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The utilization of goat manure waste into organic fertilizer to support sustainable agriculture

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ABSTRACT

Reliance on chemical fertilizers in Petungsewu Village, Wagir District, has led to a decline in land quality, threatening the sustainability of local agriculture. On the other hand, the abundant goat manure waste has not been utilized optimally and tends to pollute the environment. This community service activity aims to educate and train the People's Forest Farmers Group (KTHR) in producing organic fertilizers through accelerated fermentation techniques using bioactivators. The methods used are technical assistance and direct practice of fertilizer manufacturing with control of moisture and aeration parameters. The results of the activity showed that within three weeks, goat manure waste was successfully transformed into mature organic fertilizer with physical characteristics of being crumbly, dark in color, and free of an ammonia odor. Application tests on cayenne pepper plants, the leading commodity in the Wagir region, showed a more stable increase in vegetative growth than with conventional chemical fertilizers. In addition to improving soil chemistry, this initiative has a positive economic impact by reducing farmers' production costs. Overall, this independent waste treatment is a sure strategy in supporting sustainable agriculture and fertilizer independence at the village level.

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ABSTRAK

Ketergantungan pada pupuk kimia di Desa Petungsewu, Kecamatan Wagir, telah memicu penurunan kualitas lahan yang mengancam keberlanjutan pertanian lokal. Di sisi lain, limbah kotoran kambing yang melimpah belum dimanfaatkan secara optimal dan cenderung mencemari lingkungan. Kegiatan pengabdian masyarakat ini bertujuan untuk mengedukasi serta melatih Kelompok Tani Hutan Rakyat (KTHR) dalam memproduksi pupuk organik melalui teknik fermentasi yang dipercepat dengan menggunakan bioaktivator. Metode yang digunakan adalah pendampingan teknis dan praktik langsung pembuatan pupuk dengan kontrol parameter kelembapan dan aerasi. Hasil kegiatan menunjukkan bahwa dalam waktu tiga minggu, limbah kotoran kambing berhasil ditransformasi menjadi pupuk organik matang dengan karakteristik fisik yang lemah, berwarna gelap, dan tidak berbau amoniak. Uji aplikasi pada tanaman cabai rawit sebagai komoditas unggulan wilayah Wagir menunjukkan peningkatan pertumbuhan vegetatif yang lebih stabil dibandingkan dengan penggunaan pupuk kimia konvensional. Selain memperbaiki sifat kimia tanah, inisiatif ini memberikan dampak ekonomi positif berupa efisiensi biaya produksi bagi para petani. Secara keseluruhan, pengolahan limbah mandiri ini menjadi strategi jitu untuk mendukung pertanian berkelanjutan dan kemandirian pupuk di tingkat desa.

Kata Kunci: *cabai rawit; fermentasi; kotoran kambing; pertanian berkelanjutan*

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INTRODUCTION

The agriculture and livestock sectors are the main economic pillars for the community in Petungsewu Village, Wagir District, Malang Regency. As an area on the slopes of Mount Kawi, this village has specific potential for commodity development. The Wagir area has a very high level of land suitability for the development of cayenne pepper plants (Simanjuntak et al., 2020). However, the future of this land's productivity is being threatened by the massive use of synthetic chemical fertilizers. The phenomenon of soil quality degradation caused by these chemicals requires an urgent restoration strategy. The effectiveness of chemical fertilizers is beginning to decline relative to organic fertilizers in maintaining the long-term health of soil ecosystems (Gomes et al., 2024; Halawa et al., 2025). Therefore, a transition to an organic farming system is strongly recommended to ensure the sustainability of the agricultural sector (Gamage et al., 2023; Oyebiyi et al., 2026).

The main problem that is visible to the naked eye in Petungsewu Village is the accumulation of goat manure waste that has not been managed optimally. In fact, goat dung can be processed into fertilizer to repair deteriorating soil structures (Azuka & Idu, 2022; Maula, 2023). Practical steps for the manufacture of solid organic fertilizers have been shown to restore the quality of agricultural land in practice (Rahmayanti et al., 2023; Rohmaniah et al., 2021). Not only does improving the soil, but the use of these organic nutrient sources effectively increases nutrient uptake in food crops (Teressa et al., 2024; Ukamaka, 2023). However, farmers need to understand the nutrient release patterns of livestock manure, particularly the importance of synchronizing nitrogen release with the plant's phase of need, to maximize results.

To address the challenge of time efficiency, waste management in Petungsewu Village is now focused on fast fermentation techniques. The use of bioactivators such as EM4 can significantly accelerate the breakdown of organic matter (Prasteyo et al., 2021). To ensure the resulting fertilizer is stable and mature, strict process control parameters are highly recommended (Kim et al., 2023; Pezzolla et al., 2021). On the other hand, alternative technologies such as vermicomposting are also recognized as sustainable waste management solutions in peri-urban areas (Pezzolla et al., 2021; Sarkar et al., 2023). Especially in the Malang region, the use of goat manure compost enriched with other organic residues yields tangible improvements in the availability of soil nutrients P and K (Susanto & Kurniawan, 2020).

The efficacy of fermenting goat manure has been tested across various commodities. Its benefits have been demonstrated in crops such as mustard greens and eggplants, which showed increased yields (Aulia & Suntari, 2023; Yulianingsih, 2019). These findings are further supported by research on various types of leafy vegetables (EL-Dkeshy et al., 2022; Liu et al., 2025). To significantly increase plant biomass, implementing more advanced integrated nutrient management is strongly recommended (Abdul-Hafeez et al., 2026). From a socio-economic perspective, independence in processing village waste is believed to reduce production costs and provide an additional source of income for farming families (Afandi et al., 2023; Anam et al., 2025). While many studies focus on general organic farming, this service activity introduces a novel approach by integrating livestock waste management specifically within the institutional framework of the People's Forest Farmers Group (*Kelompok Tani Hutan Rakyat*/KTHR) in a highland ecosystem, transforming goat dung into high-value economic assets that support long-term sustainable agroforestry.

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Literature Review

Implementation of Community Service in Livestock Waste Treatment

The implementation of service programs in the agricultural sector is increasingly focused on optimizing local resources to improve farmers' welfare. Goat waste management is a strategic tool that not only cleans the environment but also improves the economic well-being of families in rural areas (Afandi et al., 2023). In line with this view, the use of village waste as raw material for organic fertilizers is a key step toward achieving independence for production facilities (Anam et al., 2025). Furthermore, the success of this technology transfer is greatly influenced by the accuracy of the waste management methods applied, especially in peri-urban areas that require robust environmental solutions (Sarkar et al., 2023).

Characteristics of Goat Manure and the Concept of Organic Fertilizer

Goat manure has long been recognized to have an excellent nutritional profile for agricultural land. The use of goat manure as organic fertilizer is a crucial solution for restoring the quality of land that is becoming saturated (Maula, 2023). The application of organic fertilizers noticeably improves soil physical and chemical properties, especially on coarse-textured land (Azuka & Idu, 2022). Furthermore, livestock compost has great potential for soil improvement when appropriately processed to leverage its specific characteristics (Kim et al., 2023). Fertilizer maturity is also critical, as goat manure must be processed into a stable, solid organic fertilizer before application to ensure optimal benefits for the soil (Rohmaniah et al., 2021).

Basic Principles of Fermentation with Bioactivator M21

Fermentation technology is the answer to the slow natural decomposition process of organic matter. The addition of bioactivators such as EM4 can significantly accelerate the fertilizer manufacturing process by leveraging active microbes. The use of specific parameters to monitor the fermentation process is essential for optimizing organic waste decomposition and achieving high-quality results (Pezzolla et al., 2021). In addition to liquid and solid fermentation, vermicomposting has been introduced as a highly effective, sustainable method for processing agricultural waste. This nutrient integration strategy is part of an integrated nutrient management system that can systematically increase plant productivity (Prasteyo et al., 2021).

Sustainable Agriculture and People's Forest Strategy

The sustainability of agriculture depends heavily on how farmers manage soil nutrient balance, with organic farming playing a vital role in achieving long-term sustainability (Gamage et al., 2023). The application of goat manure has been shown to improve P absorption and mustard green growth (Aulia & Suntari, 2023). Furthermore, the effectiveness of this organic fertilizer has been demonstrated in the growth of eggplant plants (Yulianingsih, 2019). The efficiency of various combinations of organic fertilizers for crop yields has also been well documented, particularly in improving the quality of leafy vegetables and cabbage (EL-Dkeshy et al., 2022; Liu et al., 2025). In the Malang region, research provides an important foundation regarding the evaluation of land suitability for chili plants, while the use of goat manure compost enriched with urea-huma-residue has proven very effective in increasing P and K nutrients in the soil (Simanjuntak et al., 2020; Susanto & Kurniawan, 2020). More broadly, the use of organic matter is

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recognized as the best remediation strategy for restoring soil function and sustainably supporting carbon resilience (Gomes et al., 2024; Oyebiyi et al., 2026).

METHODS

The method used in this service activity is Plot Demonstration combined with participatory technical assistance. This approach is based on the Community Development method, which positions partners as active subjects in the process of technological transformation. The activity was carried out in one of the houses of residents who have goats and agricultural land and are KTHR members.

The stages of implementing the service are systematically arranged, which include five phases: 1) Observation and socialization stage; 2) Literacy education stage; 3) Plot demonstration stage; 4) Direct practice of making fermented fertilizer (**Figure 1**); and 5) Monitoring and evaluation stage. The success of this service activity is measured based on 1) The change in attitude is the shift of the farmer's paradigm from disposing of waste to collecting waste for processing; 2) Socio-cultural is the formation of a culture of cooperation in producing fertilizer at the KTHR level; 3) Economically, farmers can estimate production costs by reducing the use of chemical fertilizers after using fermented fertilizers that are produced independently.

RESULTS AND DISCUSSION

Result

The implementation of service activities in Petungsewu Village is systematically arranged through five main phases to ensure effective technology transfer to partners. These stages include:

1. Observation and socialization stage
   At this stage, an initial assessment was conducted of the volume of goat manure waste and farmers' knowledge of organic fertilizers. Socialization was conducted to equalize perceptions of the importance of fermented goat manure.

2. Literacy education stage
   Presentation of material on fertilizer classification and the role of microorganisms in M21 Bioactivator as an agent for restoring organic matter.

3. Plot demonstration stage

4. Direct practice of making fermented fertilizer (**Figure 1**).

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Figure 1. Fertilizer Manufacturing
Source: Author Documentation 2025

The fermentation procedure is modified from the anaerobic composting standard with the following steps:

a. Preparing materials and tools
   Material: M21/EM4 Decomposer, Dolomite Lime, Sugarcane Drops, and Goat Manure;
   Tools: Tarpaulin, hoe, and bucket.

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b. Cleaning the location
   Cleaning of work areas and shaded places or expanses that are not waterlogged if it rains. Then mix the ingredients by making a layer.

c. Layer manufacturing
   Creation of a layer of manure from goats, 20-30 cm thick. Sprinkle dolomite, ash, and M21 decomposer to taste.

d. EM4 Addition
   Prepare EM4 at the set dose, dissolve in water, and then water on a layer until the moisture content reaches 40%, measured by hand kneading and checking that no water drips and that no organic matter breaks when the hand grip is opened.

e. Creation of new layers
   Make the next layer until all the ingredients are gone. Then the layer is hoed from one side in the same direction to create a new pile. Do it again in the opposite direction, then pile it up or make mountains as wide as the cover.

f. Fermentation process
   The pile is tightly covered with a tarp. The edges of the tarpaulin are weighted down so they do not flap in the wind. Let it sit for a week. After 1 week, the tarpaulin is opened, and the pile is stirred to aerate the compost. During successful composting, heat is generated and can be felt when dismantling the mound. After 3 weeks, the compost can be dismantled and aerated to remove the ammonia smell, then used.

5. Monitoring and evaluation stage
   At this stage, a physical examination of the fermentation results is conducted in the third week to ensure the fertilizer meets maturity standards.

Through this service activity, the team successfully processed goat manure into fermented fertilizer products designed to reduce farmers' reliance on chemical fertilizers. During the three-week process, there were significant physical changes to the raw materials. The resulting final product has a smooth texture and a fresh organic aroma without a sharp ammonia smell. According to the team's observations, the loss of pungent odor strongly indicates that the ammonia compounds have completely decomposed during the process. The success in accelerating the maturity of this fertilizer is inseparable from the role of microbial bioactivators. The addition of active microbial inoculants is crucial for optimizing the process of overhauling organic matter, thereby minimizing the risk of process failure, as often encountered in the old composting method (Rizki et al., 2025).

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Table 1. Physical Maturity Indicator of Goat Manure Fermentation Fertilizer

No	Parameters of Observation		Results Description
1	Texture	Smooth and crumbs	Facilitates application to the ground
2	Aroma	Non-stinging	Ammonia-free
3	Color	Dark brown	Indication of humic acid
4	Application	Immerse at the root end	Nutrient absorption efficiency

Source: Primary Data of Service Team (2025)

The physical quality of the products of this service is summarized in **Table 1**.

Discussion

A one-month trial application to chili plants yielded encouraging results compared with the use of regular chemical fertilizers. Plants given fermented fertilizers show lusher, sturdier vegetative growth. The choice of cayenne pepper as a commodity is highly relevant to land suitability evaluations, which identify the Wagir District area as having excellent potential for the plant (Simanjuntak et al., 2020). Based on visual observations, this fertilizer significantly increases the availability of essential elements such as nitrogen and phosphorus in the soil. Deeper analysis shows that goat manure fermentation fertilizer acts as both a soil improver and a nutrient provider. The effectiveness of organic fertilizers in chili plants is often superior in the long term because nutrients are released slowly (Halawa et al., 2025). Furthermore, a more stable pattern of organic nitrogen release is essential to ensure that plants receive a sustainable nutrient supply compared with chemical fertilizers, which are immediate but susceptible to being washed away by rainwater (Ikhwal et al., 2026). Similar results regarding increased crop production through organic intake have also been demonstrated in eggplant plants and various leafy vegetables (EL-Dkeshy et al., 2022; Liu et al., 2025; Yulianingsih, 2019).

Additionally, the long-term use of organic fertilizers has been shown to improve the composition of soil microbes and fungi, which is crucial for sustainable land productivity (Wen et al., 2020). Ecologically, the application of this technology directly impacts environmental cleanliness in Petungsewu Village. The use of this waste effectively reduces the pile of cage manure that is at risk of polluting settlements. Proper waste management is recognized as the primary strategy for minimizing pollution at the district level (Halawa et al., 2025; Prasteyo et al., 2021). In addition, the use of organic fertilizers has a wide positive impact on soil health and overall environmental sustainability (Gomes et al., 2024). This approach further establishes organic farming as a fundamentally more environmentally friendly instrument (Gugalia, 2021). From an economic perspective, farmers can now reduce operational costs because raw materials are readily available at service locations. Independence in processing village waste can significantly increase family income by reducing agricultural input costs (Afandi et al., 2023; Anam et al., 2025).

Collective initiatives through farmer groups (KTHR) to produce independent fertilizers will strengthen village food security and align with the global vision of sustainable agriculture (Gamage et al., 2023; Rhofita, 2022). From a broader perspective, organic farming systems are considered an essential strategy for achieving a safe and self-sustaining food system, especially amid fluctuations in global agricultural supply (Kumari et al., 2023; Manisha et al., 2025). The technical challenge that had arisen was an unpleasant odor when moisture content and air circulation were not maintained. The team worked around this by adding dry ingredients, such as dried leaves or ash, and keeping the humidity within the 40% range.

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The use of stricter control parameters is highly recommended to optimize the decomposition process across different types of organic waste (Pezzolla et al., 2021). Education regarding early detection through pile temperature remains a primary focus so that farmers can make independent improvements. This risk management approach is essential for ensuring the quality of the final product and meeting standard requirements for livestock compost characteristics (Kim et al., 2023). Finally, consistent improvement of soil chemical properties through organic matter is the key to maintaining long-term soil fertility in the Malang region (Aulia & Suntari, 2023; Susanto & Kurniawan, 2020).

CONCLUSION

Based on the results of the service activities carried out, it can be concluded that the application of fermentation technology using bioactivators is effective in converting goat manure waste into high-quality organic fertilizer in a relatively short time. Physically, the resulting product meets good fertilizer maturity standards, characterized by changes in texture and color, and a loss of pungent aroma. The use of this fertilizer in chili plants has been shown to provide more stable nutrient release (slow-release) and improve soil health that was previously saturated by chemical inputs. From an environmental perspective, this program has succeeded in minimizing odor pollution and waste accumulation in residential areas. Meanwhile, from an economic perspective, the collective production of fertilizers by farmer groups can reduce agricultural operational costs in real terms. As a suggestion, continuous assistance is needed for KTHR to maintain the standardization of fertilizer quality, so that this product not only meets the village's internal needs but also has competitive economic value as a village economic asset.

AUTHOR'S NOTE

The author states that there is no conflict of interest in the form of financial or personal relationships with other parties related to the publication of this article. The author also emphasizes that the article's data and content are original and free from all forms of plagiarism. All sources of citations and references used have been listed in accordance with the applicable scientific writing rules. Thank you to the people of Petungsewu Village, Wagir District, especially to the management and members of KTHR, who are willing to be partners and provide full support during the implementation of the service.

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