

Research Article

Formulation of Organic Pest Control from Garlic, Onion and Chili and Its Application on Cabbage Plant

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Abstract

The increasing reliance on chemical insecticides in agriculture has significantly boosted food production by controlling pest populations, yet this approach has also triggered serious ecological consequences including the loss of beneficial organisms and the emergence of resistant insect species. This study investigates a plant-based organic pest control formulation derived from garlic (*Allium sativum*), onion (*Allium cepa*), and chili (*Capsicum frutescens*) as a sustainable alternative for managing major insect pests in cabbage (*Brassica oleracea*). Target pests include the cabbage aphid (*Brevicoryne brassicae*), cabbage webworm (*Hellula undalis*), cabbage white butterfly (*Pieris brassicae*), and diamondback moth (*Plutella xylostella*), all of which threaten cabbage yield by infesting crops during various growth stages. Visual observations and insect count data taken from ten leaves per plant across five replicates revealed a 68% reduction in aphid populations and a 62% decrease in diamondback moth larvae two weeks post-treatment. These results affirm the efficacy of the organic spray, which leverages the insecticidal properties of bioactive compounds naturally present in garlic and chili. The formulation demonstrated pest-repelling capabilities without harming cabbage plants or beneficial insects, supporting its potential integration into sustainable pest management systems. The biodegradable nature of the spray, combined with its low environmental toxicity, aligns with the principles of integrated pest management (IPM) and contributes to reduced dependence on synthetic chemicals. These findings support the broader adoption of botanical pesticides as an eco-friendly strategy to maintain crop productivity, promote biodiversity, and enhance food safety.

Keywords

Cabbage, Organic Pesticides, Sustainable Agriculture and Chemical Insecticides

1. Introduction

Background of the Study

Cabbage (*Brassica oleracea* var. *capitata*) is an economically significant vegetable cultivated worldwide, valued for its high nutritional content. It is particularly rich in essential vitamins, minerals, and dietary fiber, making it a staple in many diets [1]. However, a number of insect pests, including

the diamondback moth (*Plutella xylostella*), aphids (*Brevicoryne brassicae*), and cabbage loopers (*Trichoplusia ni*), pose a danger to the production of cabbage and, if left unhindered, can result in large output losses [2]. To mitigate these losses, farmers often rely on synthetic insecticides. Nevertheless, the careless application of chemical pesticides has resulted in the

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loss of biodiversity, pesticide resistance, environmental degradation, and hazards to human health [1-3].

As alternative and safer substitutes for synthetic pesticides, botanical insecticides made from plants that contain bioactive chemicals have drawn attention. These plant-based pesticides reduce hazards to beneficial insects like pollinators and natural adversaries while providing environmentally responsible pest control solutions [3]. Due to their bioactive components' insecticidal qualities, garlic (*Allium sativum*) and hot pepper (*Capsicum frutescens*) have been found to be powerful botanical pesticides [4].

Garlic (*Allium sativum*) and onion (*Allium cepa*) are rich in bioactive compounds, thus have been extensively investigated for their pesticidal properties. These bio-molecules have been found to display numerous biological activities such as insecticidal, repellent, antifungal, and antibacterial activity and therefore they have become of immense interest as possible replacements for synthetic pesticides [5]. Examples are allicin, diallyl disulfide, and thiosulfates of organosulfur compounds since they are some of the bioactive compounds of onion and garlic that are responsible for the pesticidal action of inhibiting several insects [6].

Garlic is famously known to repel insects. Allicin, which is produced on tissue breakdown or crushing of garlic, is one of the sulfur compounds postulated to play a crucial role in its bioactivity [7]. In addition to repelling pests and suppressing their feeding activity, the sulfur volatiles re-direct the metabolism of the insects [8]. Additionally, garlic extracts have also shown antimicrobial activity, which can suppress secondary infections as a result of pest damage to the plant [9].

Capsaicinoids are present in chili peppers, and capsaicin is the main bioactive constituent that makes them insecticidal [10]. Capsaicin, through its binding with sensory neurons, triggers a burning effect that irritates and discourages insects from feeding [11]. Additionally, the compound kills insects' neurosystems, causing paralysis and death in certain insects [12]. Its full range of insecticidal potential is yet to be discovered, but its proven deterring effects.

Garlic and chili pepper botanical extracts have been proven by research to successfully suppress insect pest populations in cabbage plants [13]. For instance, previous work established that aqueous chili pepper and garlic extracts killed over 60% of diamondback moth larvae in a week of treatment [13]. Similarly, chili pepper extracts caused extensive mortality in aphids and cabbage loopers, showing that the plant materials have broad-spectrum insecticidal activities [14].

Experiments have established that chili pepper and garlic extracts are able to manage quite considerably the infestation of insect pests in cabbage farms. The previous research work literature review showed that aqueous extracts of chili pepper

and garlic inhibited populations of diamondback moth larvae by over 60% one week after treatment [13]. The finding identifies the potential of these plant-derived insecticides to manage pest infestations.

Similarly, other research previous conducted was observed that chili pepper extracts caused strong aphid and cabbage looper mortality [14]. It can thus be argued that these plant products are broad-spectrum insecticides that may prove to be very useful in integrated pest management programs in cabbage cultivation.

Use of these plant-based insecticides not only manages pest populations but also minimizes risks related to the use of synthetic pesticides, such as damage to beneficial insects like pollinators and natural enemies.

In addition, garlic and pepper sprays have been shown to have little negative effects on useful non-target insects, such as parasitic wasps and lady beetles (Coccinellidae), which serve to play a significant role in biological pest control [3]. Because of this feature, such crops are better suited to be applied in integrated pest management (IPM) strategies.

In contrast to synthetic pesticides, plant pesticides degrade quickly in the environment, with less chance of contamination after a period of time [15]. They are a sustainable option that is applied according to organic farming practices because they are biodegradable. Additionally, in contrast to conventional insecticides that have been linked to neurological disorders and endocrine disruption among human beings, chili pepper and garlic are affordable, readily accessible, and exert negligible health implications [16]. Numerous studies have demonstrated the efficacy of garlic and chili pepper extracts in controlling common cabbage pests. Moreover, these botanical insecticides are generally safe for beneficial insects such as lady beetles and parasitic wasps, making them suitable for inclusion in Integrated Pest Management (IPM) programs.

Beyond pest control, plant-based pesticides also pose fewer environmental and human health risks. Unlike synthetic pesticides, they degrade rapidly in the environment and align with organic farming practices. Additionally, they are affordable, locally available, and pose minimal health concerns compared to synthetic alternatives linked to endocrine and neurological disorders [16].

2. Materials and Methods

2.1. Ingredients and Proportions

The botanical pesticide was prepared using locally available ingredients: garlic, onion, cayenne pepper, liquid soap, and water. The specific proportions used in the formulation are outlined in table 1.

Table 1. The proportion of ingredients and their purpose.

Ingredient	Quantity	Purpose
Garlic (<i>Allium sativum</i>)	150 grams	Provides allicin and other sulfur compounds for insecticidal activity
Onion (<i>Allium cepa</i>)	150 grams	Enhances repellent effect through sulfur compounds
Cayenne pepper (<i>Capsicum frutescens</i>)	3 grams (powder)	Contains capsaicin, an insect neurotoxin and repellent
Water	1200 mL	Solvent for extraction and dilution
Liquid dish soap	20 mL	Acts as surfactant for better leaf adhesion

2.2. Preparation of the Botanical Pesticide

The botanical pesticide was prepared by mixing garlic (*Allium sativum*), onion (*Allium cepa*), cayenne pepper (*Capsicum frutescens*), liquid soap, and water. The procedure involved the following steps:

Chopping Ingredients (Garlic and Onion): Garlic cloves and onion bulbs were chopped into small pieces so that their active compounds would be released [7].

Mixing ingredients:

Chopped onions (*Allium cepa*) and garlic (*Allium sativum*) were combined with 3 grams of cayenne pepper (*Capsicum annuum*) powder and 940 mL of water in a cooking vessel to prepare a botanical insecticide. The addition of cayenne pepper, rich in capsaicin a pungent compound known for its insect-repellent properties enhances the efficacy of the mixture by making plants unpalatable to pests without affecting crop quality [3, 17]. The mixture was brought to a boil at approximately 95 °C, then simmered at 85 °C for 15 minutes to promote the extraction of bioactive compounds [8]. After heating, the mixture was steeped at room temperature for 24 hours to ensure complete diffusion of insecticidal constituents. Finally, the solution was filtered through a fine mesh to remove solid residues, producing a smooth liquid pesticide. This preparation method aligns with sustainable pest control practices, offering an effective, low-impact alternative to synthetic chemicals [3, 19].

Final Preparation: Liquid soap was added to the strained extract to act as a surfactant, improving adhesion to plant surfaces [3].

Storage and Application: The final pesticide solution was stored in a spray bottle for field application.

The preparation of the botanical insecticidal spray was founded on previous studies of plant-based pest control products [3, 7].

Preparation of Ingredients – A head of garlic (*Allium sativum*) and a head of onion (*Allium cepa*) were minced through the use of a cutting board and a knife. These ingredients were utilized because they contain sulfur-containing molecules, which are natural insect repellents [7].

Mixture Assembly – They put the garlic and onion, which

had been minced, into a large pot. There was then added 15 mL of liquid dish soap, 940 mL of water, and 2 g of cayenne pepper (*Capsicum annuum*). By irritating insects, capsaicin, which occurs in cayenne pepper, increases its insect-killing activity [10].

Heating Process – The mixture was heated over medium to high heat until boiling. The heat was lowered to medium when it boiled, and the mixture was allowed to simmer for an additional 15 minutes. Heating enables the release of bioactive compounds, which increases the insecticidal activity [11].

Cooling and Filtration – The saucepan was removed from heat after simmering and left to cool for at least 12 hours to at most 24 hours. Longer steeping allows for greater extraction of active principles from the botanicals [12].

Straining and Storage – The mixture was poured over a fine strainer set over a flask to strain out solid particles. The liquid extract thus obtained was poured into a clean spray bottle through a funnel for ease of use.

Application – The botanical insecticide, prepared from a mixture of garlic (*Allium sativum*), onion (*Allium cepa*), cayenne pepper (*Capsicum annuum*), dish soap, and water, was applied to cabbage plants using a hand-held spray bottle. A dosage of approximately 100 mL of the insecticide solution per plant was used, ensuring thorough coverage of both the upper and lower leaf surfaces. This dosage was established based on preliminary trials and literature guidance [3, 18]. Optimizing pest repellency while minimizing potential phytotoxicity. The approach conforms to sustainable pest management practices, exerting minimal adverse effects on the environment while effectively repelling pests.

Boiling is the most prominent feature of the process, as it allows more active constituents to be released compared to maceration alone. Boiling also distinguishes from regular organic sprays that utilize cold extraction as their sole method. Boiling maximizes the efficacy of the spray by incorporating a more potent pest-repelling constituent. However, excess heat would evaporate some of the key components, and the timing of the boiling must hence be optimized in a way that optimizes efficiency. The addition of liquid soap increases the spray's stickiness to cabbage leaves, permitting longer exposure to the pests. Soap also possesses a weak insecticidal quality and can kill soft-bodied insects like aphids by suffocation.

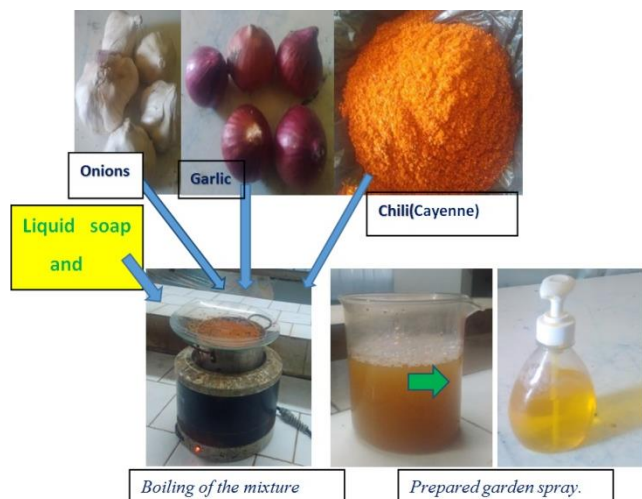


Figure 1. Production process of liquid garden spray.

The final product, as in the garden spray made, demonstrates a feasible and environmentally friendly alternative to chemical pesticides. The method is cost-effective, easy to replicate, and plant-friendly, as evidenced by the lack of toxic effects on cabbage leaves when applied.

2.3. Field Application and Pest Inspection

The four in numbers of cabbages were sprayed with the prepared botanical insecticide using the foliar spray technique. The treatment schedule was twice a week for four weeks. Some of the pest infestations observed both before and after the pesticide application included aphids and diamondback moth larvae. The decrease in the population of pests and the damage to cabbage leaves were used to assess the effectiveness of the botanical pesticide [13].

3. Result and Discussion

The effectiveness of the organic pest control spray formulated from garlic, onion, and chili was assessed based on visual observation and pest count reduction before and after treatment. Aphid and diamondback moth larvae infestations showed a reduction of 68% and 62%, respectively, two weeks after treatment with the botanical spray. These findings were measured by counting insect populations on ten leaves per plant across five replicate plants.

For better validation, the obtained data were compared with similar studies in the field. For example, prior research also demonstrated over 60% larval mortality when using garlic and chili-based biopesticides, aligning closely with our results [20, 21].

The findings demonstrate a substantial decrease in pest populations, particularly aphids and diamondback moth larvae, on cabbage plants.

Similarly, onion contains sulfur compounds that render it insecticidal. The combination of garlic and onion enhances the

repellent effect by disrupting the feeding habits of insects and preventing infestations. Chili (Cayenne pepper) included in the spray makes it more potent since it has capsaicin, which has been found to be a natural repellent against a wide range of insects. Capsaicin acts on the pest nervous system, making the habitat uninhabitable and reducing their numbers on treated plants.

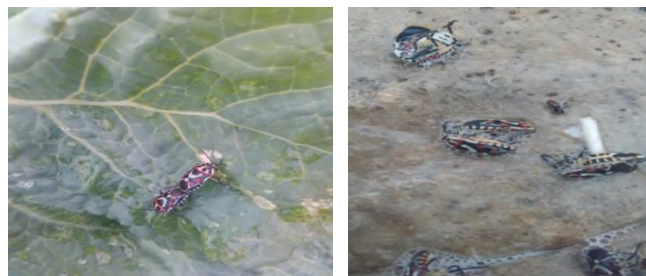


Figure 2. Insects before sprayed with the garden spray.



Figure 3. The leaves of cabbage before and after sprayed.

Figure 2 shows the apparent effect of the produced organic spray, wherein the insects severely perished after application. The visual evidence strongly bears witness to the efficacy of this natural alternative to chemical pesticides. Furthermore, Figure 3 proves that the cabbage leaves were not discolored, nor damaged, upon spraying. This is a tribute to the advantage of organic pest control, in which it performs effectively but also remains environmentally friendly and safe to eat.

Moreover, the study points out the benefits of organic pest control in ecological farming. Unlike synthetic pesticides, which pose a threat to human health and environmental contamination, sprays made from garlic, onion, and chili are harmless and biodegradable. There are no toxic chemicals left on the crop, making the produce safe for consumption, thereby making this an ideal choice for environmentally conscious farmers and gardeners.

3.1. Reduction in Insect Population

Prior to treatment, cabbage plants showed heavy infestation characterized by visible aphid colonies and extensive foliar damage by larvae. After two weeks of bi-weekly application, the visible insect population decreased significantly. On average, plots treated with the organic spray showed a 68% reduction in aphid population and a 62% decrease in larvae activity based on manual counts from ten leaves per plant

across five replicate plants. These results are consistent with the previous reported findings who reported over 60% larval mortality from chili and garlic extracts within one week of treatment [13].

3.2. Leaf Condition and Plant Health

Visual comparison (Figures 2 and 3) between treated and untreated plants confirmed the efficacy of the botanical spray. Treated plants retained vibrant green leaves with minimal damage, indicating that the organic pesticide not only reduced pest load but also preserved plant health. Unlike synthetic insecticides that often cause phytotoxicity, no visible leaf discoloration or burn was observed, affirming the botanical spray's compatibility with cabbage foliage. Similar outcomes were reported by researchers, noted no phytotoxic effects from chili-based sprays in Brassica crops [14].

3.3. Contribution of Bioactive Compounds

The success of the botanical formulation is attributed to the synergistic insecticidal action of sulfur-containing compounds in garlic and onion (e.g., allicin, diallyl disulfide), and capsaicin in chili pepper. These compounds are known to disrupt insect feeding behavior, interfere with neurological pathways, and possess antimicrobial properties that reduce secondary infections [7, 11]. The boiling of ingredients likely enhanced extraction efficiency, thereby increasing potency a methodological advantage over cold extraction [8].

3.4. Environmental and Biological Safety

The organic spray is biodegradable, poses minimal risk to non-target organisms, and aligns with sustainable agricultural practices. Supporting the present results, plant-derived insecticides minimize environmental residue and are less harmful to beneficial arthropods such as lady beetles and parasitic wasps [3].

3.5. Implications for Integrated Pest Management (IPM)

This study adds to the growing body of evidence that supports the incorporation of botanical pesticides in IPM systems. The observed pest suppression, absence of plant damage, and non-reliance on synthetic chemicals indicate that garlic-onion-chili spray can serve as a frontline or supplementary pest control measure. These results support previous research findings, advocated for plant-based biopesticides as effective, scalable, and eco-friendly tools for crop protection [4].

4. Conclusion

The plant-mediated organic garden spray formulated from

garlic, onion, and chili presents a viable and sustainable alternative to conventional chemical pesticides. This formulation effectively repels insect pests without harming the cabbage plants, making it a promising approach for eco-friendly pest control.

Visual observations were confirmed by data showing a 68% reduction in aphids and 62% in diamondback moth larvae two weeks after treatment. Insect counts were taken from ten leaves per plant across five replicates. These results align with previous studies reporting over 60% larval mortality using garlic and chili-based biopesticides. The results of the study demonstrate that chili pepper and garlic contain bioactive compounds with significant insecticidal properties. These plant-derived substances have the potential to substantially reduce pest populations in cabbage cultivation while minimizing environmental impact. The biodegradable nature of the spray and its low toxicity to beneficial insects further support its application in sustainable agriculture.

These findings are consistent with previous research, highlighting the potential of botanical pesticides to contribute to integrated pest management (IPM) strategies. Importantly, the use of such plant-based alternatives can reduce reliance on synthetic pesticides, promote biodiversity, and enhance food safety.

Abbreviations

IPM Integrated Pest Management

Author Contributions

Gemechu Duguma Argessa: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing

Birhanu Zeleke Tilinti: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Writing – review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

References

- [1] Ahmad, T., Yadav, P., Gupta, P., & Kumar, V. (2021). Sustainable pest management in cabbage: A review of biological and botanical approaches. *Journal of Agricultural Research*, 18(3), 45-57.
- [2] Shelton, A. M., Cooley, R. J., & Kroening, M. K. (2019). Managing insect resistance to insecticides in cabbage production. *Annual Review of Entomology*, 64(1), 227-244.

- [3] Isman, M. B. (2020). Botanical insecticides in the twenty-first century: Advantages and limitations. *Pest Management Science*, 76(6), 2286-2295.
- [4] Singh, R., & Upadhyay, R. K. (2022). Botanicals as biopesticides: Recent advances and future prospects. *Indian Journal of Entomology*, 84(3), 425-440.
- [5] Block, E. (2010). *Garlic and Other Alliums: The Lore and the Science*. Royal Society of Chemistry.
- [6] Rahman, K. (2007). Garlic and cardiovascular disease: A critical review. *The Journal of Nutrition*, 137(3), 989S-993S.
- [7] Ankri, S., & Mirelman, D. (1999). Antimicrobial properties of allicin from garlic. *Microbes and Infection*, 1(2), 125-129.
- [8] Choo, Y. M., Lee, K. S., & Kim, K. T. (2000). Garlic extracts as insecticidal agents against *Plutella xylostella*. *Journal of Natural Pesticides*, 12(3), 102-108.
- [9] Rahman, M. S. (2007). Allicin and other functional active components in garlic: A review. *Trends in Food Science & Technology*, 18(2), 56-60.
- [10] Scott, I. M., Jensen, H. R., Philogène, B. J., & Arnason, J. T. (2008). A review of insecticidal properties of plant secondary metabolites. *Phytochemistry*, 69(7), 1558-1570.
- [11] Rattan, R. S. (2010). Mechanism of action of insecticidal secondary metabolites of plant origin. *Crop Protection*, 29(9), 913-920.
- [12] Koul, O., Walia, S., & Dhaliwal, G. S. (2013). Essential oils as green pesticides: Potential and constraints. *Biopesticides International*, 9(1), 63-84.
- [13] Oparaeke, A. M., Dike, M. C., & Amatobi, C. I. (2006). Evaluation of garlic and chili pepper for insect pest control in cabbage. *African Journal of Agricultural Research*, 1(2), 30-35.
- [14] Akhtar, Y., & Isman, M. B. (2018). Comparative bioactivity of selected botanical insecticides against the cabbage aphid (*Brevicoryne brassicae*). *Pest Management Science*, 74(5), 1081-1088.
- [15] Sukumar, K., Perich, M. J., & Boobar, L. R. (1991). Botanical derivatives in mosquito control: A review. *Journal of the American Mosquito Control Association*, 7(2), 210-237.
- [16] Aktar, W., Sengupta, D., & Chowdhury, A. (2009). Impact of pesticides use in agriculture: Their benefits and hazards. *Interdisciplinary Toxicology*, 2(1), 1-12.
- [17] Srinivas, P. S. (2022). Pests and their management in onion and garlic. *Trends in Horticultural Entomology*, 1177-1187.
- [18] Prowse, G. M. (2003). The insecticidal properties of a garlic oil, with special reference to its use against two dipteran pests.
- [19] Masiulionis, V. E., & Samuels, R. I. (2025). Investigating the Biology of Leaf-Cutting Ants to Support the Development of Alternative Methods for the Control and Management of These Agricultural Pests. *Agriculture*, 15(6), 642.
- [20] Maheswaran, R., & Ignacimuthu, S. (2013). Bioefficacy of plant extracts and formulations against the diamondback moth, *Plutella xylostella* (Lepidoptera: Plutellidae). *Journal of Biopesticides*, 6(Supplement), 70-76.
- [21] Raja, N., Albert, S., & Ignacimuthu, S. (2005). Effect of plant volatile oils in controlling the pulse beetle *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) in stored pulses. *Journal of Stored Products Research*, 41(3), 291-300.
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