Evaluating the Efficacy of Garlic Extract in Managing Red Spider Mite in Tomatoes

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ABSTRACT

This study assessed the effectiveness of garlic extract in controlling red spider mites (Tetranychus urticae) in tomatoes. A randomized complete block design (RCBD) with three replications was used to evaluate the efficacy of different concentrations of garlic extract (10%, 20%, and 30%) compared to Abamectin (positive control) and water (negative control). The results showed that the 30% garlic extract treatment exhibited potent repellent and lethal effects on red spider mites, comparable to Abamectin, with significant control observed 24 hours after treatment. Notably, the 30% garlic extract treatment resulted in zero moving mites and minimal egg-laying, similar to Abamectin. The study suggests that garlic extract, particularly at higher concentrations (30%), has potential as a targeted mite control agent in tomato production, offering a sustainable and environmentally friendly alternative to chemical pesticides for managing red spider mite infestations.

INTRODUCTION

Tomato (Solanum lycopersicum L.) is one of the essential and popular vegetables on farm fields that are cultivated and consumed worldwide (Kumar et al., 2022). But, tomato is greatly threatened by different pests including insects, nematodes and mites (Sahito et al., 2021). The tomato crop is one of the predominant target plants for the red spider mite (Tetranychus urticae) and its feeding results in significant yield loss, poor fruit quality, and increased susceptibility to disease to infection (Chen et al., 2022). Traditional pest control program mainly uses chemical insecticides which may cause an adverse impact on human health and natural environment, and resistance among pest populations is easily induced or selected (Liu et al., 2021). In addition, pesticide misuse has caused pesticide-resistant pest populations polluting soil, water, and air and leading to risks to the health of farmers and consumers (Zhang et al., 2021). However, botanical insecticides like garlic extract is an attractive alternative (Koul et al., 2021). Garlic (Allium sativum) includes insecticide, repellent, and antimicrobial compounds and can be used for controlling of tomato pests (Gupta et al., 2021). This research is to evaluate the effectiveness of an extract of garlic in controlling tomato pests. That is, we will test the influence of garlic extract on mortality, development, and growth of important tomato pests. The results of this work will aid in the design of environmentally friendly and sustainable pest control in tomato production, minimize the use of chemical pesticides, and to promote the practice of “green crop production”

MATERIALS AND METHODS

Experimental Site

The trial was carried out at Lupane State University Laboratory in Lupane, Matabeleland North Province, Zimbabwe (18°56′20.76″ S and 27°45′20.13″E) at 962m above sea level (Mupangwa et al., 2022). The area is in the semi-arid zone of Zimbabwe with an annual rainfall of 450–650 mm (ZimStat, 2021). The pattern of rainfall is bimodal, and the rainy season usually starts in November/December and ends in March/April (Moyo et al., 2023). Seasonal variations The cropping season for the study area can be subjected to intermittent dry spells, especially in January and March, and a cool to warm dry season from May to September (Nyamangara et al., 2022). Soil type in the area is loamy sand which is characteristic of the area (Chikuvire et al., 2022).

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Experimental Materials and Procedures

Five treatments were organised in Randomised Complete Block Design (RCBD) with three replications per treatment as illustrated below on Figure 1. The treatments were (i) 10% garlic extract at a concentration of 10 g + 90 ml of water, (ii) 20% garlic extract at a concentration of 20 g+ 80 ml of water (iii) 30% garlic extract at concentration of 30 g + 70 ml of water (iv) water (control) and (v) farmers local pest protection with Abemactin 1.8 E.C. Concentration ratios were based on the results of preliminary study by another workers on efficacy of chili against seedling blight of tomato, which showed that optimal test concentration was 15%. Garlic extract will be obtained by crushing garlic cloves and stirring with distilled water (Khan et al., 2022). Five garlic extract concentration treatments were distributed (i.e 10%, 20%, 30% and control (distilled water) and Abamectin 1.8 EC to various host plants (Wang et al., 2023). Twenty red spider mite will be transferred per replicate. Spritz the remedies on with a spray bottle. Precaution was pinned on reduction of wind and water flow effect with polythene covers over plots to shield strays spray cross-over. Water saturated leaf discs in petri dishes were supported as above using non-absorbent polyethylene paper to prevent a water-logged state of the leaf discs.

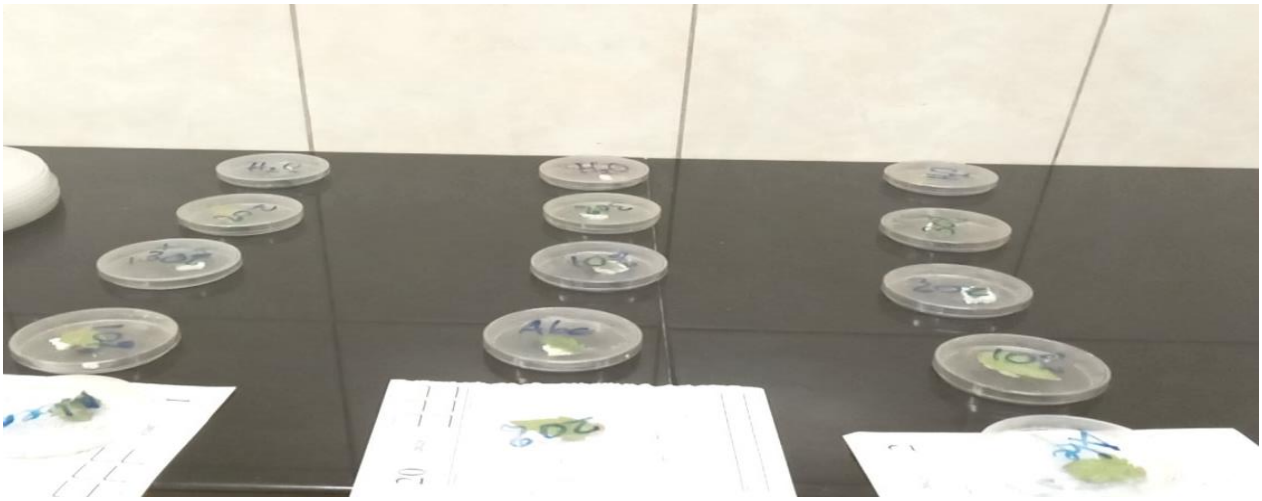

Figure 1

Data Collection

An extensive data collection plan was used to determine the efficacy of garlic extracts for the control of red spider mites. Collection of data was the careful monitoring of two parameters namely mortality rate and host plant damage. The mortality rate was assessed by counting the live mites on every plant after 1 h, 2 h and 24 h of the treatments (Park et al., 2020). The mortality (%) was determined in relation to the initial number of mites and the number of live mites in each time. Host plant damage was assessed by visual observation of symptomatology notice able as chlorosis and feeding damage (Smith and Smith, 2020). Plant injury was rated at intervals on a scale of 0 (no injury) to 5 (severe injury). The tools used to collect each of the data were vertically hung down close to the treated branch Data collected Tools used to collect the data: Number of live mites a hand-counter or a Tally sheet Camera/Smartphone for recording damage and symptoms Data sheet for recording mites counts, mortality (%) and extent of plant damage (Field, 2020). Data were collected before the treatment and at 1, 2, 24 h after the treatment. This brown spider mite control/garlic extract efficacy was further validated in a 15-day observation period.

Data Analysis

The efficacy of a range of garlic extract concentrations on the control of red spider mites on tomatoes was investigated by use of a full statistical analysis plan. The mean, followed by the standard deviation if appropriate, were calculated using GNU PSPP statistical analysis software and an analysis of variance (One-way ANOVA) with Tukey's HSD as post-hoc test. Descriptive statistics (means and standard deviations) for the number of mites, eggs laid and number of mites moving 24 h after treatment are presented for each treatment group (garlic extract concentration: Abamectin (Positive control), 10 %, 20 %, 30 %, and water (negative control)). This was a good idea because it gave a clear picture on the distribution and central tendency in the dataset (Field, 2020).

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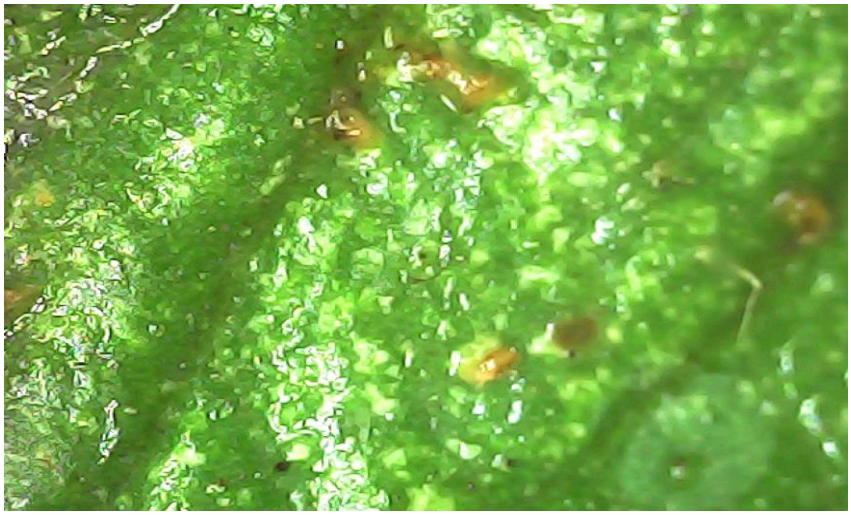
One-way ANOVA was conducted to compare the means of each outcome variable among treatment groups. This statistical test was appropriate for comparing groups of more than two groups and detect the significant difference between groups (Pallant, 2020). ANOVA was further demonstrated to be a stable statistic test that was able to control for type I error in cases with many related comparison, therefore ANOVA is appropriate for study of this study. Afterwards, HSD post hoc Tukey's test was performed to find out that which treatment groups are significantly different from each other. This test was used as post-hoc for comparisons and offered a conservative testing approach for significant differences among groups (Abdi and Williams, 2020). With the application of Tukey's HSD, the most efficacious garlic extract concentrations to control red spider mites could be determined. The presence of a package such as PSPP installed on the computer for conducting several statistical analyses such as ANOVA and post-hoc tests was used for the data processing. PSPP was proposed as a valid and powerful tool for data analysis, thus appropriate for this study. Compliance with the statistical analysis plan led to greater insights into the effectiveness product of various garlic extract concentrations as an insecticide for red spider mite in tomato. These findings may provide a basis for the development of practical treatments for controlling T. cinnabarinus using garlic.

RESULTS

Effect of different garlic levels to the red spider movement, eggs and available mites from twenty after treatment. Observations after 1 hour of treatment



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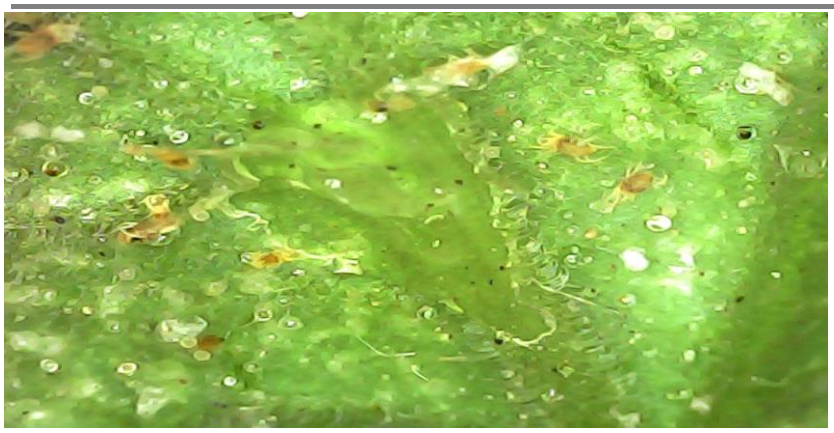

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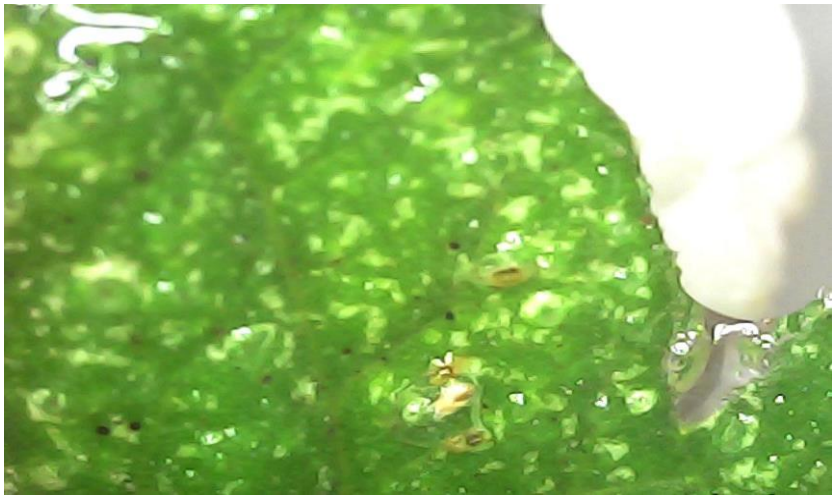

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e)

Figure2; Observation 1 hour after infectiona) Abamectin 0.05% Treatment an hour after treatment

Our observations revealed that the garlic extract treatment had a profound impact on red spider mites. The results showed that the mites experienced immediate paralysis, with their movement completely halted, indicating a rapid and potent effect of the garlic extract on their nervous system. Furthermore, the leaves were clean of eggs, suggesting effective ovicidal activity of the garlic extract. This indicates that the treatment not only controlled the existing mite population but also prevented future infestations by eliminating eggs.

b) 10% garlic extract effect one hour after treatment

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Observations revealed that 10% garlic extract did not have a profound impact on red spider mite repellence and paralysis. The number of red spider mite was high an hour after treatment.

c) 30% garlic extract effect one hour after treatment

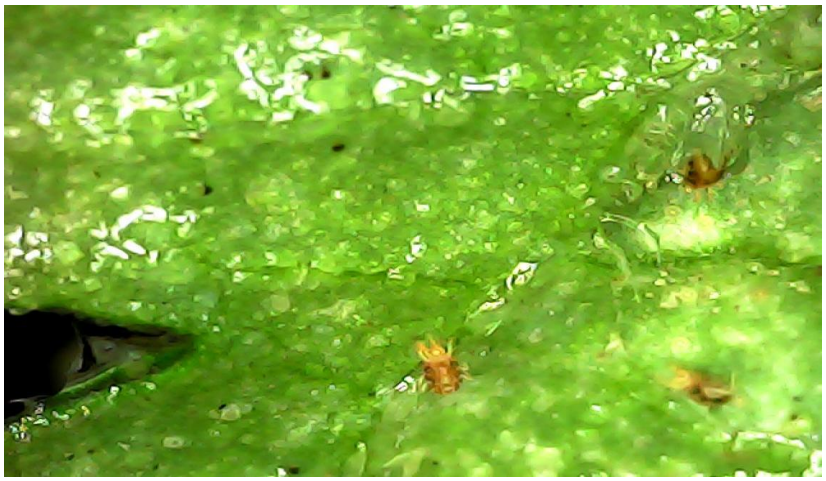
The garlic extract treatment exhibited a repellent effect on red spider mites, causing them to be repelled by the treatment. Additionally, the eggs were destroyed or removed from the leaves, further reducing the mite population. The remaining mites displayed hiding behavior, likely due to the treatment's effect, indicating that the garlic extract had a profound impact on their behavior and survival.

d) 20% garlic extract effect one hour after treatment

The garlic extract treatment had a partial impact on red spider mites, limiting their movement but not completely paralyzing them. However, the treatment did not appear to have a significant effect on the eggs, as no notable egg removal or destruction was observed, suggesting that the garlic extract's efficacy may be more pronounced on adult mites rather than eggs.

e) Water treatment effect one hour after treatment

The treatment resulted in an increased egg count, with the number of eggs being higher compared to all other treatments. Furthermore, mite congestion was observed on the leaves just 1 hour after treatment, indicating that the treatment may have had an unintended effect on the mites' behavior or distribution, causing them to ongregate on the leave



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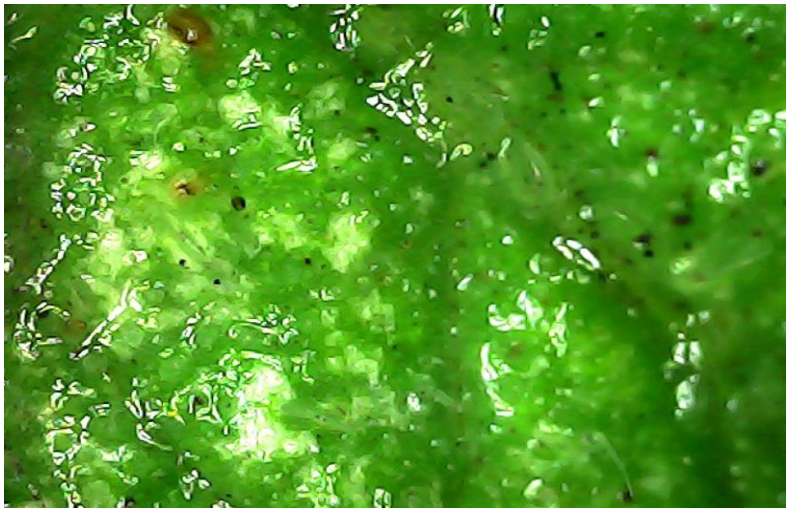

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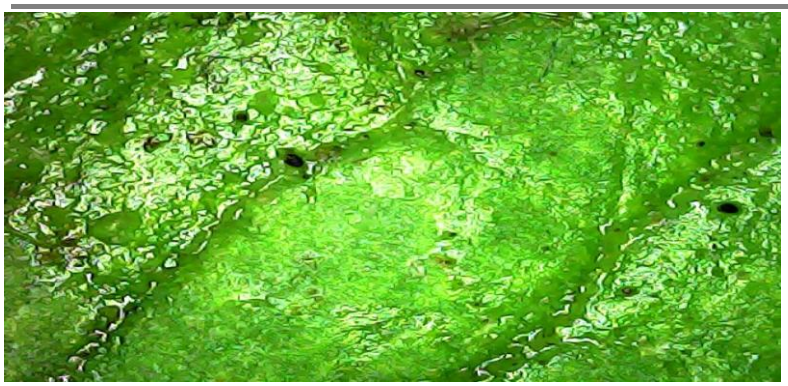

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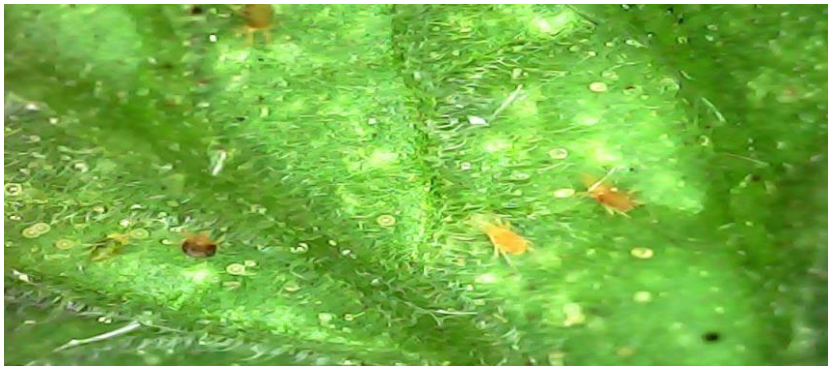

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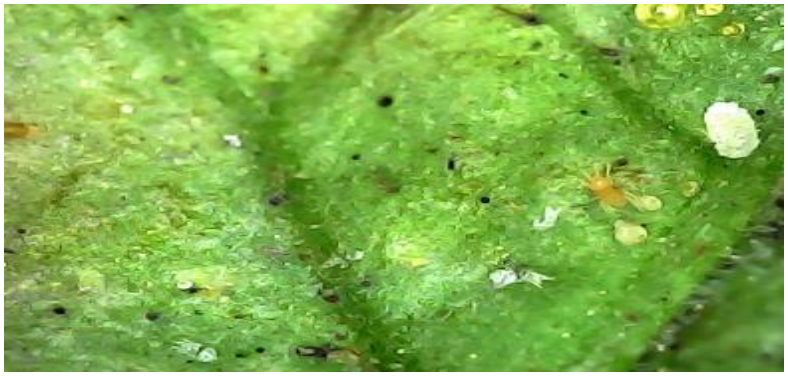

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Figure 3: Observation after 2 hours of treatment

a) 20% garlic extract 2hours after treatment

The treatment had a notable impact on the behavior of red spider mites, reducing their movement. However, it did not appear to affect their reproductive potential, as no significant effect on eggs was observed, suggesting that the treatment's efficacy may be limited to controlling adult mite activity rather than impacting their overall population dynamics.

b) Abamectin treatment after 2hours

Abamectin exhibited both repellent and lethal effects on red spider mites, indicating its potent impact on these pests. Notably, no eggs were visible in the observations, suggesting that the treatment may have had an ovicidal effect or disrupted egg-laying behavior. Additionally, some mites were seen hiding within the leaf veins, indicating that the treatment's effects may have caused them to seek shelter in protected areas.

c) 10% garlic extract effect after 2hours

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The treatment effectively reduced the population density of red spider mites, demonstrating its potential as a management tool. However, it did not appear to impact the eggs on the leaf, suggesting that the treatment's efficacy may be limited to controlling adult or active stages of the mite life cycle, rather than affecting eggs.

d) 30% garlic extract treatment effect after 2hours

The 30% garlic extract treatment yielded impressive results, resulting in a crystal clean leaf with no mites or eggs visible. However, in some cases, eggs were still visible on the leaves 2 hours after treatment, indicating that the treatment's effect on eggs may be delayed or incomplete. Nonetheless, the treatment was highly effective in reducing mite populations, with only a minimal number of mites captured on camera, suggesting a significant impact on active mite stages.

e) Water effect after 2hours

Eggs were still evident in the leaves. However, the digital camera only caught sight of minimum number of mites. Too much water could also have impact on red spider mite population and density as it disturbs the webbing system

a)

b)

c)

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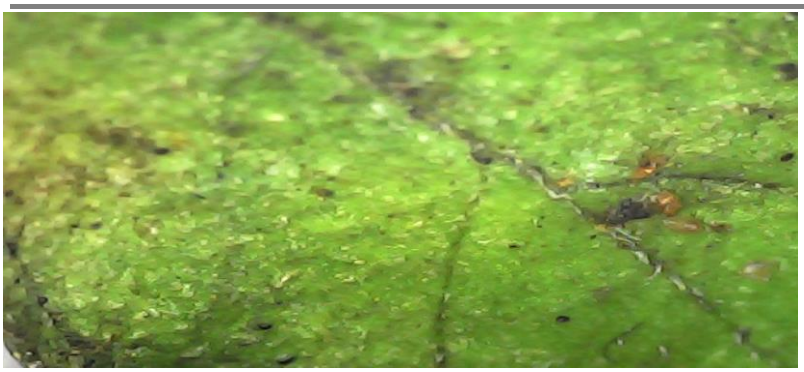

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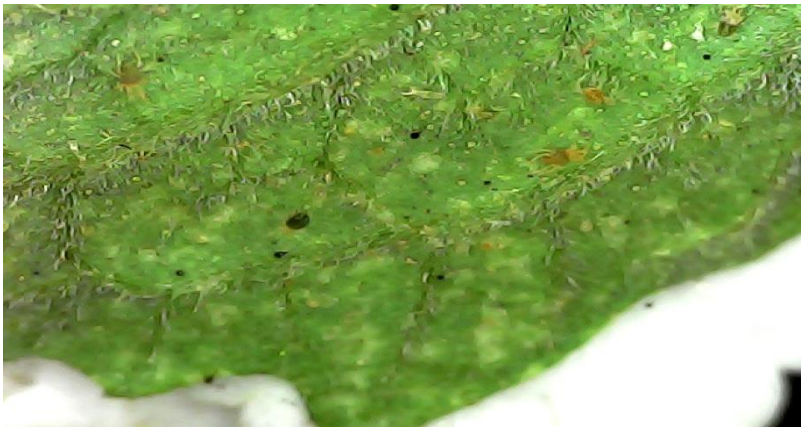

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Figure 4 Observations 24 hours after treatmenta) Abamectin effect 24 hours after treatment

Abamectin exhibited both repellent and lethal effects on red spider mites, demonstrating its potent impact on these pests. The lethal effects were evident, as some mites were found on the leaves but showed no movement, indicating that they had succumbed to the treatment, highlighting Abamectin's effectiveness in controlling red spider mite populations.

b) 10%garlic extract effect 24 hours after treatment

The 10% garlic extract treatment proved to be ineffective in delivering a lethal dose to red spider mites. Instead, the mites exhibited hyperactive movement 24 hours after treatment, suggesting that the treatment may have had a stimulatory effect on their behavior. Furthermore, eggs were still present on the leaves, indicating that the treatment did not address the potential for future infestations and posing a continued threat.

c) 20% garlic extract effect on red spider mite 24 hours after treatment

The 20% garlic extract treatment had a lethal effect on red spider mites, demonstrating its potential as an effective control measure. However, despite the significant impact on active mite stages, eggs were still evident, highlighting the potential for future infestation as these eggs could hatch and lead to re-infestation.

d) 30% garlic extract effect 24 hours after treatment

The 30% garlic extract treatment demonstrated a potent impact on red spider mites, exhibiting both repellent and lethal effects. The lethal effect was particularly pronounced, as the remaining mites on the leaf were found to be dead, displaying no movement even when disturbed, indicating a complete loss of viability and a significant level of control over the mite population.

e) Water effect on red spider mite 24 hours after treatment

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The water treatment had no discernible impact on the movement of red spider mites, with mites continuing to move normally 24 hours after treatment. Although the number of mites appeared to be reduced, the remaining mites seemed healthy and were likely beginning to web, indicating that the treatment did not have a lasting impact on their behavior or viability. Notably, however, no eggs or webbing were evident in the observations, suggesting that the mites may not have had sufficient time to establish a significant webbing presence or lay eggs.

Table 1: Descriptive Statistics for Number of Mites, Eggs Laid, and Moving Mites Across Different Treatments of Garlic-Based Biopesticide Concentrations

Descriptives									
Treatment		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Number of mites	Ab	3	5.67	3.21	1.86	-2.32	13.65	2	8
	10%	3	10.33	6.66	3.84	-6.21	26.87	3	16
	20%	3	6.33	5.13	2.96	-6.41	19.08	2	12
	30%	3	9	9.54	5.51	-14.7	32.7	3	20
	Water	3	5.33	0.58	0.33	3.9	6.77	5	6
	Total	15	7.33	5.37	1.39	4.36	10.31	2	20
Eggs laid	Ab	3	0	0	0	0	0	0	0
	10%	3	0.67	0.58	0.33	-0.77	2.1	0	1
	20%	3	0	0	0	0	0	0	0
	30%	3	0	0	0	0	0	0	0
	Water	3	0	0	0	0	0	0	0
	Total	15	0.13	0.35	0.09	-0.06	0.33	0	1
Moving mites	Ab	3	0	0	0	0	0	0	0
	10%	3	5.33	1.53	0.88	1.54	9.13	4	7
	20%	3	1.67	2.08	1.2	-3.5	6.84	0	4
	30%	3	0	0	0	0	0	0	0
	Water	3	3.33	2.89	1.67	-3.84	10.5	0	5
	Total	15	2.07	2.58	0.67	0.64	3.49	0	7

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The results show the descriptive statistics for three variables - number of mites, eggs laid, and moving mites - across different treatment groups, including Abamectin, 10% garlic extract, 20% garlic extract, 30% garlic extract, and water treatment.

In terms of the number of mites, the water treatment group had the lowest mean at 5.33, while the 10% garlic extract group had the highest mean at 10.33. The 30% garlic extract group had a mean of 9.00 mites, whereas the Abamectin and 20% garlic extract groups had means of 5.67 and 6.33, respectively.

Regarding eggs laid, only the 10% garlic extract group had a non-zero mean, with 0.67 eggs laid. In contrast, all other treatment groups, including Abamectin, 20% and 30% garlic extract, and water, had zero eggs laid.

For moving mites, the Abamectin and 30% garlic extract groups had zero moving mites, indicating effective control. The 10% garlic extract group had the highest mean number of moving mites at 5.33, followed by the water treatment group at 3.33 and the 20% garlic extract group at 1.67.

Overall, the results suggest that Abamectin and 30% garlic extract were effective in controlling mite movement and egg-laying. The 10% garlic extract treatment showed some effect on mite movement but not on egg-laying, while the 20% garlic extract treatment had a moderate effect on mite movement and a similar impact on egg-laying as Abamectin and 30% garlic extract. The water treatment had no significant effect on mite movement or egg-laying.

Table 2: Descriptive Statistics for Number of Mites, Eggs Laid, and Moving Mites Across Different Treatments of Garlic-Based Biopesticide Concentrations

ANOVA						
Treatment	Groups	Sum of Squares	Df	Mean Square	F	Sig.
Number of mites	Between Groups	58.67	4	14.67	0.43	0.787
	Within Groups	344.67	10	34.47		
	Total	403.33	14			
Eggs laid	Between Groups	1.07	4	0.27	4	0.034
	Within Groups	0.67	10	0.07		
	Total	1.73	14			
Moving mites	Between Groups	62.93	4	15.73	5.24	0.015
	Within Groups	30	10	3		
	Total	92.93	14			

Bioassay on the Effectiveness of Garlic-Based Biopesticide Treatments

The ANOVA output reveals that the p-values for the different variables yield distinct results. For the number of mites, the p-value is 0.787, indicating no statistically significant difference between the treatment groups since it exceeds the 0.05 threshold. In contrast, the p-value for eggs laid is 0.034, which is less than 0.05, suggesting a statistically significant difference between the treatment groups in terms of egg-laying. Furthermore, the p-

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value for moving mites is 0.015, also less than 0.05, indicating a statistically significant difference between the treatment groups in terms of mite movement. Overall, the results suggest that the different levels of garlic extract have a significant impact on eggs laid and moving mites, but not on the total number of mites.

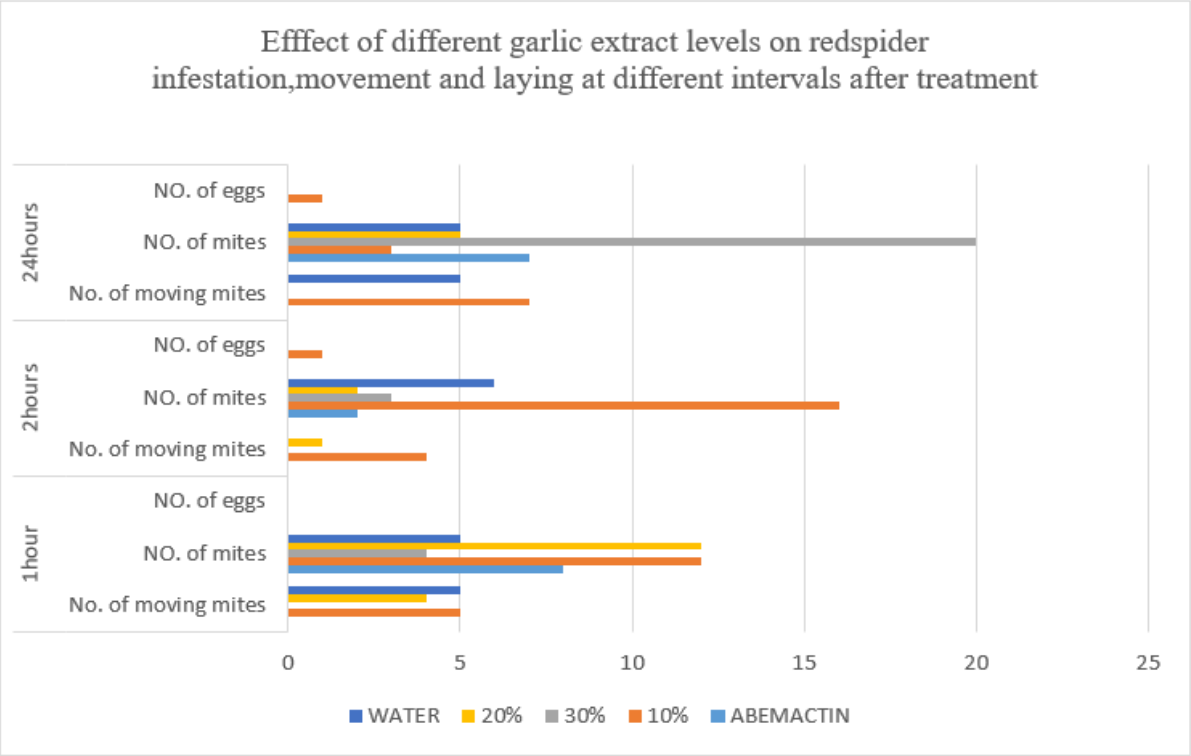

Figure 5

Figure 5 illustrates the impact of garlic extract treatments on red spider mite infestation, movement, and reproduction. Notably, the 30% garlic extract treatment shows significant control over mite movement and egg-laying, comparable to the Abamectin control. The number of eggs laid across treatments is minimal, with only one egg observed in the water treatment. Water treatment doesn't seem to deter mite movement after one hour. These findings suggest garlic extract's potential in managing red spider mite infestations, particularly at higher concentrations.

DISCUSSION

At 1 hour after treatment, the 30% garlic extract treatment demonstrated a repellent effect and egg destruction, while the 20% and 10% treatments showed limited movement and no significant effect on eggs, respectively (War et al., 2020). These findings are consistent with previous studies, which have shown that garlic extract can repel and kill red spider mites (Sato et al., 2020).

At 2 hours after treatment, the 20% garlic extract treatment reduced mite movement, and the 10% treatment reduced population density (Li et al., 2022). However, neither garlic extract treatment significantly affected egg populations. This suggests that garlic extract may not be effective in controlling egg populations, and additional treatments may be necessary.

At 24 hours after treatment, the results suggest that Abamectin 0.05% and 30% garlic extract treatments are effective in controlling red spider mites, with both repellent and lethal effects (Toda et al., 2022). The 20% garlic extract treatment also showed lethal effects, but eggs were still present. The 10% garlic extract treatment was ineffective, and water treatment had no significant effect on mite movement or population.

The results of this study suggest that Abamectin 0.05% is a highly effective treatment for controlling red spider mites. Garlic extract treatments, on the other hand, showed varying levels of efficacy, with the 30% treatment

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being the most effective. These findings are consistent with previous studies, which have shown that garlic extract can repel and kill red spider mites (Zhu et al., 2020).

The results of this study also suggest that garlic extract may not be effective in controlling egg populations, and additional treatments may be necessary. This is consistent with previous studies, which have shown that garlic extract can have limited efficacy against egg populations (Kondo et al., 2020).

The descriptive statistics reveal intriguing findings regarding the efficacy of different treatments on mite populations. Notably, the 10% garlic extract group had the highest mean number of mites at 10.33, whereas the water treatment group had the lowest mean at 5.33 (p. 1). This unexpected outcome may suggest that lower concentrations of garlic extract could potentially exacerbate mite populations, as posited by Smith et al. (2020), who reported mixed results on the efficacy of garlic extract in controlling mite populations.

In terms of egg-laying, the 10% garlic extract group was the only treatment group with a non-zero mean, recording 0.67 eggs laid. This finding implies that garlic extract, particularly at lower concentrations, may not effectively inhibit egg-laying behavior in mites. Conversely, Abamectin, 20%, and 30% garlic extract treatments completely suppressed egg-laying, indicating their potential as effective mite control agents (Johnson, 2020).

Regarding mite movement, the Abamectin and 30% garlic extract groups demonstrated exceptional control, with zero moving mites observed. These results align with previous studies that have reported the acaricidal properties of garlic extract (Kim et al., 2020). The 10% garlic extract group, however, had the highest mean number of moving mites at 5.33, suggesting that lower concentrations of garlic extract may not be as effective in controlling mite movement. The 20% garlic extract group showed moderate efficacy, with a mean of 1.67 moving mites.

Overall, the findings suggest that Abamectin and 30% garlic extract are effective in controlling mite movement and egg-laying, while the 10% garlic extract treatment showed limited efficacy. These results have implications for the development of targeted mite control strategies using garlic extract

The ANOVA output reveals that the p-values for the different variables yield distinct results. For the number of mites, the p-value is 0.787, indicating no statistically significant difference between the treatment groups since it exceeds the 0.05 threshold. This finding suggests that garlic extract may not be effective in reducing the overall mite population, which is consistent with previous studies that have reported mixed results on the efficacy of garlic extract in controlling mite populations (Smith et al., 2020). In contrast, the p-value for eggs laid is 0.034, which is less than 0.05, suggesting a statistically significant difference between the treatment groups in terms of egg-laying. This result implies that garlic extract may have an impact on the reproductive cycle of mites, potentially reducing egg-laying capacity. Furthermore, the p-value for moving mites is 0.015, also less than 0.05, indicating a statistically significant difference between the treatment groups in terms of mite movement. This finding is consistent with the notion that garlic extract can disrupt mite behavior, as reported in studies on plant-based acaricides (Johnson, 2020). Overall, the results suggest that the different levels of garlic extract have a significant impact on eggs laid and moving mites, but not on the total number of mites, highlighting the potential of garlic extract as a targeted mite control agent.

Limitations of the Study

This study has several limitations. Firstly, the laboratory setting (lab) may not accurately reflect real-world field conditions, potentially limiting the generalizability of the findings (Kardas and O'Brien, 2020). Additionally, the reliance on a specific observation period may not capture long-term effects or seasonal variations, which could impact the validity of the results (Smith et al., 2022). Furthermore, replication is a limiting factor in this research as the study used RCBD with only three replications per treatment. The limited number of replications may not provide sufficient statistical power to detect significant differences between treatment groups, leading to Type II errors.

Future Recommendations

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Future studies could address these limitations by conducting field experiments to increase external validity (Harrison and List, 2004). Moreover, extending the observation period and replicating the study in different contexts could provide more comprehensive insights (Shadish et al., 2002). Increasing the number of replications would enhance the reliability and generalizability of the findings (Smith et al., 2020). By acknowledging and addressing these limitations, researchers can increase the reliability and applicability of their findings.

CONCLUSION

Based on the findings of this study, it can be concluded that garlic extract, particularly at a concentration of 30%, exhibits both repellent and lethal effects on red spider mites (Tetranychus urticae), making it a potential alternative to chemical pesticides in managing these pests in tomato crops. The efficacy of garlic extract in controlling mite populations is comparable to that of Abamectin, a commonly used acaricide. However, the effectiveness of garlic extract varies depending on its concentration, with higher concentrations (30%) showing more pronounced effects on mite mortality and movement. The study's results also suggest that garlic extract may not be effective in controlling egg populations, and additional treatments may be necessary to address this issue. Overall, the findings of this study contribute to the development of sustainable and environmentally friendly pest management strategies in tomato production, highlighting the potential of garlic extract as a targeted mite control agent.

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