

Evaluating the Effectiveness of Garlic (*Allium sativum*) in Controlling Aphids (*Aphis gossypii*) in Tomato (*Solanum lycopersicum*) Production in Zvimba District, Mashonaland West

Moreblessing Mugovi¹, Rumbidzai D. Katsaruware-Chapoto²

¹Department of Agricultural Management, Zimbabwe Open University, Mashonaland West Regional Campus, Chinhoyi, Zimbabwe and

Ministry of Lands, Agriculture, Fisheries, Water and Rural Development, Department of Veterinary Services, Zvimba District, Mashonaland West Province

²Department of Agricultural Management, Zimbabwe Open University, Mashonaland West Regional Campus, Chinhoyi, Zimbabwe
Corresponding Author Email: [katsaruwarer\[at\]zou.ac.zw](mailto:katsaruwarer[at]zou.ac.zw)

Abstract: This study evaluated the efficacy of garlic (*Allium sativum*) extract as a biopesticide for the control of aphids (*Aphis gossypii*) and its effects on crop growth, development, and marketable yield in tomato (*Solanum lycopersicum*) production. The objectives were to determine the effects of different concentrations of garlic extract on plant height, aphid population, leaf damage, and marketable yield, assessing its potential as an environmentally sustainable alternative to synthetic pesticides. The field experiment was conducted in Ward 17 of Zvimba District, Mashonaland West Province, Zimbabwe, laid out in a Randomized Complete Block Design (RCBD) with six treatments and three replications. The treatments evaluated were 5%, 10%, 15%, and 20% (w/v) crude aqueous garlic extract, a positive chemical control (flubendiamide, Belt 480 SC at 0.1 mL/L), and an untreated negative control. Data were subjected to analysis of variance (ANOVA) at the 5% significance level using GenStat. Garlic extract concentration significantly influenced plant height, aphid population, leaf damage, days to flowering, and marketable yield ($P < 0.05$). Plant height increased progressively with concentration; at 10 weeks after transplanting, the 20% garlic extract produced plants measuring 72.00 cm, compared with 49.00 cm in the untreated control and 75.00 cm in the chemical control. Aphid populations decreased substantially with increasing garlic extract concentration: by day 7 post-application, the 20% extract suppressed aphid densities to 3.33 aphids/plant compared with 23.00 aphids/plant in the untreated control. Cumulative leaf damage scores at week 8 were markedly reduced from 15.33 in the untreated control to 3.33 in the 20% treatment. Days to flowering were shortened by 10 days under 20% garlic extract (35.33 days) relative to the untreated control (45.33 days). Marketable fruit yield increased progressively, achieving 10.8 t/ha under the 20% extract relative to 6.0 t/ha in the untreated control and 12.0 t/ha in the chemical standard. The findings demonstrate that crude garlic extract at 20% provides substantial aphid suppression and yield protection, serving as an accessible, cost-effective botanical component in integrated pest management.

Keywords: *Allium sativum*, *Aphis gossypii*, biopesticide, integrated pest management, *Solanum lycopersicum*.

1. Introduction

Tomato (*Solanum lycopersicum*) is one of the most widely cultivated vegetable crops globally, serving as a critical dietary source of vitamins A, C, and lycopene, while sustaining rural smallholder livelihoods through rapid cash generation [1], [2]. In Zimbabwe, tomato cultivation is central to smallholder horticultural production and peri-urban supply chains [3]. However, productivity remains severely constrained by biotic stress factors, particularly sap-sucking insect pests [4]. Aphids (*Aphis gossypii* Glover and *Myzus persicae* Sulzer) cause substantial direct yield losses through phloem ingestion, physiological stunting, and honeydew deposition, and act as vectors for devastating plant viruses such as tomato yellow leaf curl virus [4], [5].

Smallholder pest management has historically relied on synthetic neurotoxic insecticides, including organophosphates and synthetic pyrethroids [6]. Continued and improper chemical usage has driven pest resurgence, insecticide resistance, secondary pest outbreaks, environmental degradation, and severe consumer health hazards [6], [7]. Consequently, research into plant-derived biopesticides has gained traction globally [7], [8]. Botanical

extracts from neem (*Azadirachta indica*), pawpaw (*Carica papaya*), and chili (*Capsicum annum*) have demonstrated broad-spectrum suppression against hemipteran pests [9], [10].

Garlic (*Allium sativum* L.) produces organosulfur metabolites, notably allicin (diallyl thiosulfinate), diallyl disulfide, and trisulfide, which possess strong repellent, antifeedant, neurotoxic, and membrane-disrupting insecticidal activities [11]–[13]. Bioactive garlic compounds exhibit low persistence and rapid environmental degradation, presenting a minimal risk of insecticidal residue accumulation [13].

Despite growing interest, empirical field research defining the optimal concentration-response dynamics of crude garlic extract on aphid suppression and simultaneous tomato crop growth under field conditions in Zimbabwe remains scarce [14], [15]. Smallholder farmers in Zvimba District report low yields averaging 5–10 t/ha against an agro-ecological potential of 15–30 t/ha, driven primarily by uncontrolled insect infestations [15], [16]. This study evaluated the bio-efficacy of crude aqueous garlic extract concentrations (5%, 10%, 15%, and 20%) on aphid suppression, leaf damage

reduction, phenological development, and marketable yield in open-field tomato production in Zvimba District, Mashonaland West Province.

2. Materials and Methods

2.1 Experimental Site

The field trial was carried out in Ward 17 of Zvimba District, Mashonaland West Province, Zimbabwe (17°21'00" S, 30°12'00" E). The site is located in Natural Agro-ecological Region IIb, characterized by unimodal annual rainfall ranging between 750 mm and 1,000 mm, with mean summer temperatures of 20–29 °C and winter temperatures of 14–19 °C [17]. Soil textural analysis confirmed well-drained sandy loam with a pH range of 5.5 to 7.0 [18]. Water was sourced from protected deep boreholes typical of peri-urban farming systems [19].

2.2 Preparation of Garlic Extract

Certified fresh, undamaged garlic bulbs were procured from local agricultural markets. Cloves were peeled, rinsed with distilled water, weighed, and blended into a smooth paste. A stock concentrate (10% w/v base) was prepared by blending 100 g of crushed paste into 100 mL of distilled water, followed by dilution with 900 mL of distilled water to make a 1 L concentrated slurry [20]. The mixture was incubated at ambient room temperature (25 ± 2 °C) in darkness for 24 h to extract thiosulfates and allicin [11], [20]. The crude suspension was filtered through multi-layered muslin cloth to yield clear liquid stock. Spray mixtures were reconstituted using the dilution formula $C_1V_1 = C_2V_2$, where C_1 represents stock concentrate, V_1 is aliquot volume, C_2 is target concentration, and V_2 is total solution volume (1,000 mL). Four working spray concentrations were prepared: 5% (50 mL stock/L), 10% (100 mL stock/L), 15% (150 mL stock/L), and 20% (200 mL stock/L). Treatments were prepared fresh within 24 h of spraying to avoid allicin volatilization and oxidative breakdown [11], [13].

2.3 Experimental Design, Crop Management, and Field Operations

The trial was laid out in a Randomized Complete Block Design (RCBD) with three replications. Six treatments were evaluated: T1 (5% garlic extract), T2 (10% garlic extract), T3 (15% garlic extract), T4 (20% garlic extract), T5 (positive chemical control: flubendiamide, Belt 480 SC at 0.1 mL/L), and T6 (untreated negative control). Eighteen plots measuring 3 m × 3 m (9 m²) were established, separated by 1 m access paths. Each plot accommodated three rows of six tomato plants ($n = 18$ plants/plot, plant density of 20,000 plants/ha). Seedlings of the determinate open-pollinated variety 'Rodade' (12–18 cm height) were transplanted into raised beds (15–30 cm high).

Basal Compound C fertilizer (6% N : 15% P₂O₅ : 12% K₂O + 14% S) was banded at transplanting at 1,000 kg/ha (50 g/station; 900 g/plot). Top-dressing included split applications of monoammonium phosphate (MAP at 25 kg/ha at 7 days post-transplant), ammonium nitrate (50 kg/ha at weeks 2, 3, and flowering), sulphate of potash (50 kg/ha at

fruit set), and foliar calcium nitrate (10 g/L) to prevent blossom-end rot. Staking, trellising, and sucker pruning were initiated 14 days post-transplanting.

2.4 Pest Inoculation, Spray Application, and Data Collection

Field-collected *Aphis gossypii* populations were artificially inoculated onto two permanently tagged index plants per plot at 15 insects per plant (10 apterous adult females and 5 males/nymphs) placed on young terminal shoots. Insects were left undisturbed for 7 days without overhead wetting. Foliar treatments were applied weekly using calibrated compression knapsack sprayers fitted with hollow-cone nozzles delivering 30 mL/plant, ensuring complete abaxial and adaxial coverage during calm morning hours. Parameters measured included: (a) Plant height (cm) recorded bi-weekly from ground level to the terminal bud; (b) Aphid counts on tagged shoots evaluated at 1, 2, 5, and 7 days post-spraying using a 10× magnification lens; (c) Leaf damage assessed 48 h after application across five upper fully expanded leaves; (d) Days to 50% flowering; and (e) Marketable fruit yield (t/ha) converted from graded mature fruits harvested across 7-day intervals.

2.5 Statistical Analysis

Data were subjected to Analysis of Variance (ANOVA) using GenStat Release 14. Residual normality and homoscedasticity were verified. Differences between treatment means were separated using Fisher's Protected Least Significant Difference (LSD) test at the 5% probability level ($P \leq 0.05$) [21].

3. Results

3.1 Plant Height Growth

Garlic extract concentration significantly altered tomato vegetative elongation ($P < 0.001$; Table 1). Plant height displayed an upward linear trajectory corresponding to higher garlic extract concentrations across all observation stages. At 10 weeks, plants treated with 20% garlic extract achieved 72.00 cm, approaching the chemical control (75.00 cm), whereas plants under the untreated control experienced severe stunting, reaching only 49.00 cm.

Table 1: Effects of garlic extract concentrations on tomato plant height (cm)

Treatment	4 Weeks	6 Weeks	8 Weeks	10 Weeks
T1 (5% garlic extract)	24.33	39.33	51.67 b	57.00b
T2 (10% garlic extract)	27.33	44.33	57.33c	62.00 c
T3 (15% garlic extract)	30.33	48.33	62.33 d	67.00 d
T4 (20% garlic extract)	33.33	52.33	67.33 e	72.00 e
T5 (Chemical control)	35.33	56.33	71.33 f	75.00 f
T6 (Untreated control)	20.33	33.33	44.33 a	49.00 a
Grand Mean	28.5	45.67	59.06	63.67

Note: Means within a column sharing identical superscript letters are not significantly different at $P \leq 0.05$. LSD (5%): Week 8 = 0.4288, Week 10 = 1.102; $P < 0.001$.

3.2 Aphid Population Suppression

Foliar garlic applications elicited significant concentration-dependent mortality and deterrence against *A. gossypii* ($P < 0.001$; Table 2). Aphid populations expanded unchecked in the untreated control, rising from 18.33 aphids/plant at Day 1 to 23.00 at Day 7. In contrast, 20% garlic extract drove populations down to 2.67 aphids/plant by Day 5 and maintained control at 3.33 aphids/plant by Day 7. The positive chemical control maintained the lowest counts (1.00–1.67 aphids/plant).

Table 2: Effects of garlic extract concentrations on *Aphis gossypii* population per plant

Treatment	Day 1	Day 2	Day 5	Day 7
T1 (5% garlic extract)	10.33 e	9.33 e	8.33 e	11.00 e
T2 (10% garlic extract)	8.00 d	7.33 d	6.33 d	8.33 d
T3 (15% garlic extract)	5.67 c	5.00 c	4.67 c	5.67 c
T4 (20% garlic extract)	3.67 b	3.00 b	2.67 b	3.33 b
T5 (Chemical control)	1.67 a	1.33 a	1.00 a	1.67 a
T6 (Untreated control)	18.33 f	20.33 f	21.67 f	23.00 f
Grand Mean	7.94	7.72	7.44	8.83

Note: Means within a column sharing identical superscript letters are not significantly different at $P \leq 0.05$. LSD (5%): Day 1 = 0.636, Day 2 = 0.791, Day 5 = 0.791, Day 7 = 1.448; $P < 0.001$.

3.3 Leaf Damage

Foliar feeding injury differed significantly across treatments over the 8-week monitoring window ($P < 0.001$; Table 3). Cumulative feeding injury reached 15.33 in untreated control plots at week 8. Plants protected by 20% garlic extract sustained low damage (3.33), closely trailing the positive control (1.67).

Table 3: Effects of garlic extract concentrations on leaf damage severity score

Treatment	Week 2	Week 4	Week 6	Week 8
T1 (5% garlic extract)	5.00 e	7.00 e	8.00 e	9.33 e
T2 (10% garlic extract)	4.00 d	5.00 d	6.00 d	7.33 d
T3 (15% garlic extract)	3.00 c	4.00 c	5.00 c	5.33 c
T4 (20% garlic extract)	2.00 b	3.00 b	3.00 b	3.33 b
T5 (Chemical control)	1.00 a	1.00 a	1.67 a	1.67 a
T6 (Untreated control)	10.33 f	12.33 f	14.33 f	15.33 f
Grand Mean	4.22	5.39	6.33	7.06

Note: Means within a column sharing identical superscript letters are not significantly different at $P \leq 0.05$. LSD (5%): Week 2 = 0.4288, Week 4 = 0.4288, Week 6 = 0.5753, Week 8 = 0.4288; $P < 0.001$.

3.4 Phenological Days to Flowering and Marketable Yield

Garlic extract application significantly accelerated floral initiation and elevated marketable tomato fruit yields ($P < 0.001$; Table 4). High aphid feeding pressure in untreated plots delayed floral development (45.33 days), whereas 20% garlic treatment reduced flowering time to 35.33 days. Marketable fruit yields followed an upward linear trend with extract dosage: the 20% concentration yielded 10.80 t/ha- an 80% increase over the untreated control (6.00 t/ha)- compared with 12.00 t/ha produced under the synthetic insecticide regimen.

Table 4: Effects of garlic extract concentrations on flowering time and marketable tomato yield

Treatment	Days to Flowering	Marketable Yield (t/ha)	Mean Separation (Yield)
T1 (5% garlic extract)	41.33	8.5	b
T2 (10% garlic extract)	39.33	9.2	c
T3 (15% garlic extract)	37.33	10.1	d
T4 (20% garlic extract)	35.33	10.8	e
T5 (Chemical control)	33.33	12	f
T6 (Untreated control)	45.33	6	a
Grand Mean	38.67	9.43	—

Note: Means within the yield column sharing identical lowercase letters are not significantly different at $P \leq 0.05$. LSD (5%) for yield = 0.1485 t/ha; $P < 0.001$.

4. Discussion

This study confirms that aqueous garlic bulb extracts exert concentration-dependent insecticidal and deterrent activity against *Aphis gossypii* in field-grown tomatoes. The reduction in aphid density with higher extract strength matches findings by Hussain et al. [11], who observed that increasing concentrations of *A. sativum* extracts led to lower leaf damage, suppressed aphid populations, and enhanced tomato fruit yields.

The insecticidal activity of garlic is largely attributable to low-molecular-weight organosulfur constituents, principally allicin, diallyl trisulfide, and diallyl disulfide [12], [13]. These volatile lipophilic compounds penetrate the insect cuticle and respiratory spiracles, inhibit acetylcholinesterase, and generate cytotoxic reactive oxygen species within hemipteran tissues [13], [22]. Strong volatile emissions also mask tomato kairomones, acting as olfactory deterrents that disrupt host recognition, feeding settling, and reproductive larviposition [22], [23].

Suppressing aphid feeding preserved plant photosynthetic surface area, as reflected in lower leaf damage and greater plant height. In untreated control plots, sap depletion led to chlorosis, epinastic curling, and delayed flowering (45.33 days). By contrast, plants sprayed with 20% garlic extract flowered 10 days earlier (35.33 days), demonstrating that suppressing sap-feeding stress maintains physiological source-sink partitioning toward generative floral buds [11], [24].

Marketable yield rose from 6.00 t/ha in untreated plots to 10.80 t/ha under 20% garlic extract. While the synthetic chemical control achieved the highest yield (12.00 t/ha), 20% garlic extract captured 90% of the synthetic insecticide's yield potential without introducing persistent synthetic residues. These results align with broader evidence on botanical pest management in sub-Saharan Africa, where crude extracts enhance smallholder productivity while conserving beneficial arthropod guilds [9], [15], [25].

5. Conclusion and Recommendations

Crude garlic extract significantly suppresses *Aphis gossypii* infestations, limits foliar feeding damage, accelerates flowering, and increases marketable tomato yields under

open-field conditions in Zvimba District. Bio-efficacy responded in a clear concentration-dependent manner, with the 20% extract providing the highest suppression and yield performance among botanical treatments. Based on these results:

- Smallholder farmers can incorporate 20% (w/v) aqueous garlic extract as a botanical component of integrated pest management (IPM) schemes, particularly within low-input and peri-urban production systems.
- Garlic extract should be positioned as an IPM rotation partner rather than an exclusive replacement for conventional chemistries, mitigating selection pressure for synthetic insecticide resistance while maintaining acceptable yield levels.
- Extension services should train growers on standardized 24-hour aqueous extraction, filtration, and timely application during early infestation.
- Further field research should explore extract concentrations between 20% and 30%, evaluate persistence across rainy and dry cropping seasons, and assess economic return profiles relative to commercial synthetic insecticides.

References

- [1] R. Kumar, S. Patel, and V. Singh, "Efficacy of garlic extract against sap-sucking insect pests in vegetable production," *Journal of Biological Pest Management*, vol. 14, no. 1, pp. 23–34, 2022.
- [2] A. Tuba, S. Ibrahim, and Y. Mohammed, "Antioxidant properties of tomatoes and human health," *Journal of Food Biochemistry*, vol. 48, no. 2, Art. no. e14567, 2024.
- [3] T. Moyo, B. Ncube, and P. Dube, "Tomato production under tropical conditions," *Zimbabwe Journal of Agricultural Research*, vol. 61, no. 1, pp. 18–30, 2023.
- [4] M. K. Kansime, I. Rwomushana, I. Mugambi, F. Makale, and J. Lamontagne-Godwin, "Farmer perception of pests and pest management in tomato production," *Crop Protection*, vol. 141, Art. no. 105470, 2021.
- [5] M. Allam, A. Hassan, and K. Ibrahim, "Economic impact of aphid infestation on tomato production," *Crop Protection*, vol. 170, Art. no. 106285, 2023.
- [6] M. Ulusoy, "Synthetic insecticides used in tomato production and their environmental implications," *Journal of Plant Protection Research*, vol. 64, no. 1, pp. 89–99, 2024.
- [7] P. Sola, J. Muriuki, and P. Kamau, "Pesticide resistance and resurgence in vegetable insect pests," *Crop Protection*, vol. 156, Art. no. 105950, 2022.
- [8] H. Zha, R. Wang, and Y. Wang, "Risk assessment of *Aphis gossypii* resistance development," *Journal of Entomological Science*, vol. 59, no. 3, pp. 258–274, 2024.
- [9] R. Pastor, "Evaluation of papaya leaf extract against insect pests of tomato," *Philippine Journal of Crop Science*, vol. 49, no. 1, pp. 60–69, 2024.
- [10] H. Sembwere, "Evaluation of Aloe vera extracts against cabbage aphids in Uganda," *Uganda Journal of Agricultural Sciences*, vol. 25, no. 1, pp. 72–81, 2024.
- [11] D. Hussain, M. Iqbal, N. Arshad, A. Ullah, M. Y. Javed, S. Ahmad, N. Fatima, N. Ud Din, U. Khalid, and M. Adeel, "Efficacy assessment of garlic extract as a natural aphid control agent on infected tomato plants," *Journal of Oasis Agriculture and Sustainable Development*, vol. 5, no. 4, pp. 27–31, 2023. <https://doi.org/10.56027/joasd.222023>
- [12] G. Giuliano, O. Campolo, G. Forte, A. Urbaneja, M. Pérez-Hedo, I. Latella, V. Palmeri, and G. Giunti, "Insecticidal activity of *Allium sativum* essential oil-based nanoemulsion against *Spodoptera littoralis*," *Insects*, vol. 15, no. 7, Art. no. 476, 2024. <https://doi.org/10.3390/insects15070476>
- [13] G. Orlando, L. Rossi, and P. Romano, "Biodegradability and resistance potential of garlic-derived biopesticides," *Crop Protection*, vol. 182, Art. no. 106724, 2025.
- [14] M. Nkiwane, "Constraints and opportunities in sustainable garlic pest management," *International Journal of Research and Innovation in Applied Science*, vol. 9, no. 3, pp. 41–52, 2024.
- [15] L. Sunic, "Farmer perceptions of botanical pesticides in Zimbabwe," *Journal of Sustainable Farming Systems*, vol. 7, no. 1, pp. 88–99, 2024.
- [16] Food and Agriculture Organization of the United Nations (FAO), "Tomato production statistics and trends," FAOSTAT Statistical Database, Rome, Italy, 2023.
- [17] United Nations Framework Convention on Climate Change (UNFCCC), "Fourth national communication of Zimbabwe to the United Nations Framework Convention on Climate Change: Revised agro-ecological zones and characteristics," UNFCCC Secretariat, Bonn, Germany, 2020.
- [18] J. Nyamangara, R. Chikowo, and K. E. Giller, "Soil fertility management for vegetable production in Zimbabwe," *Soil Use and Management*, vol. 38, no. 2, pp. 450–462, 2022.
- [19] CLAFSA, "Report on peri-urban agriculture and crop production in the study area," Chinhoyi Local Agricultural Farmers Association, Mashonaland West, Zimbabwe, Tech. Rep. 4, 2023.
- [20] M. B. Isman, "Botanical insecticides in the twenty-first century—fulfilling their promise," *Annual Review of Entomology*, vol. 65, pp. 233–249, 2020.
- [21] M. Saunders, P. Lewis, and A. Thornhill, *Research Methods for Business Students*, 8th ed. Harlow, UK: Pearson Education, 2020.
- [22] P. Sharma and R. Singh, "Mechanisms of insecticidal action of garlic-derived compounds against agricultural pests," *Crop Protection Advances*, vol. 18, no. 1, pp. 12–25, 2024.
- [23] M. Rahman, N. Islam, and T. Ahmed, "Volatile compounds from garlic and their role in insect host-selection behaviour," *Journal of Chemical Ecology and Pest Management*, vol. 7, no. 1, pp. 33–42, 2023.
- [24] Y. Hassan, A. Mohamed, and M. Farouk, "Biotic stress reduction and flowering performance in horticultural crops," *Journal of Crop Physiology*, vol. 11, no. 2, pp. 66–79, 2024.
- [25] R. D. Katsaruware, T. D. Vere, B. Chapepa, D. Masikati, and R. Mapuranga, "Botanical extracts for insect control in crops," *Global Journal of Science Frontier Research: D Agriculture and Veterinary*, vol. 20, no. 4, pp. 15–24, 2020.