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Bio-efficacy of different insecticides against leafhopper (*Amrasca biguttula biguttula)* on sunflower

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Abstract
The present field experiment were conducted to evaluate “Bio-efficacy of different insecticides against leafhopper (*Amrasca biguttula biguttula)* on sunflower” under field condition during *rabi* season of 2017 at research farm of Oilseed Research Station, Latur, Maharashtra, India. The observations on total number of leafhoppers were recorded on top, middle and bottom leaves of five randomly selected plants from each treatment at one day before and 1, 3, 7, 10 and 14 days after first and second application of insecticides. The treatments of different insecticides *viz.*, thiamethoxam 0.005 per cent, imidacloprid 0.00356 per cent, spiromesifen 0.02748 per cent, flonicamide 0.02 per cent, profenophos 0.1 per cent and triazophos 0.08 per cent were evaluated against leafhopper, *Amrasca biguttula biguttula* revealed that imidacloprid 0.00356 per cent was found most effective treatment in reducing the population of leafhopper (1.07 and 0.73 leafhoppers per 6 leaves) followed by thiamethoxam 0.005 per cent. Significantly higher seed yield (2450 kg/ha) of sunflower was recorded in treatment imidacloprid 0.00356 per cent however, it was found at par with treatment thiamethoxam 0.005 per cent (2264 kg/ha). The highest ICBR (1:20.42) was recorded with treatment imidacloprid which was followed by thiamethoxam 0.02 per cent (1:17.32).

Keywords: Bio-efficacy, different insecticides, leafhopper

Introduction
Sunflower (*Helianthus annuus* L.) is annual flowering plant belongs to family compositae with chromosome number 2n=34. It is native to Mexico and Peru, introduced into India in 16th century. Sunflower is one of the important oilseed crops. Sunflower contains 32 to 44 per cent oil, 20 to 24 per cent vitamins, 18 to 22 per cent carbohydrates and 4 to 6 per cent salts. Sunflower oil is a rich source of linoleic acid (64 per cent) and considered as finest oil which helps in cleaning of cholesterol deposition in the coronary arteries of heart and thus good for heart patients (Dake, 2015) [6]. As many as 251 insects and acarine species have been recorded on sunflower at global level (Rajamohan, 1976) [12]. In India, more than fifty insect species have been found to damage the crop at different stages of the crop growth. Among them, nine are major insect pests and remaining are of minor importance and are capable of causing considerable damage to the crop if the conditions are favorable (Basappa, 1995) [3]. Infestation of sucking insect-pests is becoming a major concern in obtaining expected yield from sunflower crop because, their incidence start from seedling stage and prevail through the entire plant life. Leafhopper (*A. biguttula biguttula*) (Homoptera: Cicadellidae) is the important sucking pest of sunflower in India. Both nymph and adults suck the plant sap from under surface of leaves and cause stunted growth of plant, yellowing, burning of leaf margins, cupped and crinkled leaves. In case of severe infestation, characteristic ‘hopper burn’ symptoms are noticed. Leafhoppers cause crop loss up to 46 per cent.
Several insecticides have been used for the management of sunflower leafhopper. But according to several findings many of these insecticides could not gave effective results. Hence, these insecticides along with some new insecticides need to be re-evaluated against sunflower insect-pests for effective management.

Materials and Methods
The studies on “Bio-efficacy of different insecticides against leafhopper (*Amrasca biguttula biguttula)* on sunflower” were conducted during *Rabi* season 2017 at Oilseed Research Station, Latur, Maharashtra, India. The experiment was conducted in a randomized block

design (RBD) with seven treatments including untreated control with three replications. Sunflower crop was sown on 20 November, 2017 in a gross plot of 4.8 m x 4.2 m maintaining net plot of 4.2 m x 3.9 m. The row to row distance of 60 cm and plant to plant distance of 30 cm was maintained. The dose of fertilizer at the rate of 60 kg N, 30 kg P_2O_5 and 30 kg K_2O per hectare was given at the time of sowing. The crop was grown under protective irrigation. The treatments of different insecticides *viz.*, thiamethoxam 0.005 per cent, imidacloprid 0.00356 per cent, spiromesifen 0.02748 per cent, flonicamide 0.02 per cent, profenophos 0.1 per cent and triazophos 0.08 per cent were applied on appearance of sucking pests and subsequent spray were given at 15 days interval using manually operated knapsack sprayer. The observations on total number of leafhopper was recorded six leaves two from each on top, middle and bottom leaves of five randomly selected plants from each treatment at one day before treatment and 1, 3, 7, 10 and 14 days after first, second and application of insecticides.

Results and Discussion
Leafhopper (*Amrasca biguttula biguttula*)
First spray
Data pertaining to effect of different insecticides on population of leafhopper, *Amrasca biguttula biguttula* after first and second spray are presented in Table 1 and depicted in figure 1 revealed that the no significant differences were observed among various treatments before one day of the spray. All the insecticides were found significantly superior over untreated control in reducing population of sunflower leafhopper at 1, 3, 7, 10, and 14 days after first spray application

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

Tr. No.	Treatment	Concentration used (%)	Mean population of leafhopper per six leaves					
			1 day before Spraying	Days after spraying				
				1	3	7	10	14
T1	Thiamethoxam 25% WG	0.005	10.17 (3.24)*	2.20 (1.63)	2.33 (1.66)	2.47 (1.67)	2.67 (1.78)	2.80 (1.80)
T2	Imidacloprid 17.8% SL	0.00356	10.13 (3.24)	1.07 (1.22)	1.20 (1.28)	1.33 (1.33)	1.47 (1.36)	1.53 (1.40)
T3	Spiromesifen 22.9% SC	0.02748	10.07 (3.21)	4.13 (2.15)	4.27 (2.18)	4.40 (2.21)	4.53 (2.23)	4.67 (2.27)
T4	Flonicamide 50% WG	0.02	10.60 (3.30)	3.13 (1.90)	3.40 (1.97)	3.73 (2.05)	3.87 (2.09)	4.07 (2.13)
T5	Profenophos 50% EC	0.1	10.53 (3.31)	5.93 (2.54)	6.13 (2.58)	6.33 (2.61)	6.47 (2.63)	6.73 (2.69)
T6	Triazophos 40% EC	0.08	10.27 (3.28)	4.73 (2.28)	4.87 (2.31)	5.07 (2.36)	5.13 (2.37)	5.20 (2.38)
T7	Untreated Control	-	10.20 (3.30)	10.33 (3.29)	10.53 (3.23)	10.67 (3.34)	10.87 (3.36)	11.07 (3.40)
	S.E. ±		0.26	0.11	0.10	0.15	0.14	0.14
	C.D. at 5%		NS	0.34	0.32	0.45	0.42	0.41
	C.V. (%)		NS	9.03	8.24	11.55	10.72	10.30

*Figures in parentheses are square root (x + 0.5) transformed values. NS: Non significant

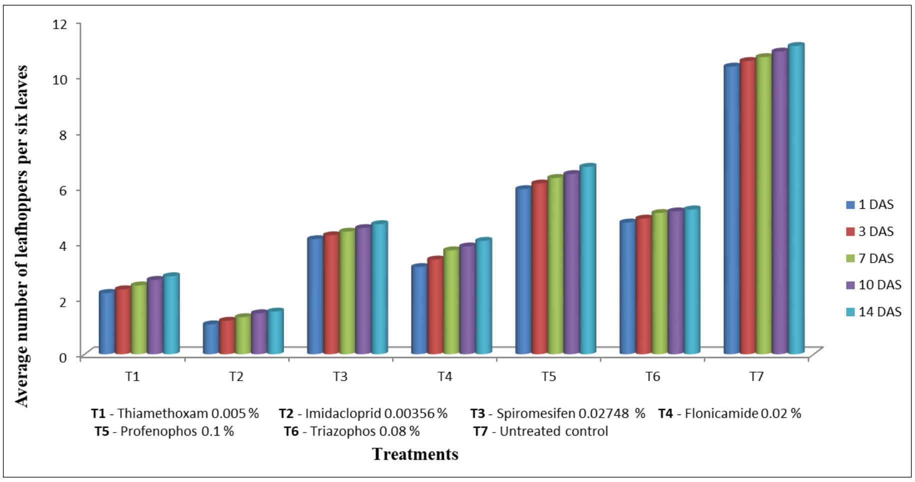

Fig 1: Effect of different insecticides on the population of sunflower leafhopper (After first spray)

At one day after first spray, significantly minimum population of leafhopper (1.07 per six leaves per plant) was recorded from the plots treated with treatment T2 i.e. imidacloprid @ 0.00356 per cent. The next effective treatment was treatment T1 i.e. thiamethoxam @ 0.005 per cent (2.20 leafhoppers per six leaves per plant) which was followed by treatment T4 i.e. flonicamide @ 0.02 per cent (3.13 leafhoppers per six leaves per plant) in reducing leafhopper population. Both these treatments were found statistically at par with each other. The subsequent order of effectiveness was treatment T3 i.e. spiromesifen @ 0.02748 per cent (4.13 leafhoppers per six leaves per plant) and treatment T6 i.e. triazophos @ 0.08 per cent (4.73 leafhoppers per six leaves per plant). The next best treatment observed was treatment T5 i.e. profenophos @ 0.1 per cent which recorded 5.93 leafhoppers per six leaves per plant. Significantly highest leafhopper population (10.33 leafhoppers per six leaves per plant) was observed in treatment T7 i.e. untreated control.

At three days after first spray, treatment T2 i.e. imidacloprid @ 0.00356 per cent recorded significantly lowest population of leafhopper to the tune of 1.20 per six leaves per plant. The next effective treatments in reducing leafhopper population were treatment T1 i.e. thiamethoxam @ 0.005 per cent (2.33 leafhoppers per six leaves per plant) followed by treatment T4 i.e. flonicamide @ 0.02 per cent (3.40 leafhoppers per six leaves per plant) and both these treatments were found statistically at par with each other. The subsequent order of effectiveness was treatment T3 i.e. spiromesifen @ 0.02748 per cent (4.27 per six leaves) and treatment T6 i.e. triazophos @ 0.08 per cent (4.87 leafhoppers per six leaves per plant). The highest leafhopper population (10.53 leafhoppers per six leaves per plant) was recorded in treatment T7 i.e. untreated control. The rest of the treatment T5 i.e. profenophos @ 0.1 per cent (6.13 leafhoppers per six leaves per plant) was intermediate.

At seven days after first spray more or less same trend was observed and the treatment T2 i.e. imidacloprid @ 0.00356 per cent observed significantly effective in minimizing leafhopper population (1.33 leafhoppers per six leaves per plant) which was followed by treatment T1 i.e. thiamethoxam @ 0.005 per cent (2.47 leafhoppers per six leaves per plant). Both these treatments were found to be statistically at par with each other. The next effective treatment was treatment T4 i.e. flonicamide @ 0.02 per cent (3.73 leafhoppers per six leaves per plant) which was followed by treatment T3 i.e. spiromesifen @ 0.02748 per cent (4.40 leafhoppers per six leaves per plant) and treatment T6 i.e. triazophos @ 0.08 per cent (5.07 leafhoppers per six leaves per plant). All these treatments were found statistically at par with each other. The next effective treatment observed was treatment T5 i.e. profenophos @ 0.1 per cent (6.33 leafhoppers per six leaves per plant) while the highest leafhopper population of 10.67 per six leaves per plant was recorded in treatment T7 i.e. untreated control.

At ten days after first spray, significantly lowest population of leafhopper was noted in treatment T2 i.e. imidacloprid @ 0.00356 per cent (1.47 leafhoppers per six leaves per plant). The next effective treatment was treatment T1 i.e. thiamethoxam @ 0.005 per cent which recorded 2.67 leafhoppers per six leaves per plant and it was found at par with treatment T4 i.e. flonicamide @ 0.02 per cent which reported 3.87 leafhoppers per six leaves per plant. Treatment T3 i.e. spiromesifen @ 0.02748 per cent, treatment T6 i.e. triazophos @ 0.08 per cent and treatment T5 i.e. profenophos @ 0.1 per cent observed to be subsequently effective insecticides with 4.53, 5.13 and 6.47 leafhoppers per six leaves per plant, respectively at ten days after first spray. Treatment T7 i.e. untreated control recorded the highest of 10.87 leafhoppers per six leaves per plant.

At 14 days after first spray, significantly lowest population of leafhoppers (1.53 leafhoppers per six leaves per plant) was recorded in the plots treated with treatment T2 i.e. imidacloprid @ 0.00356 per cent which was found at par with treatment T1 i.e. thiamethoxam @ 0.005 per cent (2.80 leafhoppers per six leaves per plant). The next effective treatments were treatment T4 i.e. flonicamide 50 WG @ 0.02 per cent, treatment T3 i.e. spiromesifen @ 0.02748 per cent and treatment T6 i.e. triazophos @ 0.08 per cent which recorded 4.07, 4.67 and 5.20 leafhoppers per six leaves per plant, respectively and found at par with each other. Among insecticidal treatments, treatment T5 i.e. profenophos @ 0.1 per cent was found least effective by recording 6.73 leafhoppers per six leaves per plant. The highest population of leafhopper (11.07 leafhoppers per six leaves per plant) was recorded in treatment T7 i.e. untreated control.

Thus, after first spray it can be concluded that the leafhopper population was decreased for only initial two days after the spray and thereafter the population slowly increased. Also, the plots treated with imidacloprid @ 0.00356 per cent recorded significantly lowest population of leafhopper on sunflower to the extent of 1.07, 1.20, 1.33, 1.47 and 1.53 per six leaves per plant, respectively at 1, 3, 7, 10 and 14 days after spraying and found effective over rest of the treatments.

Second spray

The results in respect of effect of different insecticides on population of leafhopper after second spray are presented in Table 2 and Fig. 2.

The data revealed that similar trend was observed after second spray also and all the insecticides under investigation were observed to be significantly superior over untreated control in reducing the population of leafhopper on sunflower at 1, 3, 7, 10 and 14 days after second spray.

At one day after second spray, treatment T2 i.e. imidacloprid @ 0.00356 per cent was observed as best treatment and it reported significantly minimum population of leafhoppers (0.73 leafhoppers per six leaves per plant) followed by treatment T1 i.e. thiamethoxam @ 0.005 per cent (1.67 leafhoppers per six leaves per plant). Both these treatments reported statistically at par with each other. The subsequent order of effectiveness was treatment T4 i.e. flonicamide @ 0.02 per cent (2.93 leafhoppers per six leaves per plant), treatment T3 i.e. spiromesifen @ 0.02748 per cent (3.87 leafhoppers per six leaves per plant) and treatment T6 i.e. triazophos @ 0.08 per cent (4.53 leafhoppers per six leaves per plant). All these three treatments were found at par with each other. Treatment T5 i.e. profenophos @ 0.1 per cent was found intermediate by recording 5.73 leafhoppers per six leaves per plant while the highest population of leafhopper i.e. 9.13 per six leaves per plant was observed in treatment T7 i.e. untreated control.

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

Tr. No.	Treatment	Concentration used (%)	Mean population of leafhopper per six leaves					
			1 day before Spraying	Days after spraying				
				1	3	7	10	14
T1	Thiamethoxam 25% WG	0.005	9.80 (3.19)*	1.67 (1.45)	1.80 (1.49)	1.93 (1.54)	2.13 (1.61)	2.20 (1.62)
T2	Imidacloprid 17.8% SL	0.00356	9.87 (3.20)	0.73 (1.10)	0.93 (1.18)	1.13 (1.25)	1.27 (1.31)	1.40 (1.34)
T3	Spiromesifen 22.9% SC	0.02748	9.27 (3.11)	3.87 (2.08)	4.07 (2.13)	4.13 (2.15)	4.33 (2.20)	4.47 (2.22)
T4	Flonicamide 50% WG	0.02	9.83 (3.19)	2.93 (1.84)	3.07 (1.88)	3.20 (1.91)	3.33 (1.95)	3.60 (2.01)
T5	Profenophos 50% EC	0.1	9.40 (3.14)	5.73 (2.49)	5.87 (2.52)	6.07 (2.56)	6.27 (2.60)	6.40 (2.63)
T6	Triazophos 40% EC	0.08	9.23 (3.10)	4.53 (2.23)	4.73 (2.28)	4.93 (2.33)	5.00 (2.34)	5.13 (2.37)
T7	Untreated Control	-	9.07 (3.09)	9.13 (3.10)	9.33 (3.13)	9.47 (3.16)	9.73 (3.20)	9.93 (3.23)
	S.E. ±		0.19	0.14	0.13	0.12	0.11	0.15
	C.D. at 5%		NS	0.42	0.39	0.37	0.33	0.46
	C.V. (%)		NS	11.61	10.64	9.97	8.73	12.02

*Figures in parentheses are square root (x + 0.5) transformed values. NS: Non significant

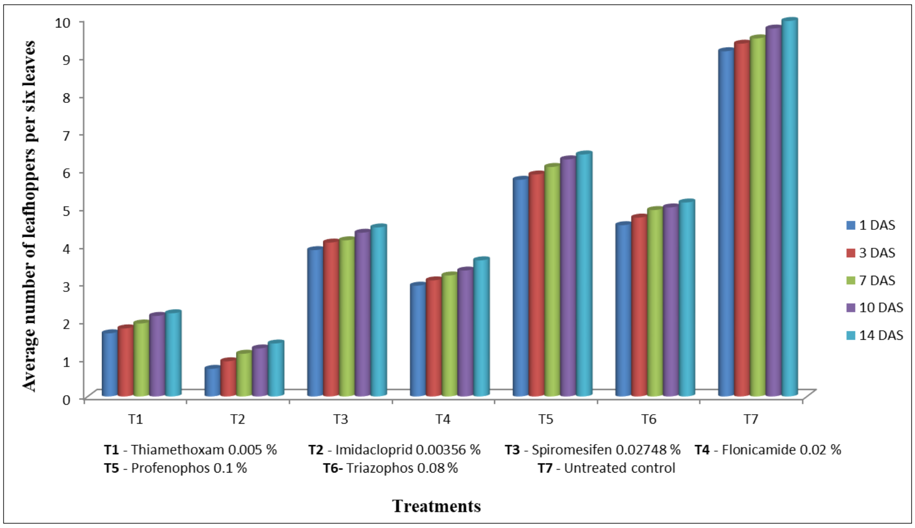

Fig 2: Effect of different insecticides on the population of sunflower leafhopper (After second spray)

From three days onwards of the second spray, the leafhoppers recorded slow gradual increase in numbers. The treatment T2 i.e. imidacloprid @ 0.00356 per cent recorded significantly lowest population of leafhopper (0.93 leafhoppers per six leaves per plant) and it was found at par with treatment T1 i.e. thiamethoxam @ 0.005 per cent which recorded 1.80 leafhoppers per six leaves per plant. The next effective treatment was treatment T4 i.e. flonicamide @ 0.02 per cent (3.07 leafhoppers per six leaves per plant) which was followed by treatment T3 i.e. spiromesifen @ 0.02748 per cent (4.07 leafhoppers per six leaves per plant). Both these treatments were found statistically at par with each other. Treatment T6 i.e. triazophos @ 0.08 per cent and treatment T5 i.e. profenophos @ 0.1 per cent observed to be subsequently effective insecticides with 4.73 and 5.87 leafhoppers per six leaves per plant, respectively at three days after second spray. Significantly highest population of leafhopper i.e. 9.33 per six leaves per plant was found in treatment T7 i.e. untreated control.

At seven days after second spray, treatment T2 i.e. imidacloprid @ 0.00356 per cent treated plot evidenced significantly lowest population of leafhoppers (1.13 per six leaves per plant) which was followed by treatment T1 i.e. thiamethoxam @ 0.005 per cent (1.93 leafhoppers per six leaves per plant) and both these treatments were found to be statistically at par with each other. The next effective treatment was treatment T4 i.e. flonicamide @ 0.02 per cent (3.20 leafhoppers per six leaves per plant) which was found at par with treatment T3 i.e. spiromesifen @ 0.02748 per cent (4.13 leafhoppers per six leaves per plant). Treatment T6 i.e. triazophos @ 0.08 per cent (4.93 leafhoppers per six leaves per plant) and treatment T5 i.e. profenophos @ 0.1 per cent (6.07 leafhoppers per six leaves per plant) were observed as next effective treatments. The highest population of leafhopper i.e. 9.47 per six leaves per plant was observed in treatment T7 i.e. untreated control.

Analogous trend was observed at ten days after second spray and significantly minimum population of leafhopper (1.27 leafhoppers per six leaves per plant) was registered from the plots treated with treatment T2 i.e. imidacloprid @ 0.00356 per cent which was found statistically at par with treatment T1 i.e. thiamethoxam @ 0.005 per cent (2.13 leafhoppers per six leaves per plant). The next effective treatment was treatment T4 flonicamide @ 0.02 per cent (3.33 leafhoppers per six leaves per plant) which was followed by treatment T3 i.e. spiromesifen @ 0.02748 per cent (4.33 leafhoppers per six leaves per plant). Both these treatments were found statistically at par with each other. Treatment T6 i.e. triazophos @ 0.08 per cent (5.00 leafhoppers per six leaves per plant) and treatment T5 i.e. profenophos @ 0.1 per cent (6.27 leafhoppers per six leaves per plant) were observed to be subsequently effective treatments at par with each other. The highest population of leafhopper (9.73 per six leaves per plant) was recorded in treatment T7 i.e. untreated control.

At 14 days after second spray the leafhopper population increased further. Significantly minimum population of leafhopper (1.40 leafhoppers per six leaves per plant) was registered from the plots treated with treatment T2 i.e. imidacloprid @ 0.00356 per cent which was followed by treatment T1 i.e. thiamethoxam @ 0.005 per cent (2.20 leafhoppers per six leaves per plant). Both these treatments were found to be statistically at par with each other. The next effective treatment was treatment T4 i.e. flonicamide @ 0.02 per cent (3.60 leafhoppers per six leaves per plant) which was followed by treatment T3 i.e. spiromesifen @ 0.02748 per cent (4.47 leafhoppers per six leaves per plant) and treatment T6 i.e. triazophos @ 0.08 per cent (5.13 leafhoppers per six leaves per plant). All these three treatments were found to be statistically at par with each other. The subsequently effective treatment was treatment T5 profenophos @ 0.1 per cent (6.40 leafhoppers per six leaves per plant). The highest population of leafhopper i.e. 9.93 per six leaves per plant was observed in treatment T7 i.e. untreated control.

Thus overall after second spray, the plots treated with imidacloprid @ 0.00356 per cent recorded significantly lowest population of leafhopper on sunflower to the extent of 0.73, 0.93, 1.13, 1.27 and 1.40 per six leaves at 1, 3, 7, 10 and 14 days after spraying, respectively over rest of the insecticides.

Earlier, the effectiveness of imidacloprid against leafhopper on sunflower was reported by (Basappa *et al*., 2004) [4] and (Santharam *et al*., 2004) [14]. The effectiveness of imidacloprid as foliar spray against leafhoppers on cotton was earlier mentioned by (Sreekanth and Reddy 2011) [17] and (Ahmed *et al*., 2014) [2]. (El-Naggar El-Hoda 2013) [8] reported that imidacloprid as foliar spray was more effective against jassids up to 14 days than the seed treatment. Thus despite the formulation, the bio-efficacy of imidacloprid against leafhoppers, as observed in the present study, was proven by these earlier workers. Imidacloprid's effectiveness against jassids on okra was also reported by (Acharya *et al*., 2002) [1], (Dey *et al*., 2005) [7], (Sinha and Sharma 2007) [16], (Gosalwad *et al*., 2008) [9], (Preetha *et al*., 2009) [10] and (Raghuraman and Birah 2011) [11]. The effectiveness of imidacloprid was also proved in vegetable crops against leafhopper by (Rana *et al*., 2016) [13]. Thus, all these earlier workers support the present finding of effectiveness of imidacloprid against leafhoppers. In present study, the next best treatment observed in management of leafhoppers was thiamethoxam 25 WG @0.005 per cent followed by flonicamide 50 WG @ 0.02 while least effective treatment found was profenophos 50 EC @ 0.1 per cent. These finding are in line with earlier work of (El-Naggar EL-Hoda 2013) [8] who found thiamethoxam seed treatment effective against leafhoppers on cotton. Also, (Bhalala *et al*., 2006) [5] found it useful against okra jassids. (Sreekanth and Reddy 2011) [17] compared neonicotinoids and conventional insecticides against sucking pests of cotton and stated that triazophos was found comparatively low effective partially supporting the findings of present study. (Shaikh *et al*., 2014) [15] found profenophos as mediocre in controlling the jassids on brinjal crop. Thus, the present finding of bio-efficacy experiment are in line with the findings of all these earlier workers.

Conclusion

The present study concluded that among the seven treatments, all the insecticide treatments were more effective than control in reducing the leafhopper, *Amrasca biguttula biguttula* and imidacloprid 0.00356 per cent was found most effective treatment for controlling leafhopper population on sunflower.

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