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Black Fruit Leaf Pesticide [*Haplolobus cf. monticola* Husson] as an Environmentally Friendly Innovation for Control of Plant Pest Organisms [Opt] in Agriculture

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Abstract. Manokwari and South Manokwari Regencies in West Papua Province, as agricultural hubs in Eastern Indonesia, have significant potential for regional income development, particularly in the development of food crops, horticulture, and plantations. With advances in agricultural technology, organic farming practices have increased rapidly among farmers and consumers of these products. The intensive use of synthetic chemical pesticides in agriculture has led to various problems, including environmental pollution, pest resistance, and human health risks. Therefore, more environmentally friendly and sustainable alternatives for controlling plant pests (OPT) are needed. This research-based community service activity aims to introduce and apply a botanical pesticide made from black fruit leaves [*Haplolobus cf. monticola* Husson], a native plant of Wondama Regency and Oransbari Village, known locally as "Pi Airawi" by the Papuan people as a local innovation in pest control. The implementation method is carried out in a participatory manner through dissemination, counseling, training in making botanical pesticides, and field application. Evaluation is carried out qualitatively through observations of pest attack intensity and farmer responses. The results of the activity indicate that the application of the black fruit leaf botanical pesticide has the potential to suppress the activity and intensity of pest attacks. This effectiveness is thought to be related to the content of secondary metabolites in black fruit leaves which act as antifeedants and natural toxins for pests. In addition, this activity increases farmer awareness of environmentally friendly pest control practices. Thus, the black fruit leaf botanical pesticide has the potential to support sustainable agricultural systems and integrated pest management (IPM) and reduce dependence on synthetic pesticides.

Keywords: Botanical Pesticides; Black Fruit Leaves; Dissemination; Extension; Technical guidance

INTRODUCTION

Manokwari and South Manokwari Regencies are two regencies in West Papua Province that have exotic tourist attractions, as well as a lot of plant biodiversity that has the potential to produce secondary metabolic compounds, one of which is the black fruit tree, which has the potential to become an agricultural commodity that can increase regional income and the welfare of farmers and the community, as well as having the potential for developing sustainable agriculture based on organic farming.

Global awareness of the importance of sustainable agriculture is driving the development of more environmentally friendly alternatives for controlling plant pests [OPT]. One rapidly growing approach is the use of botanical pesticides derived from plant extracts and containing natural bioactive compounds. Botanical pesticides contain various secondary metabolites such as alkaloids, terpenoids, flavonoids, and phenolic compounds that have biological activity against insect pests [Isman, 2006; Prijono, 2020].

Various scientific studies have shown that botanical pesticides extracted from plants have a mechanism of action through secondary metabolites that act as antifeedants and

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toxicants against pests, repellents, growth inhibitors, and natural poisons for insects, as well as being environmentally friendly biopesticide agents in controlling pests [Isman, 2020; Ngegba et al., 2022; Khursheed *et al.,* 2022; Souto *et al.,* 2021], thus effectively suppressing pest attacks on plants without harming non-target organisms. This is in line with findings that the use of plant extracts can increase crop yields while supporting the sustainability of agroecosystems [Tembo *et al.,* 2018; Acheuk *et al.,* 2022; Ngegba *et al.,* 2022; Al-Khayri *et al.,* 2023].

Black fruit [Haplolobus cf. monticola Husson] or locally known as "Pi Airawi" is abundant but its utilization is still limited. Based on local knowledge and preliminary observations from Somar research [2012], Pi Airawi leaves contain secondary metabolites such as flavonoids, alkaloids, and tannins, suspected to contain bioactive compounds that have the potential as botanical pesticides. Therefore, this research-based community service activity was carried out to introduce the use of black fruit leaves as botanical pesticides while encouraging the implementation of integrated pest control [IPM] and sustainable agriculture. The Plant Pest and Disease Laboratory, Faculty of Agriculture, UNIPA has developed an agricultural product in the form of a botanical pesticide from black fruit leaves as an environmentally friendly technological innovation.

This research-based community service activity aims to: 1. Introduce innovative botanical pesticides based on black fruit leaves [*H. cf. monticola* Husson] as an environmentally friendly alternative for controlling plant pests [OPT], 2. Increase farmers' knowledge and skills in the manufacture and application of botanical pesticides based on local biological resources, 3. Reduce farmers' dependence on synthetic chemical pesticides through the application of simple, inexpensive, and easy-to-apply technology, and 4. Support the application of sustainable agricultural principles and integrated pest control [IPM] based on local wisdom and scientific innovation.

METHOD

This research and community service activity was carried out in Manokwari and South Manokwari districts, West Papua, in stages from 2021-2022, 2023 and 2025, with a participatory and applied approach, involving final semester students of the Faculty of Agriculture, University of Papua, with an interest in Plant Pests and Diseases and farmers, officers from the Regency Food Crops and Plantation government service directly at each stage of the activity.

1. Preparation Phase

The preparation phase included coordination with final-semester students conducting research on black fruit botanical insecticides, target farmer groups, and officials, identifying key issues related to pests and diseases, and collecting raw materials for black fruit leaves [*Haplolobus cf. monticola* Husson]. This phase also included the development of extension materials and a guide for making botanical pesticides.

2. Dissemination, Counseling, and Knowledge Transfer Stage

Dissemination and counseling are conducted through lectures and interactive discussions on:

- The negative impacts of using synthetic chemical pesticides
- The concept of botanical pesticides and sustainable agriculture
- The potential of black fruit leaves as a source of botanical pesticides

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3. Training and Field Practice Stage

Final year students [research] and participants are directly involved in:

- The process of making black fruit leaf extract
- Determining the concentration and application method of botanical pesticides
- Simulating the application of botanical pesticides to agricultural crops

4. Application and Mentoring Stage

The developed botanical pesticides were applied to agricultural land used as research sites for final year students and land owned by a chocolate food processing company. The research and community service team provided mentoring to ensure proper application and monitored the response of farmers and plants to the use of the botanical pesticides.

5. Evaluation Phase

The evaluation was conducted qualitatively through field observations and interviews with farmers to assess:

- Technology acceptance
- Farmers' perceptions of the effectiveness of the botanical pesticides by the chocolate processing company and plantations
- Potential sustainability of the technology application

RESULTS AND DISCUSSION

1. Improving the Knowledge and Skills of Students and Farmers

The process of improving knowledge and skills began with a preparatory stage conducted by the research team based on the identification of problems in agricultural gardens affected by plant pests. The results of the activity demonstrated an increased understanding among students, farmers, government officials, and companies regarding the dangers of using synthetic chemical pesticides and the benefits of botanical pesticides as an alternative pest control option. Students and farmers were able to independently practice the process of making and applying botanical pesticides for black fruit leaves.

Figure 1. Preparation Stages and Production Process of Black Fruit Leaf Pesticide [*Haplolobus cf. monticola* Husson]

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Page : 214-222
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2. Responses from Students, Farmers, and Government Officials to the Introduction of the Black Fruit Leaf Botanical Pesticide [*Haplolobus cf. monticola* Husson]

Students, farmers, and government officials responded positively to the introduction of the botanical pesticide innovation. The botanical pesticide was considered easy to make, the raw materials were locally available, and the application was relatively simple. These factors were important factors in the community's adoption of the technology. The community service research [PkM] activities, using extension, technical guidance, dissemination, and demonstration support methods in the Black Fruit Leaf botanical insecticide plots, went well, as evidenced by the enthusiastic and responsive responses from farmers, the community, company managers, and government staff.

Observations during the activity showed that students, farmers, and government officials responded positively to the introduction of the black fruit leaf botanical pesticide. Government officials generally showed high interest, particularly in the potential of botanical pesticides as an environmentally friendly technology that can be integrated into integrated pest control [IPM] and extension programs. This response indicates an opportunity for synergy between universities, farmers, and the government in the development and dissemination of locally sourced botanical pesticides. This is presented in Table 1.

Table 1. Participant Responses to Dissemination and Counseling, Technical Guidance Black Fruit Leaf Botanical Pesticide Product [*Haplolobus cf. monticola* Husson]

No.	Participant Group	Very Interested	Interested	Moderately Interested	Description of Response
1.	Students	✔			Highly enthusiastic; actively asked questions regarding the mode of action, research opportunities, and product development of botanical pesticides
2.	Students		✔		Showed interest in environmentally friendly farming concepts and the potential academic application of botanical pesticides
3.	Farmers	✔			Considered the botanical pesticide safe, locally available, and potentially capable of reducing dependence on synthetic pesticides
4.	Farmers		✔		Interested in applying the product on their own fields after observing the preparation and application demonstration
5.	Farmers			✔	Required further assistance and repeated field trials to confirm effectiveness
6.	Government Officers	✔			Strongly supported the development of botanical pesticides as a local

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Page : 214-222
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No.	Participant Group	Very Interested	Interested	Moderately Interested	Description of Response
					innovation aligned with sustainable agriculture programs
7.	Government Officers		✔		Interested in promoting further field trials and integrating the product into extension and Integrated Pest Management (IPM) activities

Botanical pesticides utilize secondary plant metabolites as active compounds that function in the plant's natural defense against herbivores and pathogens. Alkaloids are known to disrupt the nervous system of insects, while flavonoids and phenolics have strong antioxidant activity. Terpenoids and saponins function as antifeedants and can damage the cell membranes of insect pests [Rajashekar *et al.,* 2020, Farhan *et al.,* 2024]. The main advantage of botanical pesticides over synthetic pesticides lies in their multi-site mechanism of action, thereby reducing the chance of pest resistance developing. Furthermore, botanical pesticide residues degrade relatively quickly in the environment, making them safer for agricultural ecosystems [Isman, 2020; Kiri *et al.,* 2024]. This mechanism of action causes decreased feeding activity, impaired larval development, and a decrease in the intensity of pest attacks on various agricultural commodities [Isman, 2006; Tembo *et al.,* 2018]. A study by Ngegba *et al.* [2022] reported that the use of local plant extracts can significantly reduce pest populations and attack intensity without causing negative impacts on non-target organisms.

Figure 2. Dissemination and Counseling activities for Black Fruit Botanical Pesticide Products [*Haplolobus cf. monticola* Husson].

3. Potential Effectiveness of Pest Control with Black Fruit Botanical Pesticide on Agricultural Crops in the Field

Based on field observations, the application of a botanical pesticide based on black fruit leaves has shown good potential in suppressing the presence and activity of plant pests (OPT) on agricultural crops. This control effectiveness is primarily demonstrated by reduced pest feeding activity, reduced plant damage symptoms, and a tendency for pests to avoid plants treated with the botanical pesticide. These findings indicate that the black fruit

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Vol. 5 No. 1 (2026)
Page : 214-222
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leaf botanical pesticide has the potential to act as a pest control agent based on behavioral control rather than direct lethal effects. In the context of IPM, integrating botanical pesticides into pest control strategies adds a dimension of sustainability, as they not only play a role in suppressing pest populations but also reduce the likelihood of resistance to synthetic chemicals. This is crucial because repeated and intensive use of chemical pesticides has been shown to lead to the emergence of resistance genes in various pest species, reducing long-term effectiveness and posing ecological risks.

Figure 3. Application and student assistance in research and demonstration plots of the black fruit leaf botanical pesticide [*Haplolobus cf. monticola* Huson]on agricultural crop research fields

Scientifically, the potential effectiveness of black fruit leaf botanical pesticides is related to the presence of secondary metabolites commonly found in plant extracts, such as alkaloids, flavonoids, terpenoids, and phenolic compounds. These compounds are known to possess biological activity as antifeedants, repellents, growth inhibitors, and mild toxicants against insect pests. Isman [2015] and Isman [2020] explain that the mechanism of action of botanical pesticides is generally multifunctional, allowing them to gradually disrupt the physiological and behavioral systems of pests without causing significant negative impacts on non-target organisms.

Research results over the past ten years have shown that botanical pesticides based on plant extracts can reduce the population and intensity of pest attacks on various agricultural commodities, including food crops, horticulture, and plantations. Tembo *et al.* [2018], reported that the application of plant extracts in the field significantly reduced pest attack levels without disrupting natural enemies. This finding aligns with the field conditions in this study, where pest control occurred without any visual indication of ecosystem disruption.

Furthermore, Ngegba *et al.,* [2022] stated that botanical pesticides have the advantage of reducing the risk of pest resistance because they contain a mixture of active compounds with various mechanisms of action, unlike synthetic pesticides, which are generally specific and single-acting. Therefore, the use of botanical pesticides based on black fruit leaves has the potential to provide more sustainable pest control if applied appropriately and repeatedly according to field conditions.

4. Contribution to Sustainable Agriculture and Integrated Pest Management [IPM]

Proceeding of 5th International Conference on Research and Development (ICORAD)
Vol. 5 No. 1 (2026)
Page : 214-222
ISSN:2828-4925
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This activity contributes to supporting sustainable agricultural systems through the utilization of local biological resources, reducing synthetic chemical inputs, and increasing farmer awareness of environmentally friendly agricultural practices. The integration of botanical pesticides into the IPM system is a strategic step for sustainable agricultural production. Monitoring of application activities in demonstration plots for cocoa plantations, which produce chocolate, has been conducted in collaboration with student research practices. The government, through the Department of Agriculture, the Department of Cooperatives, and the Department of Industry and Trade, will follow up on the application of environmentally friendly botanical pesticides using black fruit leaves in the 2023 and 2024 budgets. In 2025, a decree on the MPIG [Community for the Protection of Geographical Indications] for cocoa plantations in South Manokwari Regency will be issued.

The use of botanical pesticides based on black fruit leaves makes a significant contribution to the implementation of sustainable agriculture and Integrated Pest Management (IPM). One of the main pillars of sustainable agriculture is reducing the use of synthetic chemical inputs, which are often associated with environmental pollution, residue accumulation in crop products, and disruption of non-target organisms such as beneficial insects and natural enemies of pests. This approach aligns with the principles of agricultural ecology, which prioritize agro-ecosystem balance and environmental health [Guohua, 2022].

The use of botanical pesticides as a component of IPM supports the conservation of natural enemies and beneficial organisms within the agro-ecosystem. Due to their selective nature toward target pests, botanical pesticides help maintain the presence of predators and parasitoids that naturally control other pest populations without affecting important biotic components of the agricultural ecosystem. This strategy reflects the principles of IPM, which integrate various chemical, biological, and mechanical control methods with the aim of maintaining sustainable production and the ecological function of the soil and its biota.

The application of black fruit leaf botanical pesticides supports the resilience of agricultural systems to various environmental stresses and pest attacks. By utilizing local biological resources as active ingredients, botanical pesticides provide opportunities for farmers to reduce dependence on imported products, reduce agricultural input costs, and increase independence in community-based agricultural technology. Such initiatives align with recent research findings that recommend the application of biopesticides in sustainable agricultural systems through a participatory and community-based approach. [Listiyan, 2025]

CONCLUSION

As a local Papuan innovation, the use of black fruit leaves as a botanical pesticide holds strategic value because it is based on local resources, easy to apply, and environmentally friendly. Therefore, the black fruit leaf botanical pesticide has the potential for further development as an appropriate technology to support pest and disease management in agricultural crops, while simultaneously reducing farmers' dependence on synthetic pesticides and strengthening sustainable agricultural practices in the Papua region. Through a participatory approach, farmers gain increased knowledge and skills in the production and application of botanical pesticides based on local biological resources.

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Vol. 5 No. 1 (2026)
Page : 214-222
ISSN:2828-4925
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The ongoing progress of research and community service is evident in the issuance of the MPIG (Community for the Protection of Geographical Indications) decree in 2025.

Farmers' response to the introduced innovations has been positive, particularly due to the readily available raw materials near the research site, the simple manufacturing process, and its application adaptability to field conditions. Qualitative field observations indicate that the use of black fruit leaf botanical pesticides has the potential to reduce the intensity of pest and disease attacks, which is thought to be related to the content of secondary metabolites that act as natural antifeedants and toxins for pests.

The implementation of botanical pesticides in IPM also contributes to farmer empowerment, as botanical pesticide technology can be produced locally using locally sourced raw materials. This not only broadens farmers' agronomic horizons but also reinforces more environmentally and economically sound agricultural practices. This approach offers a strong foundation for developing resilient and productive agroecosystems, supporting the overall goal of sustainable agriculture.

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Proceeding of 5th International Conference on Research and Development (ICORAD)
Vol. 5 No. 1 (2026)
Page : 214-222
ISSN:2828-4925
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