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RESEARCH

Efficacy of Insecticides Against Thrips (*Thrips tabaci*) in Cucumber (*Cucumis sativus* var. Chadani)

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Abstract

Both biotic and abiotic factors have a considerable impact on cucumber production; the frequency of pests and diseases operate as important restrictions, resulting in yield losses ranging from 35 to 60%. Among pests, cucumber leaves, flowers, buds, stems, and fruits are severely damaged by thrips. This study compares the effectiveness of various insecticides in controlling cucumber thrips. The Chadani variety was the subject of an experiment utilizing a Randomized Complete Block Design (RCBD) with seven treatments and three replications at the Gauradaha Agriculture Campus in Jhapa, from February 14 to May 30, 2023. Treatments were applied 3 times using a foliar spray method. Data regarding the thrips population before spraying insecticides and after the 2nd, 4th, and 6th days of spraying were recorded. Data were collected and analyzed using ANOVA in GenStat (15th edition), with mean separation by Duncan's Multiple Range Test (DMRT). Thiamethoxam exhibited the highest Population Reduction over Control (PROC) at 68.65% (first spray), 28.00% (second spray), and 34.44% (third spray), followed by Imidacloprid (61.54%, 27.95%, and 32.27%) and Dimethoate (53.66%, 18.11%, and 17.31%). The highest yield was recorded in Thiamethoxam (28.13 tons/ha), followed by Imidacloprid (26.62 tons/ha) and Dimethoate (19.09 tons/ha). These findings demonstrate that Thiamethoxam significantly reduces thrips populations and enhances productivity and economic returns, making it a superior choice for pest management in cucumber cultivation in Jhapa, Nepal.

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Statement of Sustainability: This study focused on the systematic evaluation of insecticide efficacy against *Thrips tabaci* in cucumber cultivation under Jhapa's agro-climatic conditions. By identifying the most effective treatment, this research supports Sustainable Development Goal (SDG) 2 (Zero Hunger) by enhancing crop productivity and food security. Additionally, it aligns with SDG 12 (Responsible Consumption and Production) by guiding the judicious use of insecticides to minimize environmental contamination. The findings provide actionable insights for farmers, promoting sustainable pest management practices that balance agricultural productivity with ecological responsibility, ultimately contributing to resilient and efficient food systems in Nepal.

1. Introduction

Cucumbers, which belong to the Cucurbitaceae family along with melons, pumpkins, and other gourds, are long, green fruits characterized by their high water content. They are often eaten fresh in salads or used for pickling. Of the 66 known species in the *Cucumis* genus, cucumbers are the only ones with 2n = 2x = 14 chromosomes (Weng, 2021). Composed of more than 90% water, they are very low in calories (Sharma et al., 2020). Besides their use in food, cucumbers are also employed in cosmetics and traditional medicine. They are rich in polyphenols and cucurbitacin, which offer a range of health benefits, including anti-carcinogenic, antimicrobial, anti-inflammatory, diuretic, antioxidant, and analgesic properties (Uthpala et al., 2020). In Nepal, cucumber cultivation is most abundant during early summer

(Dahal et al., 2021), with production concentrated in tropical and subtropical regions. China is the leading global producer of cucumbers, accounting for over 81% of worldwide production, with 77,258,256 tons, followed by Turkey and Russia (FAO, 2022). In Nepal, the total production of cucumbers is 159,625 metric tons, with a productivity rate of 15.48 t/ha (Krishi Diary, 2022).

Different types of insects feed on cucumbers. The most common insect pests include the red pumpkin beetle, spotted beetle, fruit fly, stink bug, whitefly, and thrips. Herbivorous thrips, such as *Thrips tabaci* (Thysanoptera, Thripidae), are significant pests of ornamental and vegetable crops worldwide and pose multiple challenges: they are highly polyphagous, difficult to control due to their complex life cycle, and transmit harmful viruses (Steenbergen et al., 2018). The life stages of thrips include the egg, two larval instars, two pupal instars, and the adult. According to Bagheri et al. (2002), thrips eggs are whitish upon deposition and develop an orange tint as they mature. Eggs are deposited separately in various plant tissues. Larvae go through two stages, during which they consume plant tissues. When the second instar larvae mature, they drop to the ground and molt into pre-pupae and pupae in the soil. Once adults emerge, they move to young leaves, flowers, and fruits, where they feed and lay eggs (Kawai, 2015). Thrips populations can become very large in hot and dry conditions (Pourian et al., 2009). In both lowland and highland regions, *Solanum melongena* had the highest thrips abundance, followed by *Cucumis sativus* (Johari, 2015). Thrips reduce the photosynthetic area and cause leaf reddening and yellowing by sucking plant sap. Their toxic saliva damages plant tissues, harming both larvae and adults. Severe infestations can injure or kill the apical meristem (Cook et al., 2011). Aside from feeding on cucumbers, thrips have a highly diverse host range, including various herbaceous cultivated plants and weeds from the Cucurbitaceae, Liliaceae, Leguminaceae, Solanaceae, and Cruciferae families (Varela et al., 2022).

In Nepal, cucumber is a staple summertime vegetable. Its production is affected by various biotic and abiotic factors. Diseases and pests are major constraints, causing nearly 35–60% yield loss (Bacci et al., 2006). Thrips (Order Thysanoptera, Family Thripidae), which are highly damaging and costly for farmers, can significantly reduce cucumber productivity (Mound et al., 2022). Temperature influences thrips larval development. Research indicates that temperatures between 15 and 25°C favor maximal (>80%) hatchability, whereas adult longevity decreases with rising temperatures (Karuppaiah et al., 2023). Farmers extensively use chemical insecticides, but their indiscriminate application results in the death of beneficial insects, insecticide resistance, toxic residues, and phytotoxicity (Serrão et al., 2022). These persistent effects disrupt the agro-ecosystem balance. According to the research conducted by Ullah et al. (2010) in onion, different types of systemic insecticides such as imidacloprid, acetamiprid, and thiamethoxam are found to be best for the control of *T. tabaci*. Numerous crops are protected using imidacloprid via seed coating, foliar spraying, soil drenching, and trunk injection (Jeschke et al., 2011). Commonly used chemical pesticides for thrips control include Dimethoate and Spinosad. Azadirachtin is considered less harmful to beneficial and non-target organisms, as it is selective, non-mutagenic, relatively non-toxic, and biodegradable (Medina et al., 2004). Additionally, *Beauveria* species antagonize, parasitize, and kill insects, making them effective biocontrol agents (Keswani et al., 2013). Integrated pest management (IPM) is a practical and environmentally responsible pest control approach that combines multiple strategies to minimize risks to humans, property, and the environment while managing pest damage cost-effectively (Hagstrum et al., 2018). Azadirachtin is compatible with other biological control agents and aligns well with traditional IPM programs (Immaraju, 2002). Nowadays, cucumber thrips cause significant damage to the leaves, flowers, buds, tender stems, and fruits of cucumbers. While most research focuses on controlling major cucumber pests such as the red pumpkin beetle and fruit fly, limited studies have addressed cucumber thrips management. Farmers primarily rely on conventional insecticides, often without considering their long-term environmental impact. Our study aims to identify and recommend the most effective insecticides to control thrips populations, enhance cucumber yield, and promote sustainable pest management practices with minimal environmental impact.

2. Materials and Methods

2.1. Description of Study Area

In Gauradaha Municipality-2 (Figure 1), Jhapa district, eastern Nepal, the experiment was conducted from February 14 to May 30, 2023, at the Institute of Agriculture and Animal Science (IAAS), Gauradaha Agriculture Campus. Located at 26° 55' 86" N latitude and 87° 71' 74.4" E longitude, the study location is 79 meters above sea level.

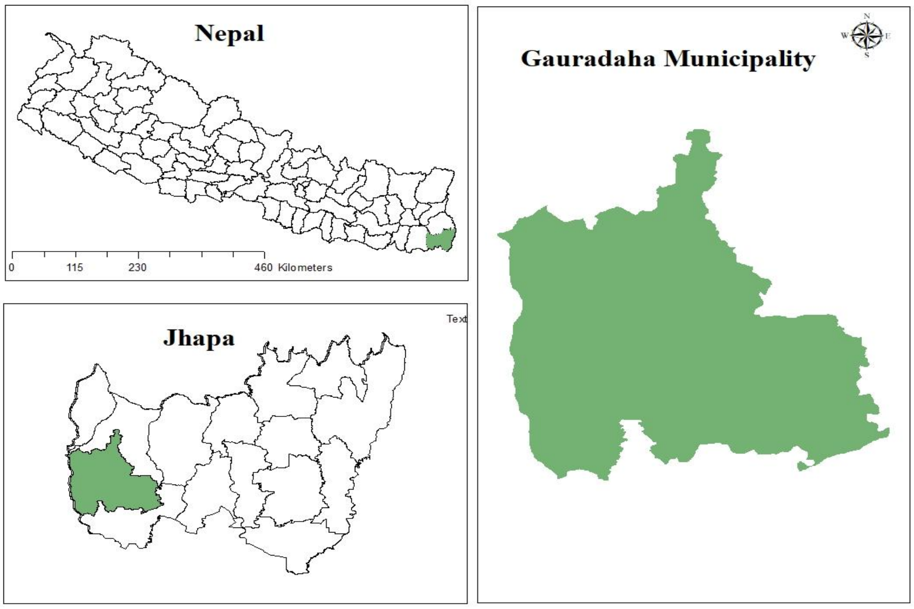

Figure 1. Representing the study area for experimentation.

2.2. Experimental Details

The experiment was conducted on Randomized Complete Block Design (RCBD) with 3 replications and 7 treatments. The total area of the experimental plot was 194.7 m^2 (17.7 × 11 m). The spacing between replications was 1m and between plots was 0.5 m. Each replication contains 7 plots with an area of 6.3 m^2 (3 × 2.1 m) per plot. In each replication, treatments were distributed at random using the lottery method. A total of 9 plants were maintained at spacing of 1 m (row-row) x 0.7 m (plant-plant). Out of the 9 plants, 5 plants were randomly selected as sample plants and tagged with yellow woolen rope.

2.3. Cultivation Practices

2.3.1. Raising Seedlings

The research was conducted on 'Chadani', one of the popular varieties of Cucumber. Seeds were sown in polybag size (3 × 3 × 7 in) following the recommended agronomic practices. Before preparation of media farm soil was treated with 2 % formalin solution and covered by plastic over 24 hours to kill harmful microorganisms. Media was prepared by mixing farm soil, coco peat, FYM, and sand in the ratio of 2:1:1:1 proportion respectively. A single seed was sown in each polybag. A small plastic tunnel was prepared 1 m in breadth and 2 m in length with the help of plastic and bamboo sticks to maintain temperature and humidity.

2.3.2. Field Preparation and Transplanting

The field was carefully prepared 15 days before transplantation. The field was prepared by two deep plows with the power tiller to make the final tilth and level field. Finally, 25-day-old seedlings were transplanted in the field.

2.3.3. Manure and Fertilizers

The recommended dose of nutrients for cucumber cultivation includes Farmyard Manure (FYM) at 1500 kg per ropani and a combination of Urea, Diammonium Phosphate (DAP), and Muriate of Potash (MOP) at a ratio of 7:2:5 kg per ropani, respectively. A basal application of 18.75 kg of Farmyard Manure, 43.33 g of Urea, 24.76 g of Diammonium Phosphate, and 61.91 g of Muriate of Potash was made per plot. The entire dose of phosphorus and potassium, along with half of the nitrogen, was applied in the planting pits, while the remaining nitrogen was top-dressed in three split doses at 20-day intervals.

2.3.4. Intercultural Operations

Initially, light irrigation was done regularly with a rose can until the seedlings were established in the field. Then the subsequent furrow irrigation was given at an interval of 6-7 days. Manual weeding was done at 15 days intervals. For greater crop growth and yield, one hoeing and weeding activity was followed by an earthing practice. Especially at the stage when the vine began to spread or when they were ready for training (30-40 cm) and long vines weeding and hoeing were done. Generally hoeing was done at 20 days and earthing at 30 days after sowing. To apply insecticide consistently throughout each plot, hand sprayers were employed. In order to prevent spray drift, spraying was only done during periods of less air movement. To reduce the danger to human health, aprons and masks were utilized. Before being used again, the hand sprayers were cleaned and washed after each usage.

2.3.5. Staking and Harvesting

Staking was provided by a bamboo stick 0.5 to 1 m high for climbing the vine of cucumber. Staking was done after 20 days of transplanting and the first harvesting was done 40 days after transplanting of seedlings and subsequent harvesting was done at intervals of 3-4 days.

2.4. Insecticide Preparation and Application

An insecticidal solution was prepared and applied to each plot according to the recommended dosage specified in Table 1. *Beauveria bassiana* was collected from Chitwan. Azadirachtin was collected from Damak and Thiamethoxam, dimethoate, imidacloprid, and emamectin benzoate were collected from the Gauradaha bazaar. Hand sprayers were utilized to ensure the uniform application of insecticide in each plot. For each plot, 0.7 g of Thiamethoxam 25% Water-Granules (WG) was dissolved in 1 L of water and applied. Similarly, 1.5 mL of Dimethoate 30% Emulsifiable Concentrate (EC), 0.5 mL of Azadirachtin, 6.6 g of emamectin benzoate 5.7% Water Dispersible Granules (WDG), 3 g of *B. bassiana* 1.15% Wettable Powder (WP), and 0.4 g of Imidacloprid 70% WG were prepared in the same manner. Spraying was conducted at 7-day intervals using hand sprayers. Treatments were applied on the 80th day after sowing (March 25, 2023), with three foliar sprays of insecticides conducted at 7-day intervals.

Table 1. List of treatments with their notation, common name, trade name, and dose.

Common name	Treatments	Trade Name	Formulation	Dose
Thiamethoxam	T1	Evident	25% WG	0.7 g/L water
Dimethoate	T2	Rogar	30% EC	1.5 mL/L water
Azadirachtin	T3	Dada guard plus	2% W/W	0.5 mL/L water
Emamectin benzoate	T4	Top killer	5.7% WDG	6.6 g/L water
Beauveria bassiana	T5	Bio power	1.15% WP	3 g/L water
Imidacloprid	T6	IMD-70	70% WG	0.4 g/L water
Control (water)	T7	-	-	2 L/plot

2.5. Observation, Data Collection, and Statistical Data Analysis

The parameters for the data collection were insect population and yield of cucumber. The first sign of thrips was seen earlier after 16 DAS. The data of insect population were collected from 18 days after the sign of thrips. Three foliar sprays of insecticides were done by hand sprayer at the interval of 7 days from 20 DAS. The first harvest was on April 18 after 40 DAS and the subsequent harvest was done after a certain interval when the fruits were matured. Primarily data was recorded from the field and secondarily through various sources such as research proceedings, journals, books, annual reports, and web pages related to the study. Five randomly chosen plants from each plot were used to calculate the insect population 1 day before and after spraying insecticide in 2, 4, and 6 days. The yield of cucumber from each plot was recorded. The yield was converted later into metric tons. The collected data were tabulated and processed in Microsoft Excel (2016).

The one-way ANOVA was done to check the significance level and means were separated by using L.S.D. at 5%. Data were analyzed using GenStat software (15^{th} edition). Population Reduction Over Control (PROC) and percent increase in yield over control are calculated by the given formulas:

$$\mathrm{PROC}\ (\%) = 1 - (\mathrm{Ta} \times \mathrm{Cb} / \mathrm{Tb} \times \mathrm{Ca}) \times 100$$

Where, Ta: population of insects after treatment application; Tb: population of insects before treatment application; Ca: population of insects in control after treatment application; Cb: population of insects in control before treatment application.

$$\text{Increase in Yield over control}\ (\%) = (\mathrm{T} - \mathrm{C}) / \mathrm{C} \times 100$$

Where, T: yield from the treated plot; C: yield from the untreated plot (control plot).

3. Results and Discussion

3.1. Effect on Population Reduction of Thrips

3.1.1. First Spray

The thrips counts recorded across different treatments following the initial spray are presented in Table 2. The above table shows the mean population of thrips in cucumber before and after treatment application, compared to the control. The data indicate that the mean population of thrips declined sharply two days after application, with the lowest population observed in thiamethoxam (21.27), followed by imidacloprid (29.16) and dimethoate (39.60). At four days after spray (4 DAS), the lowest thrips population was recorded in thiamethoxam (31.99), which was statistically at par with imidacloprid (38.84), dimethoate (49.12), and *B. bassiana* (56.53). Six days after spray (6 DAS), although the mean population of thrips increased, it remained below the economic threshold level. The lowest population was recorded in thiamethoxam (40.47), which was at par with imidacloprid (43.45), dimethoate (59.69), and *B. bassiana* (66.29). The PROC at 2, 4, and 6 days after spraying was highest with thiamethoxam (74.27, 66.12, and 65.83, respectively). The highest insect population was recorded in the control plot across all sprays.

Table 2. Effect of different insecticides against thrips *(Thrips tabaci)* after 1st insecticidal spray at Gauradaha, Jhapa.

Treatment	Insect Population (No. per Plant)	2 DAS	PROC	4 DAS	PROC	6 DAS	PROC
Control (Water)	63.93a	75.81c		86.59c		108.59d	
Thiamethoxam	69.73a	21.27a	74.27	31.99a	66.12	40.47a	65.83
Dimethoate	75.40a	39.60ab	55.71	49.12ab	51.90	59.69b	53.39
Azadirachtin	69.33a	47.82b	41.83	58.62b	37.57	67.73bc	42.48
Emamectin benzoate	71.13a	52.20b	38.11	64.18b	33.38	76.95c	36.31
Beauveria bassiana	56.47a	42.90ab	35.93	56.53b	26.09	66.29bc	30.88
Imidacloprid	68.35a	29.16ab	64.02	38.84a	58.04	43.45a	62.57
F-Test	Ns	**		***		***	
$LSD_{(0.05)}$	36.26	23.13		16.37		13.99	
CV%	30.6	29.9		17		12.1	
SEM±	11.96	7.62		5.40		4.61	

Where, CV= Coefficient of variation, DAS= Days after spray, PROC= Population reduction over control, ***=significant at a 0.1% level of significance, **=significant at a 1% level of significance, *= significant at a 5% level of significance, Ns= non-significant, LSD= least significant difference, SEM=standard error mean.

3.1.2. Second Spray

Table 3 presents the standard mean values of the thrips population in cucumber before and after treatment application in comparison with the control. The data indicate that the thrips population significantly declined 48 hours after application in treatments of thiamethoxam (24.36), followed by imidacloprid (29.31) and dimethoate (44.80). At 4 days after spray (4 DAS), thiamethoxam (34.98) recorded the lowest insect population, closely followed by imidacloprid (34.89), with dimethoate (52.44) and *B. bassiana* (61.30) showing relatively higher populations. At 6 days after spray (6 DAS), the mean standard population of thrips slightly decreased in thiamethoxam (30.66), imidacloprid (32.30), and azadirachtin (54.65) but increased in dimethoate (53.57), emamectin benzoate (68.42), and *B. bassiana* (63.73). The lowest insect count was observed in thiamethoxam (30.66), followed closely by imidacloprid (32.30). Thiamethoxam showed the highest PROC at 2 DAS (38.62), while imidacloprid (22.64) and (30.00) maintained their effectiveness at 4 DAS and 6 DAS, respectively. The highest thrips population was consistently recorded in the control plot across all time points. The effectiveness of imidacloprid after foliar application can be attributed to its strong xylem mobility, which enhances systemic absorption, making it particularly effective for seed treatment and soil application (Elbert et al., 2021).

3.1.3. Third Spray

The data showed that the mean standard population of thrips declined after 48 hours of application in treatments of thiamethoxam (20.18) followed by imidacloprid (23.19), and dimethoate (45.39). Similarly, at 4 days after spray thiamethoxam (21.34) has the lowest insect population which is at par with imidacloprid (23.06), dimethoate (46.86), and azadirachtin (51.10). Similarly at 6 days after spray mean standard population of thrips decreases in thiamethoxam, imidacloprid, dimethoate, *B. bassiana,* and azadirachtin but slightly increases in emamectin benzoate. The lowest insect count was recorded from thiamethoxam (19.74) which is at par with imidacloprid (20.44), dimethoate (42.83), and *B.*

bassiana (49.25). The PROC on the 2nd and 4th days was found highest on thiamethoxam (33.58) and (33.40) respectively. Similarly, at 6 days after spray PROC was found highest in imidacloprid (37.45). The highest number of thrips population was recorded from the control plot in all sprays. This data is summarized in Table 4.

Table 3. Effect of different insecticides against thrips (*Thrips tabaci*) after 2nd insecticidal spray at Gauradaha, Jhapa.

Treatment	Insect Population (No. per plant)	2 DAS	PROC	4 DAS	PROC	6 DAS	PROC
Control (Water)	108.59d	106.50d		112.73d		115.32d	
Thiamethoxam	40.47a	24.36a	38.62	34.98a	16.73	30.66a	28.66
Dimethoate	59.69b	44.80b	23.47	52.44b	15.37	53.57b	15.49
Azadirachtin	67.73bc	53.99bc	18.72	61.75bc	12.17	54.65b	24.02
Emamectin Benzoate	76.95c	63.08c	16.41	67.79c	15.13	68.42c	16.27
Beauveria bassiana	66.29bc	52.91bc	18.61	61.30bc	10.92	63.73bc	9.47
Imidacloprid	43.45a	29.31a	31.21	34.89a	22.64	32.30a	30
F-Test	***	***		***		***	
LSD(0.05)	13.99	13.16		12.85		13.3	
CV%	12.1	14		12.1		11.6	
SEM±	4.61	4.34		4.24		4.38	

Where, CV= Coefficient of variation, DAS= Days after spray, PROC= Population reduction over control, ***=significant at a 0.1% level of significance, **=significant at a 1% level of significance, *= significant at a 5% level of significance, Ns= non-significant, LSD= least significant difference, SEM=standard error mean.

Table 4. Effect of different insecticides against thrips *(Thrips tabaci)* after 3rd insecticidal spray at Gauradaha, Jhapa.

Treatment	Insect Population (No. per plant)	2DAS	PROC	4DAS	PROC	6DAS	PROC
Control (Water)	115.32 d	114.28d		120.77d		116.67d	
Thiamethoxam	30.66a	20.18a	33.58	21.34a	33.4	19.74a	36.36
Dimethoate	53.57b	45.39b	14.49	46.86b	16.47	42.83b	20.97
Azadirachtin	54.65bc	48.18bc	11.03	51.10bc	10.71	50.04b	9.49
Emamectin Benzoate	68.42c	61.79c	8.86	63.10c	11.93	66.77c	3.54
Beauveria bassiana	63.73bc	49.56bc	21.52	52.38b	21.51	49.25b	23.61
Imidacloprid	32.30a	23.19a	27.55	23.06a	31.82	20.44a	37.45
F-Test	***	***		***		***	
LSD(0.05)	13.3	10.33		10.36		10.47	
CV%	11.6	11.5		10.4		11.8	
SEM±	4.38	3.41		3.42		3.45	

Where, CV= Coefficient of variation, DAS= Days after spray, PROC= Population reduction over control, ***=significant at a 0.1% level of significance, **=significant at a 1% level of significance, *= significant at a 5% level of significance, Ns= non-significant, LSD= least significant difference, SEM=standard error mean.

3.2. Average Population Reduction Over Control

The PROC of 68.74% was observed with thiamethoxam, which is active both in the insect's stomach and through direct contact (Shweta et al., 2019). Additionally, thiamethoxam has been found to influence plant physiology and biochemistry, enhancing vigor during early development and increasing resistance to abiotic stress (Macedo et al., 2013). The observed high PROC could also be attributed to the dual mode of action, where both systemic and contact effects synergistically reduce pest populations. The lowest PROC values of 35.93%, 15.93%, and 8.11% were recorded after the first, second, and third applications of emamectin benzoate, respectively, indicating its lower efficacy compared to other treatments. Emamectin benzoate exerts toxicity by inhibiting neurotransmission in the peripheral nervous system (Willis et al., 2003).

However, its lower efficacy compared to thiamethoxam in this study suggests that its mode of action may be less potent or that the pests are more tolerant to the compound with repeated exposure. This aligns with other studies that have observed decreased effectiveness of emamectin benzoate over time, potentially due to resistance development in pest populations. A detailed description of these findings is provided in Figure 2.

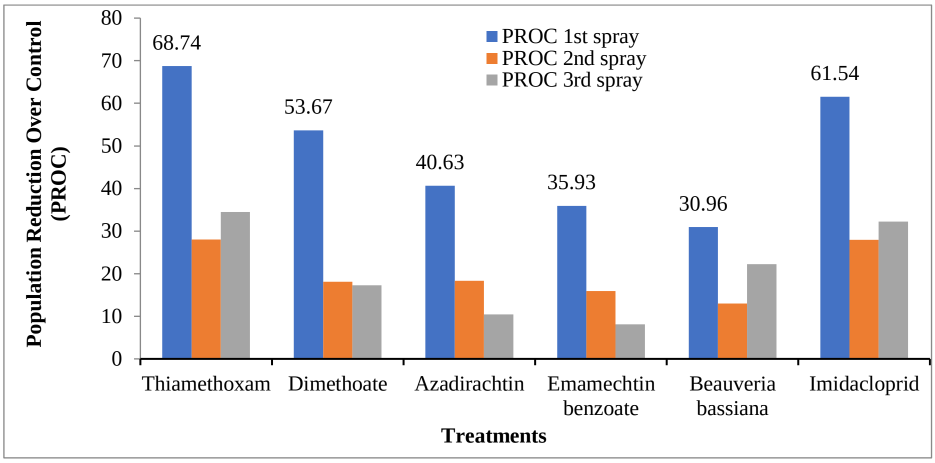

Figure 2. Bar diagram showing average population reduction over control of thrips (*Thrips tabaci*).

3.3. Yield Parameters

Table 5 presents the effects of different treatments on cucumber yield. The highest yield was recorded in the thiamethoxam-treated plot (28.13), followed by imidacloprid (26.62) and dimethoate (19.09), while the lowest yield was observed in the control plot (12.29). Among the tested treatments, imidacloprid ranked second in yield efficacy after thiamethoxam. Imidacloprid functions as an agonist of nicotinic acetylcholine receptors (nAChRs), particularly the 42 subtype, leading to neuromuscular paralysis and insect mortality (Sriapha et al., 2020). Despite its effectiveness, imidacloprid was less potent than thiamethoxam, likely due to differences in their chemical composition and systemic activity. Thiamethoxam exhibits higher mobility within plants, providing prolonged protection against insect pests. Dimethoate, a phosphorus-based pesticide commonly used to protect plants, flowers, fruits, and vegetables from insect infestations (Kong et al., 2019), exhibited moderate effectiveness compared to other treatments. Its impact, while lower than that of thiamethoxam and imidacloprid, can be attributed to its mode of action as an organophosphate, inhibiting acetylcholinesterase and disrupting the nervous system of insects. However, its effectiveness is often influenced by environmental factors like temperature and humidity, which could have led to reduced performance under field conditions.

Table 5. Effects of different insecticides on yield parameters of cucumber.

Treatment	Yield (Kg/plant)	Yield (Kg/plot)	Yield (Mt/ha)
Control	0.86a	7.74a	12.29a
Thiamethoxam	1.969c	17.72c	28.13c
Dimethoate	1.336b	12.03b	19.09b
Azadirachtin	1.180b	10.62b	16.86b
Emamectin benzoate	1.104ab	9.94ab	15.77ab
Beauveria bassiana	1.295b	11.65b	18.49b
Imidacloprid	1.863c	16.77c	26.62c
F Test	***	***	***
LSD (0.05)	0.2601	2.340	3.715
CV	10.8	10.8	10.8
SEM±	0.0857	0.772	1.225

CV: Coefficient of variation, ***: highly significant at a 5% level of significance.

B. bassiana, a widely studied entomopathogenic fungus, has shown potential as a biological control agent for various economically significant insect species (Shipp et al., 2003). However, in our study, its effect was moderate. This may indicate that while *B. bassiana* is effective under certain conditions, its performance is influenced by environmental factors, such as temperature and humidity, as well as pest susceptibility. Its lower effectiveness compared to chemical pesticides could reflect the time required for fungal development and action, which may not be as immediate as the rapid effects of chemical treatments. These results emphasize the complexity of pest management, where chemical treatments tend to offer more immediate control over pests, while biological options like *B. bassiana* may require more specific conditions for optimal performance. Additionally, the limitations of this study include the potential for pest resistance to chemical treatments over time and the variability of biological control agents under different environmental conditions. Future research could explore integrated pest management strategies that combine chemical and biological controls to enhance long-term sustainability and efficacy in cucumber cultivation.

4. Conclusion

Our study evaluated the effectiveness of seven treatments for managing thrips, the most destructive sucking pest of cucumber, under open-field conditions. Insecticides were applied three times at seven-day intervals. Among all treatments, thiamethoxam 25% WG demonstrated the highest efficacy, achieving the greatest PROC and the highest yield (28.13 t/ha), followed by imidacloprid 70% WG (26.62 t/ha) and dimethoate 30% EC (19.09 t/ha). Since thrips populations tend to peak during the early vegetative stage, applying insecticides at this critical period can effectively reduce infestation and enhance cucumber yield. However, the possibility of insect resistance, effects on creatures that are not the intended target, and soil health are possible drawbacks and environmental issues. For sustainable pest control and biodiversity preservation, future studies should concentrate on improving insecticide use and investigating IPM techniques.

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