium lecanii* @ 10% (1x108) CFU/ml (8.08%) which was significantly superior over untreated control with 20.84 percent infestation.

After 7 days of second spray, different chemical insecticides and biopesticides were significantly superior to untreated control. Among the treatments, lowest (2.56%) aphids were found in T_4-Sulfoxaflor 12% SC @ 33.75 g a.i./ha (2.56%) which was significantly superior over untreated control with 23.67 percent infestation followed by T_3-Sulfoxaflor 12% SC @ 27 g a.i./ha (2.85), T_2-Sulfoxaflor 12% SC @ 24 g a.i./ha (3.17%), T_1-Sulfoxaflor 12% SC @ 21 g a.i./ha (3.88%), T_5-Chlorpyrifos 20 EC @ 200 g a.i./ha. (4.42%), T_6 Imidacloprid @ 25.00 g a.i./ha (5.60%) and the least effective treatment was T_7-*Lecanicillium lecanii* @ 10% (1x108) CFU/ml (6.97%) which was significantly superior over untreated control with 23.67 percent infestation.

After 10 days of second spray, different chemical insecticides and biopesticides were significantly superior to untreated control. Among the treatments, lowest (1.85%) aphids were found in T_4-Sulfoxaflor 12% SC @ 33.75 g a.i./ha (1.84%) which was significantly superior over untreated control with 24.79 percent infestation followed by T_3-Sulfoxaflor 12% SC @ 27 g a.i./ha (3.42%), T_2-Sulfoxaflor 12% SC @ 24 g a.i./ha (3.78%), T_1-Sulfoxaflor 12% SC @ 21 g a.i./ha (3.89%), T_6 Imidacloprid @ 25.00 g a.i./ha (5.70%), T_5-Chlorpyrifos 20 EC @ 200 g a.i./ha. (5.78%), and the least effective treatment was T_7-*Lecanicillium lecanii* @ 10% (1x108) CFU/ml (7.10%) which was significantly superior over untreated control with 24.79 percent infestation.

After 14 days of second spray, different chemical insecticides and biopesticides were significantly superior to untreated control. Among the treatments, lowest (2.15%) aphids were found in T_4-Sulfoxaflor 12% SC @ 33.75 g a.i./ha (2.15%) which was significantly superior over untreated control with 20.30 percent infestation followed by T_3-Sulfoxaflor 12% SC @ 27 g a.i./ha (3.94), T_2-Sulfoxaflor12% SC @ 24 g a.i./ha (4.57%), T_1-Sulfoxaflor 12% SC @ 21 g a.i./ha (5.43%), T_5-Chlorpyrifos 20 EC @ 200 g a.i./ha. (5.95%), T_6 Imidacloprid @ 25.00 g a.i./ha (6.28%) and the least effective treatment was T_7-*Lecanicillium lecanii* @ 10% (1x108) CFU/ml (7.32%) which was significantly superior over untreated control with 20.30 percent infestation.

Table 1: Population of aphids per plant at different days after spray (DAS) during pre and post treatment

S. No.	Treatments	Dose g a.i./ha	PTO	Average no. of aphids/plant											Over all mean
				I spray					II spray						
				1 DAS	3 DAS	7 DAS	10 DAS	14 DAS	PTO	1 DAS	3 DAS	7 DAS	10 DAS	14 DAS	
T_1	Sulfoxaflor 12% SC	21	14.32 (2.40)	3.17 (2.04)	3.37 (2.09)	3.54 (2.12)	4.74 (2.39)	6.73 (2.78)	7.46 (3.72)	2.36 (1.18)	2.57 (1.88)	3.88 (2.11)	3.89 (2.53)	5.43 (2.53)	3.92
T_2	Sulfoxaflor 12% SC	24	16.24 (2.51)	3.10 (2.02)	3.26 (2.06)	3.39 (2.09)	4.41 (2.32)	5.52 (2.55)	6.83 (2.60)	2.22 (1.79)	2.37 (1.83)	3.17 (2.04)	3.78 (2.36)	4.57 (2.36)	3.57
T_3	Sulfoxaflor 12% SC	27	15.88 (2.48)	3.04 (2.01)	3.08 (2.02)	3.18 (2.04)	4.19 (2.32)	4.91 (2.43)	5.63 (2.36)	2.16 (1.77)	2.21 (1.79)	2.85 (1.96)	3.42 (2.22)	3.94 (2.22)	3.29
T_4	Sulfoxaflor 12% SC	33.75	13.08 (2.27)	2.98 (1.99)	3.22 (2.05)	3.02 (2.0)	3.66 (2.1)	4.02 (2.2)	5.53 (2.34)	2.75 (1.9)	2.22 (1.7)	2.56 (1.88)	1.85 (1.68)	2.15 (1.77)	2.84
T_5	Chlorpyrifos 20 EC	200	16.52 (2.53)	2.95 (1.98)	3.40 (2.09)	4.78 (2.40)	5.72 (2.59)	6.06 (2.66)	6.23 (2.49)	2.02 (1.73)	3.31 (2.08)	4.42 (2.32)	5.78 (2.63)	5.95 (2.63)	4.43
T_6	Imidacloprid	25.00	19.82 (2.68)	5.40 (2.49)	5.88 (2.62)	6.50 (2.73)	6.96 (2.82)	7.70 (2.94)	7.93 (2.80)	3.40 (2.09)	4.57 (2.36)	5.60 (2.56)	5.70 (2.69)	6.28 (2.69)	5.79
T_7	*Lecanicillium lecanii*	10% (1×10^8) CFU/ml	12.11 (2.24)	10.55 (3.38)	8.08 (2.92	6.68 (2.66)	8.35 (2.97)	9.01 (3.06)	9.63 (3.10)	8,15 (3.26)	7.95 (3.38)	6.97 (2.73)	7.10 (2.75)	7.32 (2.79)	8.01
T_8	Untreated control	-	18.17 (2.62)	18.30 (1.00)	20.84 (4.67)	23.79 (4.97)	24.15 (5.01)	26.73 (5.26)	23.79 (4.97)	19.42 (5.57)	19.53 (4.55)	23.67 (4.96)	24.79 (4.61)	20.30 (4.61)	22.15
Sem (±)			**0.263**	**0.212**	**0.266**	**0.203**	**0.992**	**0.349**	**0.231**	**0.212**	**1.215**	**1.085**	**0.176**	**0.176**	
CD at 5%			NS	**0.649**	**0.815**	**0.620**	**3.038**	**1.070**	NS	**0.649**	**3.324**	**3.324**	**0.540**	**0.540**	

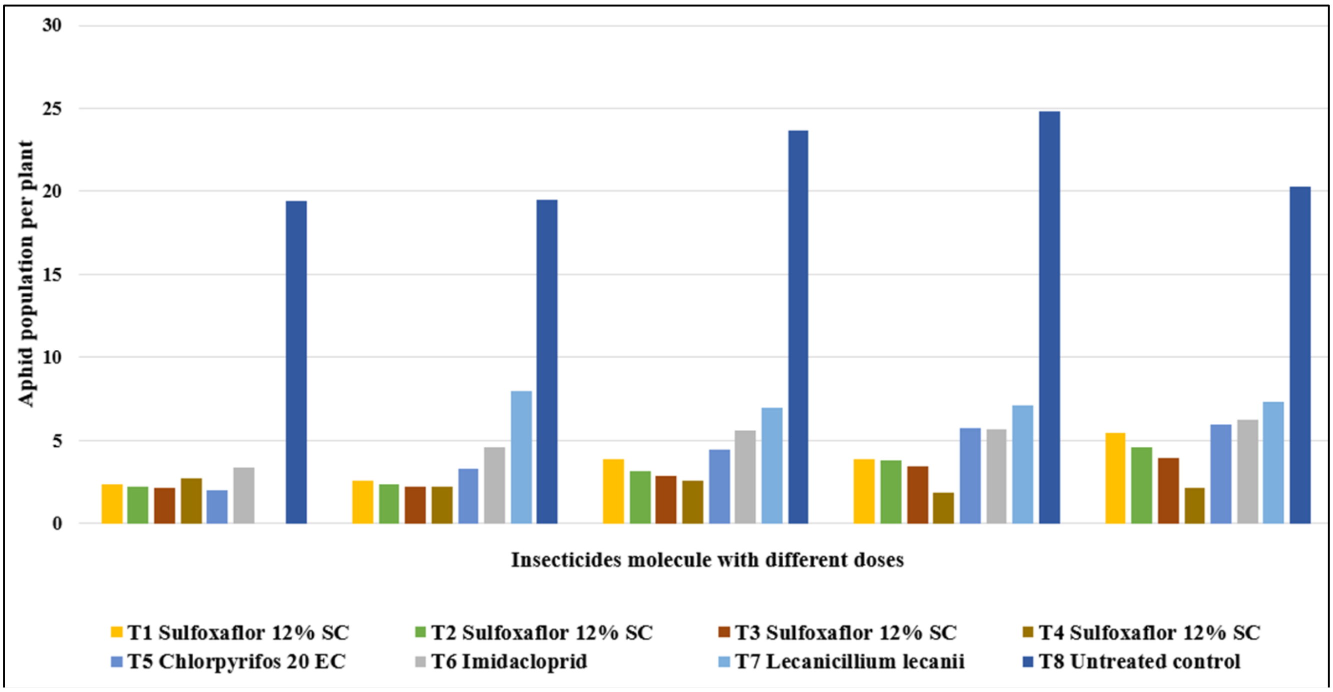

Fig 1: Population of aphid/plant at different days after spray (DAS) during 1st spray of insecticides.

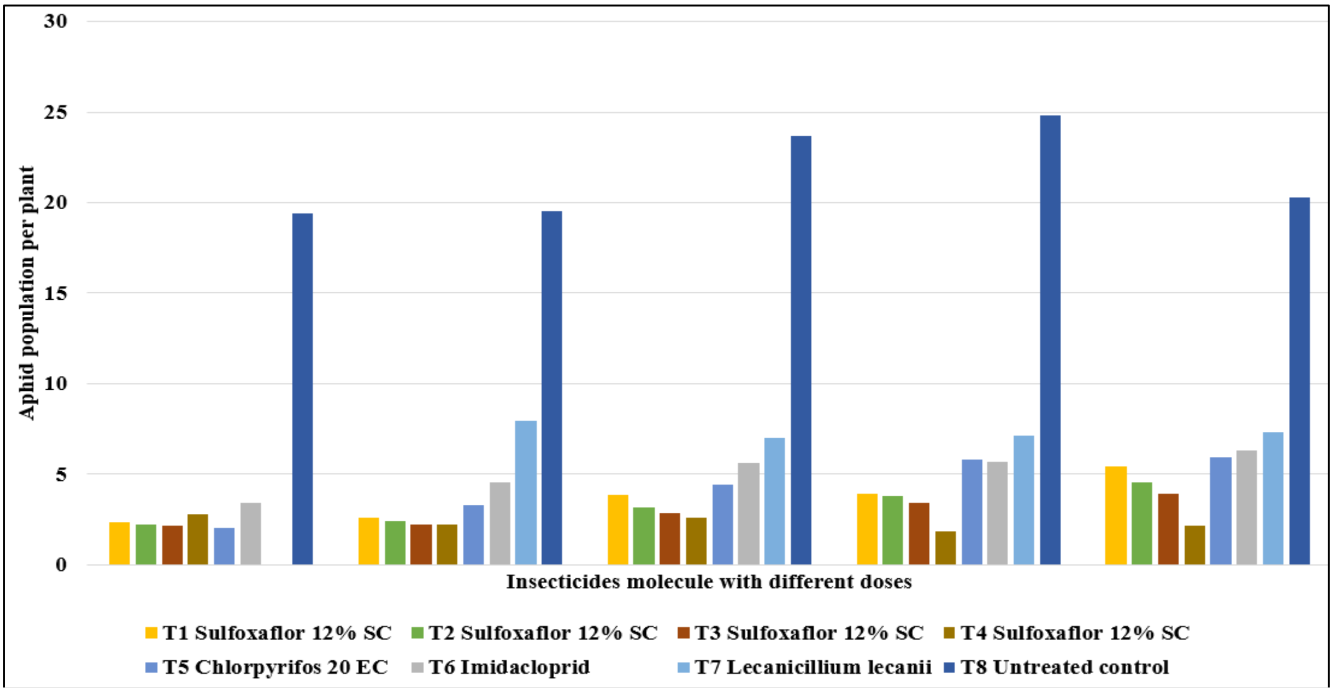

Fig 2: Population of aphid/plant at different days after spray (DAS) during 2nd spray of insecticide

Conclusion

The experimental findings showed that the Sulfoxaflor 12% SC with 33.75 g a.i./ha was found most effective against Aphid as it was recorded lowest pest population (2.84 Aphid/plant) and least damage along with maximum grain yield (34.58 q/ha). The second-best treatment was Sulfoxaflor 12% SC (27 g a.i./ha) with (32.42 q/ha) grain yield followed by Sulfoxaflor 12% SC (24 g a.i./ha) Sulfoxaflor 12% SC (21 g a.i./ha), Chlorpyrifos 20 EC (200 g a.i./ha) Imidacloprid (25.00 g a.i./ha) and *Lecanicillium lecanii* 10% 1x10^8 CFU declared least effective among all treatments.

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