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# Enhancing Tobacco Farmers' Capacity through the Development of Environmentally Friendly Biopesticides for Sustainable Farming

**Radenrara Dewi Artanti Putri[1*], Arief Arfriandi[2], Catur Rini Widyastuti[1], Megawati[1], Lutfi Nur Handayani [1], Dwi Siska Adelia [1], Atalla Bintang Fadhil[1], Muhammad Fadhlan Dzikri [1]**

*[1]Chemical Engineering Department, Universitas Negeri Semarang, Gunungpati, Semarang 50229*
*[2]Electrical Engineering , Universitas Negeri Semarang, Gunungpati, Semarang 50229*
Email: dewi.artanti@mail.unnes.ac.id

***Abstract***

Tobacco farmers in Brambang Village, Karangawen Subdistrict, face severe pest infestations and a strong dependence on chemical pesticides, which pose risks to both human health and the environment. This community service program provides a solution by utilizing low-quality tobacco leaves, which were previously unused, combined with lemongrass as raw materials for the development of eco-friendly biopesticides. Both tobacco and lemongrass contain active organic compounds with potential effectiveness in pest control. The program activities included field observations, laboratory testing, educational outreach, training, and demonstrations of biopesticide production. The results indicated that the optimal formulation, consisting of tobacco leaves, lemongrass, EM4, molasses, and distilled water, yielded a pH of 4.86, a nicotine content of 546.592 ppm, and the fastest caterpillar mortality time of 1 minute 11 seconds. The outreach and training significantly enhanced farmers' knowledge and skills in independently producing biopesticides. This program successfully reduced farmers' reliance on chemical pesticides, increased the added value and quality of tobacco, and promoted sustainable agriculture.

**Keywords:** *Biopesticides; tobacco; lemongrass; community service*

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## A. INTRODUCTION

Indonesia is an agrarian country, with a significant proportion of its population engaged in the agricultural sector. According to the 2025 Statistics Indonesia

(Badan Pusat Statistik) report, 87.31% of the agricultural workforce is employed informally. Data from the Directorate General of Plantations (2024) show that Indonesia's tobacco production reached 263,007 tons per year. One of the tobacco-producing regions is Karangawen Subdistrict, Demak Regency, Central Java. In Demak, the total tobacco cultivation area exceeds 2,525 hectares, comprising Karangawen (1,802 ha), Mranggen (351 ha), and Guntur (365 ha) (BPS Demak, 2021). Tobacco farmers face major challenges from pest attacks, such as armyworms, thrips, and whiteflies, which significantly reduce productivity (Siregar, 2016). Pest infestations can lower yields by 30–40% annually (Nugraha et al., 2021). Farmers generally rely solely on chemical pesticides for pest control. However, excessive use of chemical pesticides leads to pest resistance, soil degradation, environmental pollution, and health risks (Arif, 2015). Exposure to pesticides has been reported to cause nausea, vomiting, dizziness, and itching (Prajawahyudo et al., 2022). In the long term, such exposure disrupts the nervous system and cognitive functions of farmers (Malau & Susilawati, 2023). Therefore, the introduction of biopesticides is essential to reduce the risks of chemical pesticide use.

Biopesticides offer an environmentally friendly alternative in line with the increasing awareness of sustainable agriculture. They can be derived from natural compounds of plants, microorganisms, or other organic materials. In addition to being safer for both the environment and human health, biopesticides are more specific in targeting pests and less harmful to non-target organisms (Toyo et al., 2023). Introducing tobacco-based biopesticides to farmers in Brambang Village can also provide added value by utilizing low-quality tobacco leaves. Tobacco-based formulations have proven effective in controlling aphids and various types of caterpillars (Dewi et al., 2024). Tobacco leaves contain 2–8% nicotine and antimicrobial compounds such as saponins, flavonoids, and polyphenols (Julianto et al., 2021). Nicotine, an alkaloid of the Solanaceae family, functions as a neurotoxin highly sensitive to insects and acts as a fast-acting nerve poison with contact, fumigant, and stomach action properties (Harismah et al., 2022; Rahmawati et al., 2023). Terpenoids in tobacco act as repellents, as their strong odor disrupts insect feeding activity (Harahap et al., 2023). Flavonoids, as phenolic antioxidants, also contribute to pesticidal effectiveness (Sirodz et al., 2024). Furthermore, pyridine, which is colorless and not sharply odorous, is reported to alter the properties of alcohol as a solvent while simultaneously functioning as an insecticidal agent (Sirodz et al., 2024).

To further improve effectiveness, lemongrass (Cymbopogon citratus) can be incorporated into biopesticide formulations. Lemongrass, known for its fragrant aroma, has potential as a botanical pesticide source (Panani, 2024). Lemongrass oil contains active compounds such as linalool, α-pinene, β-pinene, and menthone, which exhibit antifungal, biodegradable, eco-friendly, non-toxic, antimicrobial, and antioxidant properties (Mulwandari, 2022). Additionally, compounds such as geraniol and citronellol function as insect repellents (Chandukishore, 2023). Lemongrass oil acts via both contact and systemic toxicity and has been shown to be effective against crop pests such as aphids, Tribolium sp., Sitophilus sp., Callosobruchus sp., nematodes (Meloidogyne sp.), and fungal pathogens such as Pseudomonas sp. (Arfianto et al., 2018). The extracts of tobacco (Nicotiana tabacum) and lemongrass (Cymbopogon citratus) thus hold strong potential as effective sources of biopesticides (Isdaryanti et al., 2024). Their use represents a practical and sustainable solution for Brambang Village, Karangawen Subdistrict, Demak Regency, to reduce dependence on

chemical pesticides. The raw materials are readily available, and the production technology is simple and easily adopted by farmers.

## B. METHOD

This community service program applied a technology-based empowerment approach to support residents of Brambang Village, Karangawen Subdistrict, Kendal Regency, in utilizing low-grade tobacco that is rejected by factories. The activities included laboratory trials, outreach and education sessions, training workshops, and program evaluation. The initiative integrated faculty members, university students, and local farmers, promoting effective knowledge transfer and sustainable implementation. Faculty members conducted laboratory-scale trials and analyses of tobacco-based biopesticides, delivered educational seminars, provided guidance and supervision to partners throughout the production and application of biopesticides. Meanwhile, students assisted in biopesticide trials, participated in community service activities, and supported participant data collection and evaluation.

The program was implemented in three key phases: pre-activity preparation, activity execution, and monitoring & evaluation. During the preparatory phase, village observations were conducted using questionnaires and interviews to identify pest complaints and local pesticide use. Subsequently, research and experimental formulation of tobacco-based biopesticides were performed in the Chemical Engineering Laboratory at Universitas Negeri Semarang, referring to established scientific literature. The objective was to obtain a formulation that meets biopesticide quality standards. The most effective formulation and supporting tools were introduced to local partners. The main implementation phase involved a series of community outreach and demonstration events in September in Brambang Village, Karangawen Subdistrict, Demak Regency. These activities aimed to increase knowledge on the benefits and economic potential of tobacco-based biopesticides and enhance skills in their production.

Monitoring and evaluation were carried out through direct observation of partners as they applied newly acquired skills, encompassing material preparation, soaking, mixing, and application of biopesticide formulations on tobacco plants. This phase was designed to assess the overall program effectiveness and the success of community empowerment outcomes.

## C. RESULT AND DISCUSSION

Observations were conducted in April during the tobacco planting season and in August during the harvest period. The findings revealed that farmer groups faced pest infestations that disrupted tobacco production, the use of chemical pesticides resulted in various health complaints, and education regarding biopesticides remained limited. These observations served as the basis for the community service team to design subsequent research activities and interventions.


**Figure 1**. Visit to Partners in Brambang Village, Karangawen, Demak

The research and experimental trials of biopesticides were successfully conducted in May–June at the Chemical Engineering Laboratory of Universitas Negeri Semarang. Multiple samples were tested, followed by analysis of pH, nicotine content using a UV-Vis spectrophotometer, and determination of pest control efficacy by measuring pest mortality time. The laboratory research results are presented in Table 1.

Tabel 1. results of laboratory research

| sample | pH | Nicotine (ppm) | Caterpillar mortality time |
|---|---|---|---|
| Tembakau, Etanol (A1) | 5,29 | 423,461 | 1 menit 15 detik |
| Tembakau, Sereh Etanol (A2) | 5,34 | 463,02 | 1 menit 13 detik |
| Tembakau, Aquades (A3) | 4,76 | 336,187 | 1 menit 40 detik |
| Tembakau, Sereh Aquades (A4) | 4,99 | 362,529 | 1 menit 25 detik |
| Tembakau, EM4, Molase, Aquades (A5) | 4,75 | 511,36 | 1 menit 40 detik |
| Tembakau, Sereh, EM4, Molase, Aquades (A6) | 4,86 | 546,592 | 1 menit 11 detik |

These results show that the biopesticide samples met the pH quality range for organic products specified by SNI 7763:2024, which is 4–9 (BSN, 2024). Based on the research findings, sample A6 was identified as the most optimal biopesticide due to its highest nicotine content (546.592 ppm), fastest caterpillar mortality time (1 minute 11 seconds), and pH of 4.86. Sample A6 is formulated from tobacco, lemongrass, EM4, molasses, and distilled water. This sample was introduced to the community during the empowerment program. Thus, the A6 sample formulation meets the permissible criteria and is suitable for use as a biopesticide product.

The community empowerment activities organized by Universitas Negeri Semarang (UNNES) were successfully conducted in Brambang Village, Karangawen Subdistrict, Demak Regency, on September 5, 2025. This program aims to encourage farmers to utilize low-quality tobacco leaves by converting them into biopesticides that can be directly applied in Brambang village. In this way, a sustainable solution is fostered that empowers farmers to independently manage pests in an environmentally friendly manner while increasing the value of tobacco leaf waste. Approximately seven farmer group representatives attended the event, which comprised a series of outreach and demonstration sessions led by Radenrara Dewi Artanti Putri, S.T., M.T., aiming to equip

participants with the skills to produce biopesticides from tobacco leaves combined with lemongrass. Documentation is presented in Figure 1 and 2.

The biopesticide formulation used consisted of a mixture of tobacco leaves and lemongrass in a 2:1 ratio, dissolved in a solvent made up of water, EM4, and molasses at a ratio of 12:1:1. The mixture was fermented for 120 hours and filtered before application. During the activity, the community service team provided equipment for biopesticide application to the partners for collective management by farmers. Figure 2 presents documentation from the program activities.


**Figure 2.** Implementation of Community Service Activities in Brambang Village, Karangawen, Demak

After the presentation of material, the activity continued with a question-and-answer session to assess participants' understanding of the topics delivered. Based on feedback received, the partners expressed a strong interest in independently producing tobacco-based biopesticides. This enthusiasm was supported by the openness of partners and farmers toward the new knowledge and skills provided during the activity. However, the implementation coincided with the pre- and post-harvest periods, so activities could only be held in the afternoon and were attended by a limited number of farmer representatives. Nevertheless, the participation of those present had a positive impact, and the materials delivered could be disseminated to other members of the farmer groups

## D. CONCLUSION

The community service program for utilizing low-grade tobacco leaves and lemongrass as biopesticide raw materials in Brambang Village, Karangawen Subdistrict, Demak Regency was successfully carried out. The community demonstrated high interest in independently producing tobacco-based biopesticides. Laboratory tests indicated that the optimal biopesticide formulation—comprising tobacco leaves, lemongrass, EM4, molasses, and distilled water—had the highest nicotine content (546.592 ppm), the fastest caterpillar mortality time (1 minute 11 seconds), and a pH of 4.86. The outreach and demonstration activities on tobacco and lemongrass-based biopesticide production offer an environmentally friendly alternative solution, reducing dependence on chemical pesticides while increasing the value of low-grade tobacco leaves. Thus, these activities not only have a positive impact on sustainable agriculture but also promote independence and wellbeing among local farmers.

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