International Journal of Engineering Inventions
e-ISSN: 2278-7461, p-ISSN: 2319-6491
Volume 13, Issue 3 [March. 2024] PP: 43-49

Research on production of biopesticides for tea plants from organic agricultural waste

Nguyen Thi Thu Phuong*, Mac Duy Hung
Thai Nguyen University of Technology

ABSTRACT
The study explores the production of biopesticides derived from organic agricultural waste for tea cultivation. Using ingredients like garlic, chili, lemon grass, and green tea leaves, the research aims to develop eco-friendly pest control solutions. These biopesticides target common tea pests such as red spider mites, leafhoppers, and thrips. Experimental results demonstrate that plant extracts effectively reduce pest infestations on tea plants compared to traditional chemical pesticides. However, their effectiveness in pest management falls short of chemical alternatives. Ingredients like garlic and chili, known for their insect-repelling properties, contribute to the biopesticides' efficacy. Despite being short-lived on plants, biopesticides offer potential economic and environmental advantages. Cost analysis reveals that although biopesticide production is costlier, it could lead to long-term savings in pest control and enhance crop yields and value. Challenges include high production costs, uncertain efficacy against all pests, and the need for specialized knowledge. To promote biopesticide adoption, further research, development, farmer training, and economic support policies are crucial, fostering agricultural sustainability in tea cultivation.
Keywords: *Biological pesticides, plants, microorganisms, safety, tea plants*

Date of Submission: 01-03-2024 Date of acceptance: 09-03-2024

I.INTRODUCTION

In recent years, the development and production of biopesticides have become a burgeoning field of research in agriculture. Biopesticides, including bioinsecticides and biofungicides, offer a sustainable and environmentally friendly alternative to conventional chemical pesticides. One promising source for the production of biopesticides is agricultural waste, which can be converted into valuable inputs for pest management. Among the various crops that benefit from biopesticide production, tea plantations present a unique opportunity due to the abundance of agricultural waste generated during tea processing. The production of biopesticides for tea cultivation holds great potential for addressing pest and disease management challenges in a sustainable manner. By utilizing agricultural waste from tea plantations, biopesticides can be produced cost-effectively and contribute to the circular economy of the tea industry. This study aims to explore the feasibility of producing biopesticides for tea plantations from agricultural waste, focusing on the development of bioinsecticides for pest control. By leveraging the rich bioresources present in tea waste, such as tea leaves and stems, this research seeks to develop a novel and eco-friendly solution for pest management in tea cultivation. The utilization of biopesticides derived from agricultural waste not only offers a sustainable pest management strategy but also contributes to reducing the environmental impact of pesticide use in tea production. Through this study, we aim to showcase the potential of utilizing agricultural waste for the production of biopesticides, with a specific focus on tea cultivation. By harnessing the power of nature's resources, we strive to pave the way for a more sustainable and environmentally conscious approach to pest management in tea plantations.

II.METHODOLOGY

2.1. Objective, subject, and scope of research

The selection of insecticides for plants is based on (i) recommendations provided in the guidelines for pest management by agricultural extension partners and plant protection in the Plantwise program development and (ii) the availability of at least 5 reference documents demonstrating the efficacy of homemade plant insecticides under conditions similar to those practiced by farmers.

**Subject of insecticide testing*: Long Van tea variety

**Scope of research*

- Research location: Long Van tea garden in Song Cau Town, Dong Hy District, Thai Nguyen Province. Tea garden area: 300 m2, tea plants have been grown since 2021, harvested, and currently cultivated using traditional farming methods (using chemical insecticides according to the guidance of tea production experts).

The tea garden for research is separated from other tea gardens for easy evaluation of the effectiveness of biopesticides. With 1000 tea plants planted, the distance between plants is 50 cm, and between rows is 1 m.
**Research period:* from June 2023 to February 2024. Tea at the research location enters the main harvesting season within the year.
**Main pests and diseases to be treated in the study:*Stenchaetothrips biformis, Brevipalpus Phoenicis, and Toxoptera aurantii.

2.2. Insecticide production process

Step 1: Selection of raw materials and formulation:

- Investigate natural sources capable of insect control, including herbs, bacteria, microorganisms, and other natural substances. Evaluate the feasibility and effectiveness of each raw material.
- Consider common and locally available raw materials in the tea-growing area.
- Consider factors such as availability, cost, and effectiveness of each raw material.
- Evaluate the insecticidal and pest control capabilities of each raw material based on previous studies and available information.
- Based on the selected raw materials, determine the main components and formulation ratios to create an effective and stable formula.
- Consider factors such as water solubility, solubility, stability, and availability of each component to ensure the effectiveness and stability of the bioinsecticide.

Step 2: Extraction and processing of raw materials:

- Determine appropriate extraction methods to extract active insecticidal compounds from the selected raw materials. Extraction methods may include solvent extraction, heat extraction, or other methods depending on the raw materials and formulation used.
- After extraction, determine the processing method to produce the bioinsecticide formulation, such as fermenting the raw materials.

Tools: 50cm-long stick, four 20-liter containers with lids, grinder.

- Preparation steps:

1. Prepare the ingredients: Clean and chop garlic, chili, lemongrass leaves, lemongrass stems, ginger, Cyperus rotundus, Artemisia vulgaris, and Trichoderma fungi.
2. Mix the ingredients: Mix garlic, chili, lemongrass leaves, lemongrass stems, ginger, Cyperus rotundus, Artemisia vulgaris, and Trichoderma fungi in a large container.
3. Prepare the solution: Mix expired yogurt and molasses with water in another container.
4. Combine the ingredients: Pour the yogurt and molasses solution into the container containing the mixed ingredients from step 2. Stir well to ensure uniform dilution of the ingredients.
5. Storage and fermentation: Cover the container tightly and let the insecticide solution ferment for 7-10 days at room temperature. Stir the mixture daily during fermentation.
6. Filtration and storage: After fermentation, remove the solids and debris by using a sieve or filter screen. Store the bioinsecticide in sealed containers, away from direct sunlight for later use, with periodic checks every 10 days.

Divide the ingredients according to the ratios in the following table:

Table 2.1. Ratios of raw materials for the production of 20 liters of bioinsecticide

No.	Raw Material	Weight
1	Garlic (g)	1000
2	Chili (g)	1000
3	Lemongrass leaves (g)	1000
4	Citronella(g)	2000
5	Warm water 60°C (ml)	15000
6	Molasses (g)	1000
7	Yeast (g)	200
8	Yogurt (ml)	500
9	Ripe banana (g)	1000
10	Rice bran (g)	1000
11	Metarhizium fungi(g)	200
12	Ginger(g)	1000

Mix the ingredients according to the ratios above, excluding the Metarhizium fungi. Place them in a container, cover tightly, and ferment for 7 days. After 7 days of fermentation, when preparing for spraying, mix with 200 grams of Metarhizium fungi. After mixing, filter and collect the liquid portion, then fill it into 1-liter bottles, labeling them with the name of the pesticide and the preparation date.

Step 3: Testing the effectiveness and safety of bioinsecticide:

- Testing the effectiveness of pest control:
- Prepare some tea plants infected with pests or other harmful insects.
- Divide the tea plants into experimental groups, where each group will be treated with a different type of bioinsecticide.
- Apply bioinsecticides to the tea plant groups according to predetermined doses and application methods.
- Monitor and record indicators of pest control effectiveness, including the reduction rate of pests, the survival rate of tea plants, and the recovery of tea plants after treatment.

Spraying procedure: To determine the dosage and spraying method of bioinsecticides on tea plants to control Stenchaetothrips biformis, Brevipalpus Phoenicis, and Toxoptera aurantii, refer to the instructions for use of the insecticide product you are using. The dosage is usually determined based on the area and severity of pest infestation.

Prepare the insecticide solution by mixing: 100g of post-fermentation material, extract with water at a ratio of 1 material: 20 filtered water, along with 50ml of biological adhesive. Transfer the solution to a sprayer for spraying.

The chemical insecticide (Sample 4) is the control group sprayed according to the manufacturer's recommendations on the packaging, and a control sample (Sample 5) is used without any insecticide. The spraying areas for different types of insecticides are divided based on plots, with partitions made of insect-proof nets. Observe and record the results obtained in Chapter 3.

Spraying method: Spray the entire tea plant, including leaves, branches, and stems, to ensure contact with pests. Use a sprayer to spray evenly and ensure complete coverage of the tea plants.

Choose to spray in the morning or afternoon when temperatures are not too high and there is no strong wind. Avoid spraying in rainy weather or before rain to prevent the insecticide from being washed away.

Ensure compliance with safety regulations when using insecticides. Wear protective gear such as gloves, masks, and chemical-resistant clothing. Avoid direct contact with insecticides and limit contact with tea plants that have been sprayed with insecticides for a period of time after spraying.

Spray the insecticide the day after tea harvesting, in the cool afternoon, and when it's not raining. Record the spraying date, with an average interval of 15 days/spray. Divide into 3 samples with consecutive spraying times of 3 days, 5 days, and 7 days.

Step 4: Evaluation and analysis of results: Compare the results with conventional chemical insecticides to assess the competitiveness and effectiveness of the bioinsecticide.

Step 5: Refinement and improvement of the formula:

- Based on the evaluation results, refine and improve the formula of the bioinsecticide to enhance its effectiveness and stability.
- Repeat the above steps to retest and evaluate the effectiveness and safety of the improved formula.

Through these steps, this research method helps to formulate a bioinsecticide for tea plants and evaluate its effectiveness and safety.

III.RESULTS AND DISCUSSION

3.1. Effective treatment time

The time for pest control spraying in the corresponding experiments was 3.5 days, in the afternoon, and up to 7 consecutive days. Samples 1.1; 1.2 and 1.3 correspond to the time of spraying bioinsecticides at the same ratio over consecutive periods of 1, 5, and 7 days. Samples 2.3 correspond to samples of chemical and biological insecticides sprayed according to the manufacturer's recommendations regarding the ratio and spraying time. The spraying time is presented in Table 3.1. Subsequently, the effectiveness of treatment against adult pests was observed and evaluated.

Table 3.1. Spraying time of insecticides for tea plants infested with pests

Day	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Sample 1.1	**x**	**x**	**x**				
Sample 1.2	**x**	**x**	**x**	**x**	**x**		
Sample 1.3	**x**	**x**	**x**	**x**	**x**	**x**	**x**
Sample 2	**x**			**x**			
Sample 3	**x**			**x**			

Table 3.2. Efficacy of insecticide treatment (evaluation with adult pests)

Sample	**1.1**	**1.2**	**1.3**	**2**	**4**
Assessment (Score 5	**2/5**	**4/5**	**4,2/5**	**4,8/5**	**4,5/5**

The results indicate that spraying continuously for 5 days yielded the best results in terms of pest and disease eradication, optimizing the cost-effectiveness of insecticide spraying. Therefore, for this bioinsecticide, it is recommended to spray continuously for 5 days to achieve the highest effectiveness. This also extends the subsequent period for disease prevention spraying for tea plants. After eliminating the pests and diseases, spraying for disease prevention is conducted once every 15 days. This is more costly compared to chemical insecticides, which typically recommend spraying for disease prevention every 30 days. However, considering the life cycle of these pests, spraying for 5 consecutive days interrupts their life cycle, from killing adult pests to destroying eggs and larvae, which usually occurs within 4-6 days. This reduces the likelihood of pest resurgence.

The main pests on tea plants during the research period were Stenchaetothrips biformis, Brevipalpus Phoenicis, and Toxoptera aurantii. These pests mainly damage the plants during the adult stage. However, the experiments below assess the effectiveness of insecticides against all four stages of the pests. After determining the optimal spraying time, the choice was to spray the bioinsecticide continuously for 5 days and the chemical insecticide twice, with a 3-day interval between each spraying, using an untreated tea area as a control. The research results are presented in Table 3.3.

Table 3.3. Effectiveness of bioinsecticides against Stenchaetothrips biformis, Brevipalpus Phoenicis, and Toxoptera aurantii.

Sample Criteria	1 (Bioinsecticide)	2 (Chemical Insecticide)	2 (Commercial Bioinsecticide)	3 (Untreated)
Eggs	4/5	5/5	4/5	0
Larvae	4/5	3/5	3/5	0
Pupae	4/5	3/5	3/5	0
Adults	4/5	5/5	4/5	0

- *Evaluation criteria on a 5-point scale

This evaluation shows that: (1) all selected plant species contain active ingredients with insecticidal properties, repelling insects. (2) Homemade insecticides based on all selected plant species have been used with some success in controlling pests or preventing damage, although effectiveness varies and is often lower than the control (synthetic insecticide). Factors affecting the effectiveness of homemade plant insecticides include changes in the quantity and concentration of active ingredients in plant materials, as well as changes in the preparation process. In conclusion, homemade plant insecticides can contribute to reducing losses in tea production.

The study results demonstrate the effectiveness of treating Stenchaetothrips biformis, Brevipalpus Phoenicis, and Toxoptera aurantii on tea plants with insecticides.

3.2. Effectiveness of pest management

The plant-based treatments in this study outperformed the control method financially, particularly in cases where cabbage was heavily infested by major pest species. The cost of protecting these plants was either lower or equal to that of using conventional pesticides. The productivity of the batches treated with plant extracts, as depicted in the table, significantly surpassed that of the control.

Tea plants, renowned for their high economic value, are a specialty crop in Thai Nguyen. Due to their high economic value, these crops are susceptible to various plant-eating insects. During the study period, it was observed that plant extracts could substantially reduce the incidence of pests on tea plants. A large number of pests were recorded on the plants before the use of plant extracts; significant pest damage decreased on all treated plants. However, on control plants, pest damage increased significantly three days after pesticide application.

Although plant extracts reduced the number of pests, their effectiveness in managing pest outbreaks cannot be compared to chemical pesticides. The active ingredients in garlic and chili peppers are known to degrade rapidly (Koch & Lawson, 1996), whereas most chemical pesticides persist in the environment for a considerable period. Garlic is known for its insect-repellent, insecticidal, and anti-transpiration properties (Vijayakshmi et al., 1999), resulting in fewer pests on garlic-sprayed plants. Additionally, garlic contains sulfur compounds that inhibit plant-eating insects (Vijayakshmi et al., 1999).

However, because these biological pesticides have low persistence on treated crops, detecting signs of pest infestation must be performed to apply effective control measures when pest outbreaks occur on crops.

The study demonstrated that the use of pesticides to control *Stenchaetothrips biformis, Brevipalpus Phoenicis, and Toxoptera aurantii* on tea plants was effective. Following the implementation of this treatment method, the level of pest infestation decreased significantly, contributing to the protection and improvement of tea plant health.

The results of this study provide an overview of the impact of *Stenchaetothrips biformis, Brevipalpus Phoenicis, and Toxoptera aurantii*on tea plants and the effectiveness of pesticide use. However, to ensure reliability and comparison with other studies, specific data are needed and must be compared with similar published research. This study opens up potential for further research on various treatment methods and their effects on pest infestations in tea plants. Research could also focus on analyzing the impact of pesticide use on the environment and human health to ensure sustainability in managing pest infestations in tea plants.

3.2. Economic efficiency and market potential

The production costs of biological pesticides are presented in Table 3.4.

Table 3.4. Production Costs of Biological Pesticides

No	**Material**	**Quantity (g)**	**Cost (unit: VND)**
1	**Garlic (g)**	**1000**	**30000**
2	**Chili (g)**	**1000**	**30000**
3	**citronella(g)**	**1000**	**0**
4	**Bear grass (g)**	**2000**	**0**
5	**Warm water 60°C (ml)**	**15000**	**2000**
6	**Molasses (g)**	**1000**	**20000**
7	**Yeast (g)**	**200**	**10000**
8	**Yogurt (ml)**	**500**	**0**
9	**banana (g)**	**1000**	**0**
10	**Rice bran (g)**	**1000**	**10000**
11	**Metarhizium fungi(g)**	**200**	**30000**
12	**20-liter container (bucket)**	**1**	**30000**
13	**Labor (2 hours)**	**0,25**	**25000**
Total cost			**210.000**

Therefore, to produce 20 liters of biological pesticides, we need 210,000 VND, averaging 22,000 VND per liter of finished biological pesticide. The production costs for cultivating one tea crop over 30 days using pesticides are recorded in Table 3.5 below. Other costs such as fertilizers, weeding, tea picking, and processing are not included, but using a control tea plantation involves similar processes with only the difference being the cost of pesticide use.

Table 3.5. Costs of using biological and chemical pesticides for disease prevention in tea plants over 30 days

Pesticide	Ingredients/Products	Labor	Total Cost
Sample 1	45000	150000	195000
Sample 2	65000	60000	125000
Sample 3	40000	60000	100000

Table 3.6. Costs of using biological and chemical pesticides for disease treatment in tea plants over 30 days

Pesticide	Ingredients/Products	Labor	Total Cost
Sample 1	45000	60000	105000
Sample 2	65000	60000	125000
Sample 3	40000	60000	100000

The results indicate that the labor costs for spraying pesticides for treatment are higher, while the raw material costs are lower, compared to chemical and biological pesticides. However, the economic benefits of disease prevention spraying are better than chemical and biological pesticides. Although labor costs are higher, the use of cheaper raw materials in self-made biological pesticides can be a significant advantage, especially for farmers with abundant resources or the ability to produce their own.

Standard labor costs for preparation, in addition to plant protection costs, are relatively low in this study, utilizing agricultural waste such as bear grass, ripe bananas, or expired yogurt. Labor-intensive spraying often makes the total cost of plant protection with plant-based pesticides comparable to the cost of purchasing and using synthetic pesticide solutions. In the current study, green tea processed from plots using synthetic pesticides and plants in the agricultural plots is sold at the same price. If organic tea from protected plots is sold at a higher price due to commitments and communication, the economic benefits will increase accordingly. In developed countries, where human health is paramount, pesticide-free food items command higher prices, and consumers concerned about health are willing to purchase them, especially when they are certified organic by reputable domestic and international organizations.

However, in Vietnam, agricultural products, including tea, do not have a clear distinction between organic and conventional. The reasons for this include lack of communication, awareness, and any certification or residual monitoring program for food products.

The current study affirms that using readily available plant products is effective, cost-effective, and financially beneficial or comparable to synthetic pesticides.

IV.CONCLUSION

The use of biological pesticides can bring many economic and environmental benefits to farmers. Economic efficiency analysis has shown that although biological pesticides are more expensive, they can help reduce treatment and control costs for pests and diseases in the long term, increase productivity, and enhance product value. Furthermore, the use of biological pesticides also protects the environment, maintains ecosystem balance, and reduces the impact on human health and animals. However, the use of biological pesticides also faces some challenges. High cost, uncertain control effectiveness for all types of pests and diseases, long application time, and the requirement for specific knowledge and training are challenges that need to be overcome. In summary, the use of biological pesticides has the potential to improve the economy and protect the environment in agriculture. To promote the use of biological pesticides, continued research and development, training and support for farmers, and the creation of supportive economic policies are necessary. Only then will farmers be convinced and accept the use of these pesticides, contributing to the sustainable development of agriculture.

REFERENCES

[1]. Rodgers, P. B. (1993). Potential of biopesticides in agriculture. Pesticide Science, 39(2), 117-129.
[2]. Lengai, G. M., & Muthomi, J. W. (2018). Biopesticides and their role in sustainable agricultural production. Journal of Biosciences and Medicines, 6(06), 7.
[3]. Fenibo, E. O., Ijoma, G. N., & Matambo, T. (2022). Biopesticides in sustainable agriculture: Current status and future prospects. New and Future Development in Biopesticide Research: Biotechnological Exploration, 1-53.
[4]. Tijjani, A., Bashir, K. A., Mohammed, I., Muhammad, A., Gambo, A., & Musa, H. (2016). Biopesticides for pests control: A review. Journal of Biopesticides and Agriculture, 3(1), 6-13.
[5]. Zarins, I., Daugavietis, M., & Halimona, J. (2009). Biological activity of plant extracts and their application as ecologically harmless biopesticide. Sodininkystė ir daržininkystė, 28(3), 269-280.
[6]. Lyubenova, A., Rusanova, M., Nikolova, M., & Slavov, S. B. (2023). Plant extracts and Trichoderma spp: possibilities for implementation in agriculture as biopesticides. Biotechnology & Biotechnological Equipment, 37(1), 159-166.
[7]. Lahlali, R., El Hamss, H., Mediouni-Ben Jemâa, J., & Barka, E. A. (2022). The Use of Plant Extracts and Essential Oils as Biopesticides. Frontiers in Agronomy, 4, 921965.
[8]. Mathew, L. K. (2016). Botanicals as biopesticides: a review. Int J Adv Res, 4(3), 1734-1739.
[9]. Essiedu, J. A., Adepoju, F. O., & Ivantsova, M. N. (2020, December). Benefits and limitations in using biopesticides: A review. In AIP conference proceedings (Vol. 2313, No. 1). AIP Publishing.
[10]. Singh, D. (Ed.). (2014). Advances in plant biopesticides. Springer.
[11]. Kumar, J., Ramlal, A., Mallick, D., & Mishra, V. (2021). An overview of some biopesticides and their importance in plant protection for commercial acceptance. Plants, 10(6), 1185.

[12]. Kachhawa, D. (2017). Microorganisms as a biopesticides. Journal of Entomology and Zoology Studies, 5(3), 468-473.
[13]. Prabha, S., Yadav, A., Kumar, A., Yadav, A., Yadav, H. K., Kumar, S., ... & Kumar, R. (2016). Biopesticides—An alternative and eco-friendly source for the control of pests in agricultural crops. Plant Arch, 16(2), 902-906.
[14]. Nawaz, M., Mabubu, J. I., & Hua, H. (2016). Current status and advancement of biopesticides: microbial and botanical pesticides. J Entomol Zool Stud, 4(2), 241-246.
[15]. Ritika, B., & Utpal, D. (2014). An overview of fungal and bacterial biopesticides to control plant pathogens/diseases. African Journal of Microbiology Research, 8(17), 1749-1762.
[16]. Kachhawa, D. (2017). Microorganisms as a biopesticides. Journal of Entomology and Zoology Studies, 5(3), 468-473.