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Efficacy of Botanicals and Insecticides against Whitefly, *Bemisia tabaci* Gennadius (Homoptera; Aleyrodidae) in Mungbean

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ABSTRACT

Background: Mungbean is the major pulse crop of India. Pulse constitute the major source of dietary protein; therefore, it has ability to fulfil required protein recommended dietary allowance for vegetarian population of India. Pulse crop attack more than 200 insect pests.

Methods: Efficacy test of Botanicals and Insecticides *viz*., Kaner powder, Garlic extract, Azadirectin 1500 ppm, Dasparni Ark, flonicamid, thiamethoxam, Imidacloprid and Dimethoate against *B. tabaci* was conducted in mungbean during *Kharif* 2022-2023 at Students' Instructional Farm, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (UP), India under field conditions with nine treatements including control in three replication.

Result: The results demonstrated that Thiamethoxam 25 WG (50 g a.i./ha) was the most effective insecticide among all treatments, with a significant population reduction above control, followed by Imidacloprid 70 WG (5 ml/l). Among the botanicals, Azadirectin 1500 ppm (5 ml/l) was the most effective against whitefly infestation in mungbean and could be applied as an eco-friendly alternative to conventional pesticides for whitefly management.

Key words: Botanicals, Efficacy, *Kharif,* Management, Mungbean, White fly.

INTRODUCTION

Mungbean [*Vigna radiata* (L.) Wilczek] is India's third most significant pulse crop, trailing only gram and pigeon pea. Mungbean, which contains protein, minerals and vitamins, is used to make both dried and green fresh legume foods. In India, the productivity of this legume is 629 kg per hectare and we consume it extensively for making papad, biscuits, bread, soup and consuming fresh sprouts by swelling them in water (Sehrawat *et al*., 2013). Mungbean seeds are rich in minerals (amounts in 100 g) like calcium (132 mg), iron (6.74 mg), magnesium (189 mg), phosphorus (367 mg) and potassium (1246 mg) and vitamins like ascorbic acid (4.8 mg), thiamine (0.621 mg), riboflavin (0.233 mg), niacin (2.251 mg), pantothenic acid (1.910 mg) and vitamin A (114 IU) (Haytowitz and Matthews, 1986). Mungbean accounts for a production of 2.45 million tons (Sireesha *et al*., 2024). More than 80 percent of mungbean production comes from 10 states of India. These are Rajasthan, Madhya Pradesh, Maharashtra, Bihar, Karnataka, Tamil Nadu, Gujarat, Andhra Pradesh, Odisha and Telangana. There can be many reasons for the low production of this mungbean crop in India, one of the most important reasons for the deficiency are insects and from sowing to the storage of mungbean, many types of insects cause harm to it and 65 types of species of such insects are found in India (Meena *et al*., 2022). Management of Whitefly, *Bemisia tabaci* is extremely reliant on synthetic pesticides. Given the worries about the consequences of these pesticides on the environment and human health, as well as the risk of insecticide resistance, alternative control strategies must be devised. Botanicals could be utilized to manage whiteflies. The current study sought to assess the efficacy of various botanicals against the whitefly, *B. tabaci*. Farmers, environmentalists and academics working on green gram development have recently expressed concern about the problems that many peasant farmers have in getting chemicals, as well as the need to reduce environmental contamination caused by insecticide use. These spurred the need to construct a long-term insect pests management plan capable of reducing pre-harvest loss, increasing production and, as a result, improving people's meals.

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MATERIALS AND METHODS

The experiments for this study were carried out in the field on the mungbean variety SML-668 at the Students' Instructional Farm of Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh, India, during the months of *Kharif* 2022 and 2023. The experimental site is located in the subtropical climatic zone of the Indo-Gangetic plains, at 26.470 N latitude and 82.120 E longitude, at an elevation of 113 meters above mean sea level. The climate in the area is subtropical and semi-arid, with an average annual rainfall of approximately 1070 mm. The majority of the rain fell during the last weeks of June until mid-September. The experiment was laid out in randomized block design with nine treatments replicated thrice in plot size of 4×3 m was sown with 30 cm row to row and 10 cm plant to plant spacing by following recommended agronomic practices and fertilizer application to study the population build up of the whitefly associated with mungbean. Four systemic insecticides and four botanicals were applied, according to the treatment plan. The treatment details are as follows: T_1: Kaner powder 5 per cent, T_2: Garlic extract 5 per cent, T_3: Azadirectin 1500 ppm 5 ml/l, T_4: Dasparni Ark 5 per cent, T_5: Flonicamid 50 WG 75 g a.i./ha, T_6: Thiamethoxam 25 WG 50 g a.i./ha, T_7: Imidacloprid 70 per cent WG 50 g a.i./ha, T_8: Dimethoate 30 EC 300 g a.i./ha and T_9: Control (water spray). Whitefly population was recorded with the help of rectangular cage of 45 cm long, 30 cm wide and 90 cm high on randomly selected 5 places.

Preparation of Kaner powder extract

Fresh Kaner seeds were collected, cleaned and dried in shade and stored in the laboratory in the Department of Entomology of the university. After removing the seed coat, kernels were crushed and grinded with the help of pestle and mortar to make the powder. In order to prepare Kaner powder extract, 250 g kernel powder was soaked into 500 ml of water for 24 hour and filtered with the help of muslin cloth. The volume of filtrate was made 500 ml by adding water and kept as stock solution for its test under field conditions (Kiran and Prasad, 2014).

Preparation of garlic extract

Garlic was bringing out from local market and crushed with the help of pestle. To prepare garlic extract, 250 g garlic paste was soaked into 500 ml of water for 24 hours and filtered with the help of muslin cloth. The volume of the filtrate was made 500 ml by adding water and kept as a stock solution for use under field conditions (Soteyome and Theeramongkol 2023).

Composition of Dasparni Ark, material and quantity

Cow urine- 20 liter, Fresh cow dung- 2 kg, Green neem leaf- 5 kg, Green dhatura leaf- 2 kg, Green mandar leaf- 2 kg, Green Kaner leaf- 2 kg, Green castor leaf- 2 kg, Green marigold leaf- 2 kg, Green sarifa leaf- 2 kg, Green papaya leaf- 2 kg, Deshi mango leaf- 2 kg, Sadabahar leaf- 2 kg, Haldi power- 500 gram, Garlic paste- 500 gram, Green chili- 500 gram, Dried tobacco leaf- 1 kg, Dried ginger powder- 200 gram, Water- 200 liter. All above material of leaves was cut into small pieces and other materials were mixed in 200 liters of water. After mixing, all these materials kept for 40 days and shake every 7 days for a good result. After 40 days the materials were sieved with the muslin cloth. The self-life of this formulation is about 60 days (Raskar and Wani, 2014).

RESULTS AND DISCUSSION

Field experiments were conducted for two consecutive crop seasons (*Kharif* 2022 and 2023) to determine the effectiveness of treatments against whiteflies. Nine treatments including one control were evaluated against whitefly. The whitefly population was recorded one day before spraying as a pre-treatment observation, while post-treatment observations were taken 3, 7 and 10 days after spraying.

The data presented in Table 1 shows that all treatments were significantly superior to the control in *Kharif* 2022. The treatment T_6 (Thiamethoxam 25 WG @ 50 g a.i./ha) showed maximum reduction (87.5%) of whitefly/cage after 3 days of spray where mean population was 1.07 whitefly/cage which was at par with T_5 (Flonicamid 50 WG @ 75 g a.i./ha) with 1.20 whitefly/cage. The next best treatment was T_7 (imidacloprid 70% WG at @ 50 g a.i./ha) (1.70 whitefly/cage) followed by T_8 (dimethoate 30 EC at @ 300 g a.i./ha) (1.90 whitefly/cage), which were at par to each other. Among botanicals, the best treatment was T_3 (azadirectin 1500 ppm at @ 5 ml/l) with 2.07 whitefly/cage that was at par with T_2 (garlic extract @ 5%) and T_8. The least effective treatment was T_4-Dasparni ark followed by T_1 Kaner powder.

When the observations were made on day 7 after spraying, treatment T_6 (thiamethoxam 25 WG at 50 g a.i./ha) showed a maximum reduction in the whitefly population/cage with a mean population of 0.93 whitefly/cage and 89.8 per cent reduction over the control population and provided more protection to mungbean. The following treatments for superiority were T_7 (imidacloprid 70 WG @ 50 g a.i./ha), T_8 (dimethoate 30 EC @ 300 g a.i./ha), T_5 (flonicamid 50 WG @ 75 g a.i./ha), T_3 (azadirectin 1500 ppm @ 5 ml/l), T_2 (garlic extract @ 5%), T_4 (Dasparni Ark @ 5%) and T_1 (kaner powder @ 5%) with a mean population that is, 1.57, 1.83, 1.97, 2.90, 4.10, 4.40 and 5.33 whitefly/cage, respectively (Table 1).

After 10 days of spray, treatment T_6 (Thiamethoxam 25 WG @ 50 g a.i./ha) again showed maximum reduction with mean population of 1.33 whitefly/cage and 84.3 per cent reduction over control. The next best treatments were T_7 (Imidacloprid 70 WG @ 50 g a.i./ha) followed by T8 (Dimethoate 30 EC @ 300 g a.i./ha), T_5 (Flonicamid 50 WG @ 75 g a.i./ha), T_3 (Azadirectin 1500 ppm @ 5 ml/l), T_4 (Dasparni Ark @ 5%), T_2 (Garlic extract @ 5%) and T_1 (Kaner powder @ 5%) with respective mean population *i.e.* 2.00,

2.40, 2.53, 4.37, 5.70, 6.07 and 6.77 whitefly/cage. Control shows increasing trend in *B. tabaci* population than before the treatment (Table 1).

When the overall mean is analyzed, treatment T_6 (Thiamethoxam 25 WG @ 50 g a.i./ha) (1.11 whitefly/cage) was the best treatment in lowering the whitefly population (87.2%), which was statistically equal to T_7 (Imidacloprid 70 WG @ 50 g a.i./ha) (1.76 whitefly/cage) with 79.8 per cent reduction over control. The next best treatments were T_5 (Flonicamid 50 WG @ 75 g a.i./ha) (1.90 whitefly/cage) and T_8 (Dimethoate 30 EC @ 300 g a.i./ha) (2.04 whitefly/cage) however, they were statistically at par to each other. T_3 (Azadirectin 1500 ppm @ 5 ml/l), T_2 (Garlic extract @ 5%), T_4 (Dasparni Ark @ 5%) and T_1 (Kaner powder @ 5%) with respective mean population of 3.11, 4.34, 4.77 and 5.30 whitefly/cage were the next best treatments in order to superiority. However, chemical treatments statistically outperformed to botanicals (Table 1).

Data collected in *Kharif* 2023 and shown in Table 2 demonstrated that the mean whitefly population on mungbean crop at pre-treatment was homogeneous and non-significant across all treatments. At 3 days after spray, treatment T_7 (Imidacloprid 70 WG @ 50 g a.i./ha) (1.23 whitefly/cage) showed maximum reduction (84.7%) in whitefly population and were superior over other treatments, which was at par with T_6 (Thiamethoxam 25 WG @ 50 g a.i./ha), T_5 (Flonicamid 50 WG @ 75 g a.i./ha), T_8 (Dimethoate 30 EC @ 300 g a.i./ha) and T_3 (Azadirectin 1500 ppm @ 5 ml/l) with mean population of 12.7, 1.47, 1.90 and 2.10 whitefly/cage, respectively. Next best treatments were T_1 (Kaner powder @ 5%), T_2 (Garlic extract @ 5%) and T_4 (Dasparni Ark @ 5%) with respective mean population of 3.27, 3.37 and 3.57 whitefly/cage (Table 2).

When the observations were made on 7 days after spray, all the treatment were found significantly superior over control. The treatment T_6 (Thiamethoxam 25 WG @ 50 g a.i./ha) showed maximum reduction in the whitefly population where mean population was 1.03 whitefly/cage and 87.5 per cent reduction of population over control followed by T_7 (Imidacloprid 70 WG @ 50 g a.i./ha), T_5 (Flonicamid 50 WG @ 75 g a.i/ha) and T_8 (Dimethoate 30 EC @ 300 g a.i./ha). Next best treatments was T_3 (Azadirectin 1500 ppm @ 5 ml/l) (3.27 whitefly/cage) which was at par with T_4 (Dasparni Ark @ 5%) (4.93 whitefly/cage). T_2 (Garlic extract @ 5%) and T_1 (Kaner powder @ 5%) were least effective treatments against whitefly.

The population of whitefly recorded 10 days after spray, treatment T_6 (Thiamethoxam 25 WG @ 50 g a.i./ha) showed maximum reduction (84.8%) in the whitefly population with 1.20 whitefly/cage which was at par with T_8 (Dimethoate 30 EC @ 300 g a.i./ha) and T_7 (Imidacloprid 70 WG @ 50 g a.i./ha). Treatment T_5 (Flonicamid 50 WG @ 75 g a.i./ha) (2.27 whitefly/cage) was the next best treatment and significantly superior to T_3 (Azadirectin 1500 ppm @ 5 ml/l), T_4 (Dasparni Ark @ 5%), T_1 (Kaner powder @ 5%) and T_2 (Garlic extract @ 5%) with respective mean population of 5.07, 6.00, 6.20 and 6.23 whitefly/cage.

Table 1: Efficacy of some newer insecticides and botanicals on whitefly in mungbean during *Kharif* 2022.

Tr. no.	Treatments	Dose	Mean population of whitefly/cage				% reduction of whitefly population over control			
			1 DBS	3 DAS	7 DAS	10 DAS	Overall mean	3 DAS	7 DAS	10 DAS	Overall mean
T_1	Kaner powder	5%	8.87 (3.06)	3.80 (2.07)	5.33 (2.42)	6.77 (2.70)	5.30 (2.41)	55.5	41.6	20.4	39.1
T_2	Garlic extract	5%	8.07 (2.93)	2.87 (1.83)	4.10 (2.14)	6.07 (2.56)	4.34 (2.20)	66.4	55.1	28.6	50.0
T_3	Azadirectin 1500 ppm	5 ml/l	8.80 (3.05)	2.07 (1.60)	2.90 (1.84)	4.37 (2.21)	3.11 (1.90)	75.8	68.2	48.6	64.2
T_4	Dasparni Ark	5%	8.00 (2.92)	4.20 (2.17)	4.40 (2.21)	5.70 (2.49)	4.77 (2.29)	50.8	51.8	32.9	45.2
T_5	Flonicamid 50 WG	75 g a.i./ha	8.40 (2.98)	1.20 (1.30)	1.97 (1.57)	2.53 (1.74)	1.90 (1.55)	85.9	78.5	70.2	78.2
T_6	Thiamethoxam 25 WG	50 g a.i./ha	8.40 (2.98)	1.07 (1.25)	0.93 (1.20)	1.33 (1.35)	1.11 (1.27)	87.5	89.8	84.3	87.2
T_7	Imidacloprid 70 WG	50 g a.i./ha	8.47 (2.99)	1.70 (1.48)	1.57 (1.44)	2.00 (1.58)	1.76 (1.50)	80.1	82.8	76.5	79.8
T_8	Dimethoate 30 EC	300 g a.i./ha	8.20 (2.95)	1.90 (1.55)	1.83 (1.53)	2.40 (1.70)	2.04 (1.60)	77.7	79.9	71.8	76.5
T_9	Control (Water spray)	-	8.60 (3.02)	8.53 (3.01)	9.13 (3.10)	8.50 (3.00)	8.72 (3.04)	-	-	-	-
	S.Em.±		-	0.09	0.12	0.09	0.08	-	-	-	-
	CD at 5%		NS	0.27	0.36	0.28	0.25	-	-	-	-

Figures in parentheses indicates transformed value($\sqrt{x+0.5}$).
DBS= Day before spray; DAS=Days after spray.

The overall mean data revealed that whitefly population count was lowest in the treatment T_6 (Thiamethoxam 25 WG @ 50 g a.i./ha) (1.17 whitefly/cage) with 85.5 per cent reduction of population over control which was significantly at par with T_7 (Imidacloprid 70 WG @ 50 g a.i./ha) (1.50 whitefly/cage), T_8 (Dimethoate 30 EC @ 300 g a.i./ha) (1.82 whitefly/cage) and T_5 (Flonicamid 50 WG @ 75 g a.i. /ha) (1.18 whitefly/cage) with 81.4, 77.4 and 77.0% population reduction, respectively. Next best treatment was T_3 (Azadirectin 1500 ppm @ 5 ml/l) (3.48 whitefly/cage) with 56.9% population reduction followed by T_4 (Dasparni Ark @ 5%), T_2 (Garlic extract @ 5%) and T_1 (Kaner powder @ 5%) with respective mean population of 4.83, 5.06 and 5.07 whitefly/cage (Table 2).

The whitefly population that was observed in *Kharif* 2022 and 2023 was likewise combined and examined. When observations were collected three days after spraying, it is clear from the data in (Table 3) that all treatments were significantly better than control during both experimental years. The treatment T_6 (Thiamethoxam 25 WG @ 50 g a.i./ha) showed minimum population (1.17 whitefly/cage) and maximum reduction (85.9%) which was at par with T_5 (Flonicamid 50 WG @ 75 g a.i. /ha) and T_7 (Imidacloprid 70 WG @ 50 g a.i./ha) with 1.33 and 1.47 whitefly/cage. Next best treatment was T_8 (Dimethoate 30 EC @ 300g a.i./ha) (1.90 whitefly/cage) and T_3 (Azadirectin 1500 ppm @ 5 ml/l) followed by T_2 (Garlic extract @ 5%), T_1 (Kaner powder @ 5%) and T_4 (Dasparni Ark @ 5%) with respective mean population of 3.12, 3.53 and 3.88 whitefly/cage.

After 7 days of spray, treatment T_6 (Thiamethoxam 25 WG @ 50 g a.i./ha) had minimum population (0.98 whitefly/cage) with maximum reduction above control (88.7%) which was significantly at par with T_7 (Imidacloprid 70 WG @ 50 g a.i./ha) (1.47 whitefly/cage). Treatments T_8 (Dimethoate 30 EC @ 300 g a.i./ha) (1.87 whitefly/cage) and T_5 (Flonicamid 50 WG @ 75 g a.i/ha) (1.90 whitefly/cage) were the next good treatments followed by T_3 (Azadirectin 1500 ppm @ 5 ml/l) (3.08 whitefly/cage). Treatments T_4 (Dasparni Ark @ 5%), T_2 (Garlic extract @ 5%) and T_1 (Kaner powder @ 5%) (4.67, 4.83 and 5.53 whitefly/cage, respectively) were significantly least effective but at par with every other (Table 3).

Pooled data after 10 days of spray revealed that treatment T_6 (Thiamethoxam 25 WG @ 50 g a.i./ha) was significantly best over other treatments and showed highest reduction in the whitefly population (84.6%) with 1.27 whitefly/cage. The next best treatment were T_7 (Imidacloprid 70 WG @ 50 g a.i./ha) (1.95 whitefly/cage), T_8 (Dimethoate 30 EC @ 300 g a.i./ha) (2.03 whitefly/cage) and T_5 (Flonicamid 50 WG @ 75 g a.i. /ha) (2.40 whitefly/cage). T_3 (Azadirectin 1500 ppm @ 5 ml/l) (4.72 whitefly/cage) was the next best treatment and significantly superior than T_4 (Dasparni Ark @ 5%), T_2 (Garlic extract @ 5%) and T_1 (Kaner powder @ 5%) with mean population of 5.85, 6.15 and 6.48 whitefly/cage, respectively (Table 3).

Table 2: Efficacy of some newer insecticides and botanicals on whitefly in mungbean during *Kharif* 2023.

Tr. no.	Treatments	Dose	Mean population of whitefly/cage					% reduction of whitefly population over control			
			1 DBS	3 DAS	7 DAS	10 DAS	Overall mean	3 DAS	7 DAS	10 DAS	Overall mean
T_1	Kaner powder	5%	7.70 (2.86)	3.27 (1.93)	5.73 (2.49)	6.20 (2.58)	5.07 (2.34)	59.5	30.7	21.2	37.2
T_2	Garlic extract	5%	7.23 (2.78)	3.37 (1.96)	5.57 (2.46)	6.23 (2.59)	5.06 (2.34)	58.3	32.7	20.8	37.4
T_3	Azadirectin 1500 ppm	5 ml/l	7.63 (2.85)	2.10 (1.61)	3.27 (1.93)	5.07 (2.35)	3.48 (1.97)	74.0	60.5	35.6	56.9
T_4	Dasparni Ark	5%	8.00 (2.92)	3.57 (2.01)	4.93 (2.32)	6.00 (2.55)	4.83 (2.30)	55.8	40.3	23.8	40.1
T_5	Flonicamid 50 WG	75 g a.i/ha	7.43 (2.82)	1.47 (1.39)	1.83 (1.51)	2.27 (1.66)	1.86 (1.53)	81.8	77.8	71.2	77.0
T_6	Thiamethoxam 25 WG	50 g a.i./ha	7.73 (2.87)	1.27 (1.32)	1.03 (1.23)	1.20 (1.29)	1.17 (1.29)	84.3	87.5	84.8	85.5
T_7	Imidacloprid 70 WG	50 g a.i./ha	8.07 (2.93)	1.23 (1.31)	1.37 (1.35)	1.90 (1.55)	1.50 (1.41)	84.7	83.5	75.9	81.4
T_8	Dimethoate 30 EC	300 g a.i./ha	7.53 (2.83)	1.90 (1.53)	1.90 (1.54)	1.67 (1.46)	1.82 (1.52)	76.5	77.0	78.8	77.4
T_9	Control (Water spray)	-	7.43 (2.82)	8.07 (2.92)	8.27 (2.96)	7.87 (2.89)	8.07 (2.93)	-	-	-	-
	S.Em.±		-	0.13	0.13	0.11	0.10	-	-	-	-
	CD at 5%		NS	0.39	0.39	0.34	0.30	-	-	-	-

Figures in parentheses indicates transformed value($\sqrt{x+0.5}$).
DBS= Day before spray; DAS= Days after spray.

Table 3: Efficacy of some newer insecticides and botanicals on whitefly in mungbean during *Kharif* 2022 and 2023 (Pooled).

Tr. no.	Treatments	Dose	Mean population of whitefly/cage				% reduction of whitefly population over control			
			1 DBS	3 DAS	7 DAS	10 DAS	Overall mean	3 DAS	7 DAS	10 DAS	Overall mean
T_1	Kaner powder	5%	8.28 (2.96)	3.53 (2.01)	5.53 (2.45)	6.48 (2.64)	5.18 (2.37)	57.5	36.2	20.8	38.2
T_2	Garlic extract	5%	7.65 (2.85)	3.12 (1.90)	4.83 (2.31)	6.15 (2.58)	4.70 (2.26)	62.4	43.9	24.7	43.7
T_3	Azadirectin 1500 ppm	5 ml/l	8.22 (2.95)	2.08 (1.60)	3.08 (1.88)	4.72 (2.28)	3.29 (1.93)	74.9	64.4	42.1	60.6
T_4	Dasparni Ark	5%	8.00 (2.91)	3.88 (2.09)	4.67 (2.27)	5.85 (2.52)	4.80 (2.30)	53.3	46.1	28.4	42.7
T_5	Flonicamid 50 WG	75 g a.i/ha	7.92 (2.90)	1.33 (1.35)	1.90 (1.54)	2.40 (1.70)	1.88 (1.54)	83.9	78.2	70.7	77.6
T_6	Thiamethoxam 25 WG	50 g a.i./ha	8.07 (2.93)	1.17 (1.29)	0.98 (1.22)	1.27 (1.32)	1.14 (1.28)	85.9	88.7	84.6	86.4
T_7	Imidacloprid 70 WG	50 g a.i./ha	8.27 (2.96)	1.47 (1.40)	1.47 (1.39)	1.95 (1.56)	1.63 (1.46)	82.4	83.2	76.2	80.6
T_8	Dimethoate 30 EC	300 g a.i./ha	7.87 (2.89)	1.90 (1.54)	1.87 (1.53)	2.03 (1.59)	1.93 (1.56)	77.1	78.5	75.3	77.0
T_9	Control (Water spray)	-	8.02 (2.92)	8.30 (2.96)	8.70 (3.03)	8.18 (2.95)	8.39 (2.98)	-	-	-	-
	S.Em.±		-	0.08	0.10	0.06	0.09			-	-
	CD at 5%		NS	0.23	0.30	0.19	0.26			-	-

Figures in parentheses indicates transformed value ($\sqrt{x+0.5}$).
DBS= Day before spray; DAS= Days after spray.

The overall mean revealed that whitefly population was lowest in treatment T_6 (Thiamethoxam 25 WG @ 50 g a.i./ha) (1.14 whitefly/cage) with highest population reduction above control (86.4%). However, treatment T_6 was statistically at par with T_7 (Imidacloprid 70 WG @ 50 g a.i./ha) (1.63 whitefly/cage) and T_5 (Flonicamid 50 WG @ 75 g a.i. /ha) (1.88 whitefly/cage) with 80.6 and 77.6% population reduction respectively. Next best treatment was T_8 (Dimethoate 30 EC @ 300 g a.i./ha) (1.93 whitefly/cage and 77.0% reduction). Among botanicals, T_3 (Azadirectin 1500 ppm @ 5 ml/l) (3.29 whitefly/cage and 60.6% reduction) was significantly superior to T_2 (Garlic extract @ 5%), T_4 (Dasparni Ark @ 5%) and T_1 (Kaner powder @ 5%) with mean population of 4.70, 4.80 and 5.18 whitefly/cage and 43.7, 42.7 and 38.2 per cent reduction over control, respectively.

The current findings are in partial agreement with the findings of Chaitanya and Kumar (2018), who demonstrated that Imidacloprid 17.8 SL was the most effective treatment recorded lowest population of whitefly followed by Thiamethoxam 25WG, Acetamiprid 20 SP, Dimethote 30 EC, Lambda cyhalothrin 5 EC, Neem oil and NSKE 5% was less effective among all insecticides. Hemadri *et al*. (2018) also found that the foliar spray of Imidacloprid 17.8 SL @ 0.5 ml/l was found to be most effective against whiteflies with higher per cent reduction of pest population (84.54 per cent), followed by acetamiprid 20 SP @ 0.5 g/l, thiamethoxam 25 WG @ 0.3 g/l, acephate 95 SG @ 0.3 g/l and clothianidin 50 WDG @ 0.25 g/l which recorded 84.36, 84.25, 76.38 and 73.53 per cent reduction in the pest population, respectively. Iqbal *et al*. (2013) found that T_2 (spray with imidacloprid) was to be the most effective and it resulted in a minimum whitefly population, per leaf *i.e*., 1.45 and followed by T_3 (spray with acetamiprid) with whitefly population 1.54 per leaf. Rajawat *et al*. (2021) Thiomethoxam 25% WG 125 g/ha against the *Bemisia tabaci* was found most Significantly. The maximum population reduction 0.923% was noticed in the plots treated with imidacloprid 24 hours after spray.

CONCLUSION

The efficacy of some newer insecticide molecules and botanicals against the white fly in mungbean was investigated and when the data from both years of experiment were combined, it was concluded that Thiamethoxam 25 WG (50 g a.i./ha) was the most effective insecticide among all the treatments, with maximum population reduction over control. Imidacloprid 70 WG (50 g a.i./ha) was the second best treatment against white fly. Among the botanicals, Azadirectin 1500 ppm (5 ml/l) was the most efficient against whitefly infestation in mungbean and could be utilized as an eco-friendly alternative to conventional pesticides for whitefly management in mungbean.

Conflict of interest

All authors declared that there is no conflict of interest.

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