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# Potential for Developing Liquid Organic Fertilizer from Agricultural, Plantation, and Livestock Waste through Ecodesign

**Mariam Mariam[a*], Andi Nur Insani[a]**

[a]Department of Animal Husbandry, Muhammadiyah University of Mamuju, 81511 Mamuju, Indonesia

*Corresponding author: E-mail: mariam@unimaju.ac.id

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**ABSTRACT**

This study aims to evaluate the potential of organic liquid fertilizers (LOF) derived from agricultural, plantation, and animal waste in Mamuju Tengah District, employing an ecodesign approach. The LOF materials used were goat urine, palm fruit leaf, rice straw, and corn straw. The research methodology employed was a randomized complete block design with four LOF treatment doses: a control (K), 10 ml, 20 ml, and 30 ml per liter of water. Each treatment was replicated four times and applied to two plant species: elephant grass (*Pennisetum purpureum*) and the legume Indigofera. The parameters observed included plant height, number of tillers, chlorophyll content, and the number of nodules on the roots of the plants. The study results indicate that LOF does not significantly affect plant height in either test species. However, a significant effect was observed on increased chlorophyll content and the number of nodules in the Indigofera plants. Furthermore, the application of LOF resulted in a notable impact on the number of seedlings and chlorophyll content in elephant grass. The findings of this study indicate that LOF, derived from agricultural, plantation, and animal by-products, benefits specific growth parameters, particularly chlorophyll and nodules. This suggests that LOF has the potential to serve as an environmentally friendly fertilizer in sustainable agricultural systems.

Keywords: Organic liquid fertilizer, goat urine, palm leaf, plant growth, ecodesign

## INTRODUCTION

The government of Central Mamuju district plays a vital role in supporting the provincial economy of West Sulawesi through its contributions to the agricultural sector. According to data released by the Central Statistics Agency of West Sulawesi in 2022, the agricultural sector, which includes food crops, plantations, and livestock, has been identified as the primary contributor to the province's economy. The main commodities are rice, with a production volume of 29,945.50 tons (cultivated on 6,313.82 hectares); corn, with a production volume of 38,349 tons; and coconut, with a production volume of 924 tons (cultivated on 1,452.5 hectares). The palm oil industry has produced 97,235 tons (from 36,159.14 hectares of land), while the banana industry has reached 948,369 quintals. The cattle and goat industries have reached 119,209 and 200,999 heads, respectively. These sectors form the backbone of the local economy, yet they frequently generate unutilized organic waste [1]. These by-products, such as straw, chaff, fruit skins, and animal manure, can lead to environmental contamination and public health issues if not appropriately managed.

The increased awareness of the importance of environmental protection and sustainable agriculture has led to the pursuit of alternative methods for managing organic waste [2]. One promising solution is the development of technology for producing liquid organic fertilizers. Liquid organic fertilizer (LOF) is a highly beneficial fertilizer that can restore soil fertility naturally. It can also be used to grow feed crops free from harmful chemicals, making them safe for livestock to consume. In addition to its nutritional value, LOF contains beneficial microorganisms for plant growth. The LOF includes the following essential nutrients: nitrogen (N), which is responsible for promoting vegetative growth; phosphorus (P), which is necessary for root development; and potassium (K), which is vital for maintaining cell turgor and osmotic balance. Phosphorus (P) plays a role in stimulating root, fruit, and seed growth. The element potassium (K) has been demonstrated to enhance plant resilience to pests and pathogens.

Implementing eco-design principles in developing point-of-care (LOF) technology is a crucial aspect that merits [3]. Ecodesign is a design approach focused on minimizing environmental impacts throughout a product's life cycle, from production to use and disposal. The application of ecodesign in LOF technology development aims to reduce carbon footprints, optimize resource use, and decrease production waste. This approach aligns with the vision of Central Mamuju District to promote sustainable development in the agricultural and livestock sectors while enhancing the quality of life for the local community. It is anticipated that utilizing agricultural, plantation, and livestock waste as the primary material for an eco-designed LOF will benefit both the environment and the local economy.

Understanding the community's knowledge and attitudes toward agricultural, plantation, and animal husbandry waste management and processing in the surrounding area poses ongoing challenges [4]. Therefore, innovative technologies must be introduced to address this issue. One potential solution for waste management is to implement an eco-design approach, specifically using a urine-based organic fertilizer combined with the microbial inoculant EM4 to produce a liquid fertilizer. This method could enhance crop production by optimizing nutrient utilization.

The sustainable management of agriculture is becoming the primary focus of global efforts to maintain ecosystem balance and mitigate the adverse effects of conventional agricultural practices [5]. One proposed approach is the utilization of liquid organic fertilizers (LOF) derived from farming, plantation, and livestock waste. The management of waste materials such as goat urine, palm fruit husks, rice straw, and corn straw, which are typically not optimally utilized, has the potential to be recycled into fertilizers that can support plant growth ecologically. Using organic liquid fertilizers derived from goat urine and agricultural waste offers a sustainable alternative to synthetic fertilizers, enhancing soil fertility and crop yields. Urine is a wealthy nitrogen source essential for plant growth. This approach has been demonstrated to improve plant height and overall health, as in tobacco plants [6].

The research results indicate that the effective processing of sheep urine can significantly enhance soil's nutritional content and promote plant growth [7]. The combination of goat urine with decomposing agricultural waste, such as coconut husks, has been demonstrated to improve soil pH and the availability of nutrients in nutritionally deficient soils, such as Ultisols. The composition of goat urine, particularly regarding nitrogen (N), phosphorus (P), and potassium (K), demonstrates its potential as a natural fertilizer. Research indicates that goat urine contains significant nutritional content, making it a valuable resource for agricultural practices.

The novelty of this research lies in the unique combination of raw materials (LOF) and the application of eco-design technology to develop environmentally friendly fertilizers that support sustainable agriculture [8]. Producing organic fertilizer from sheep waste is economically viable and promotes sustainable agricultural practices. Utilizing locally sourced waste materials in Central Mamuju District offers a pertinent solution to reducing reliance on synthetic chemical fertilizers, which are often costly and detrimental to soil and the environment. The utilization of sheep dung and urine not only mitigates environmental contamination but also transforms waste into a valuable organic fertilizer. This process may result in creating an integrated system of agriculture and animal husbandry that is free from the constraints of waste management [9].

Furthermore, this study employed a randomized complete block design with four LOF dose treatments to assess their impact on the growth of elephant grass and Indigofera legumes.

This study evaluates LOF's impact on several plant growth parameters, including plant height, number of tillers, chlorophyll content, and nodule number. Hopefully, this research will demonstrate that LOF, produced from agricultural, horticultural, and animal by-products, can offer a more efficient and environmentally friendly solution to support sustainable agriculture.

## MATERIALS AND METHODS

### Research locations

Field research was planned at a pasture in Mamuju district, West Sulawesi Province. This pasture is dominated by corn straw, rice straw, coconut belt, and goat urine, which will be processed into Liquid Organic Fertilizer (LOF).

The Feed Forage, Food Chemistry, and Integrated Laboratory analyzed field materials and samples.

### Type and Source of Data

The data required in this study consisted of primary and secondary. Primary data were obtained through laboratory test results of LOF, observation of feed crop productivity at the research location, and interviews with farmers about the use of LOF. Secondary data is information processed and obtained indirectly through literature research and other sources relevant to the research topic.

### Research Materials

The research materials consisted of: (1) Preparation of liquid organic fertilizer based on corn straw waste, rice straw, and coconut belt of 500 grams each that has been mashed + goat urine 15 liters + EM4, then the mixture of materials is fermented for 21 days using a barrel that has a lid. (2) Application to 2 types of plants in the form of tillers, namely Elephant grass (Pennisetum purpureum) (Bio-Grass) and Indigofera zollingeriana legume planted on grassland in Mamuju Regency, each plant was given liquid fertilizer with control level, 10, 20, 30 ml/1 liter of water with each treatment consisting of 4 replicates.

## RESULTS AND DISCUSSIONS

### Soil Chemical Content

The soil conditions at the research site indicate characteristics that require fertility improvements [10]. This is evidenced by low pH levels and nitrogen, phosphorus, and potassium content below optimal criteria for plant growth. Therefore, initial analysis is essential to determine appropriate interventions by applying liquid organic fertilizer (LOF).

Table 1. Chemical Content of Research Soil

| Chemical Content | Unit | Value | Criteria* |
|---|---|---|---|
| pH | - | 4 | Acid |
| N-Total | % | 0.12 | Low |
| P2O5 | Ppm | 10.41 | Low |
| K | cmol(+).kg-1 | 0.24 | Very Low |

Description: UNHAS Soil Chemistry and Fertility Laboratory Analysis, 2024
*Based on Bogor Soil Research Centre, 2009

Table 1 shows the chemical condition of the soil studied in Central Mamuju Regency, which has a pH of 4, indicating acidic soil conditions. The total nitrogen (N) content was only 0.12%, which is in the low category, meaning that the nitrogen availability for plants is minimal. Phosphorus (P) was measured at 10.41 ppm, which is also in the low category, indicating that the soil lacks phosphorus nutrients essential for root growth and seed formation. Potassium (K) content was only 0.24 cmol(+).kg-1, categorized as very low, potentially affecting plant resistance to pests and diseases.

The results of this soil chemical analysis illustrate that the soil at the study site requires fertility improvement efforts, especially by applying fertilizers rich in nitrogen, phosphorus, and potassium. Research by Adani et al. [11] states that acidic and nutrient-poor soil conditions require restoration through liquid organic fertilizer to increase the availability of essential plant nutrients. In addition to increasing soil fertility, organic fertilizers can improve soil structure, making it easier for plant roots to absorb water and nutrients. This is especially important in environments facing soil degradation, such as Central Mamuju Regency, where agricultural and livestock waste can be processed into organic fertilizer to improve soil quality without damaging the local ecosystem. In addition, Putri et al. [12] found that organic fertilizer can increase soil pH, reduce acidity, and improve nutrient availability in poor soils.

## Chemical Content Analysis of LOF

The liquid organic fertilizer (LOF) used in this study was produced by fermenting agricultural and livestock waste, including goat urine, rice straw, and coconut husks. Chemical analysis was conducted to evaluate the LOF's nutrient content compared to national standards.

Table 2. Chemical Content of Liquid Organic Fertiliser (LOF)

| Chemical Content | Unit | Value | Standard* |
|---|---|---|---|
| pH | - | 5 | Meet |
| N | % | 2.56 | Meet |
| P | % | 1.97 | Does not meet |
| K | % | 2.11 | Meet |

Description: UNHAS Soil Chemistry and Fertility Laboratory Analysis, 2024
*The minimum standard of LOF is based on the Decree of the Minister of Agriculture Number 261/KPTS/SR.310/M/4/2019 (Ministry of Agriculture, 2019).

Table 2 shows the chemical content of liquid organic fertilizer (LOF) produced from agricultural and livestock waste materials. The analysis results show that the pH of the LOF is 5, which meets the organic fertilizer standard and is ideal enough to be applied to acidic soils to increase pH. The nitrogen (N) content in the LOF of 2.56% also meets the standard, indicating that this LOF can provide sufficient nitrogen supply to support plant vegetative growth. The phosphorus (P) content in the LOF was recorded at 1.97% but did not meet the standard set by the Ministry of Agriculture. However, the potassium (K) content of 2.11% met the standard and may contribute to plant resistance to pests and diseases.

Applying LOF with a high nitrogen content can help improve nitrogen-deficient soil, as seen in the soil at the study site. The study by Putri et al. [12] showed that liquid organic fertilizer with a high nitrogen content effectively improved forage plant growth and optimized biomass production. In addition, research by Kurniawan et al. [13] also supports that sufficient potassium content in liquid organic fertilizer can increase plant resistance to environmental stress.

The acidic soil at the research site with a pH of 4 can cause problems in plant growth, as essential nutrients become less available to plants. Applying LOF with a pH of 5 can gradually increase soil pH, reduce acidity, and increase nutrient availability. Using liquid organic fertilizer can raise soil pH so that the initially acidic soil becomes more neutral, allowing plants to absorb nutrients more efficiently [14]. The continuous use of LOF is expected to improve soil pH in the long term, increasing agricultural land productivity in the Mamuju Tengah area.

Ecodesign, when applied to the development of liquid organic fertilizer, improves soil fertility and minimizes environmental impacts [9]. Ecodesign allows local resources, such as agricultural and livestock waste, to produce sustainable and environmentally friendly organic fertilizer. Thus, LOF supports sustainable agriculture by increasing soil pH and nutrient content.

### Growth of Elephant Grass Fodder Plants.

Table 3 presents the effects of LOF application on the growth parameters of elephant grass (*Pennisetum purpureum*). Observed parameters include plant height, the number of tillers, and leaf chlorophyll content, reflecting the physiological responses of plants to the treatments.

Table 3. Plant Height, Number of Saplings and Chlorophyll in Elephant Grass (Biograss)

| LOF Dosage (1/L Water) | Parameter | | |
|---|---|---|---|
| | **Plant Height (cm)** | **Number of Saplings (/Plant/Pole)** | **Chlorophyll (Unit)** |
| Control | $406.75^{a}$ | $8.00^{a}$ | $44.50^{a}$ |
| 10 ml | $435.25^{a}$ | $11.00^{a}$ | $52.50^{b}$ |
| 20 ml | $401.75^{a}$ | $12.25^{a}$ | $56.25^{b}$ |
| 30 ml | $412.00^{a}$ | $12.75^{a}$ | $55.75^{b}$ |

Description: Different superscripts in the same column indicate significant differences (P<0.05).

### Elephant Grass Plant height

Table 3 indicates that the application of liquid organic fertilizer (LOF) did not have a significant impact on the height of elephant grass plants. In the control group, the plant height was recorded at 406.75 cm, while the heights for doses of 10 ml, 20 ml, and 30 ml varied from 401.75 cm to 435.25 cm. Although there was a slight variation, the difference was not statistically significant. This suggests that the plant's response to LOF may require more time or higher doses to significantly influence plant height.

Liquid organic fertilizer (LOF) often takes longer to significantly affect plant height growth [11]. Certain plant species require more time to show noticeable changes in height after application [14]. This delay occurs because the absorption of nutrients from LOF is slower than that of chemical fertilizers, resulting in a postponed response from the plants. Some grass species may need larger amounts of fertilizer or an extended application period to observe meaningful changes in height growth [13].

The study also showed that plants receiving organic fertilizer focused on improving soil health and root establishment before experiencing significant height growth. Also, for some crops, the impact of liquid organic fertilizer is only seen over a longer growth cycle [15].

**Number of Elephant Grass Saplings**

The number of tillers increased as the dosage of LOF increased, although this increase was not statistically significant. The average number of tillers in the control was 8 per plant, while 10 ml and 20 ml doses produced 11 and 12.25 tillers per plant, respectively. At the highest dose, 30 ml, tillers reached 12.75 per plant. This suggests that LOF can potentially increase the number of tillers, but it may take a larger dose or longer application time to see more significant changes.

The nitrogen content of organic fertilizer affected the growth of the number of tillers in elephant grass [16]. Although the nitrogen content in this LOF is relatively high, the plant's response to the fertilizer takes longer to increase vegetative processes such as tiller formation. Another study also showed that higher doses of liquid organic fertilizer or a more frequent application frequency can significantly affect the number of tillers [15].

Revealed that applying liquid organic fertilizer to forage crops often takes longer to show a significant increase in vegetative aspects, such as the number of tillers [17]. This is due to the slower decomposition process and nutrient release than chemical fertilizers. Irin and Hasanuzzaman [18] also suggested that organic fertilizers require more frequent application to produce a noticeable effect on tiller formation.

**Chlorophyll Content in Elephant Grass**

The chlorophyll content of the leaves showed more significant results. In control, chlorophyll content was recorded at 44.50 units, while LOF application at doses of 10 ml, 20 ml, and 30 ml significantly increased it, reaching 52.50, 56.25, and 55.75 units, respectively. This increase indicates that LOF effectively increases the plant's ability to perform photosynthesis, which is one of the essential indicators of plant health.

Research indicates that chlorophyll content in plants receiving liquid organic fertilizer tends to increase, as organic fertilizer contains nitrogen that is more readily available to plants during the photosynthesis process [19]. Furthermore, it has been observed that the application of liquid organic fertilizer enhances the photosynthetic system of plants, which boosts light absorption efficiency and energy production [20].

The higher chlorophyll content suggests that LOF can boost photosynthetic activity by adding nitrogen, a vital component of chlorophyll. Liquid organic fertilizer rich in nitrogen can also enhance chlorophyll levels in forage plants, which is linked to improved photosynthetic efficiency and overall plant growth [12] [14].

**The Effect of LOF on Elephant Grass Growth**

Overall, the LOF application had a more significant effect on chlorophyll content than on plant height and the number of tillers. LOF improved the photosynthetic ability of plants, although it did not significantly affect vegetative growth, such as plant height and the number of tillers.

Research by [21] suggested that liquid organic fertilizer typically provides long-term benefits to soil health and crop productivity, especially when paired with effective soil management practices. Additionally, [21] noted that liquid organic fertilizer often enhances micronutrient levels in the soil, which, in turn, boosts the photosynthetic capacity of plants.

Liquid organic fertilizer must be applied in larger doses to soils with low nutrient content [22]. Higher doses or more frequent applications may increase the fertilizer's effectiveness in affecting other growth parameters, such as plant height and the number of tillers.

## Growth of Indigofera Legumes

Table 4 presents data on the effects of LOF on the growth of Indigofera zollingeriana. The parameters analyzed include plant height, the number of root nodules, and leaf chlorophyll content, which indicate plant health and productivity.

Table 4. Plant Height, Number of Nodules and Chlorophyll in Indigofera Legume

| LOF Dosage (1/L Water) | Parameter | | |
|---|---|---|---|
| | **Plant Height (cm)** | **Number of Nodules** | **Chlorophyll (Unit)** |
| Control | $133.50^{a}$ | $13.50^{a}$ | $31.00^{a}$ |
| 10 ml | $169.00^{ab}$ | $40.50^{ab}$ | $48.50^{b}$ |
| 20 ml | $142.75^{ab}$ | $25.25^{a}$ | $53.50^{bc}$ |
| 30 ml | $176.75^{b}$ | $153.50^{b}$ | $57.00^{c}$ |

Description: Different superscripts in the same column indicate significant differences (P<0.05).

### Plant Height of Indigofera Legume

Based on Table 4, the plant height of Indigofera increased along with the increase in LOF dosage. The average plant height in the control was 133.50 cm, while the 10 ml dose produced 169.00 cm, the 20 ml dose produced 142.75 cm, and the 30 ml dose produced 176.75 cm. A significant increase in plant height was seen in the 30 ml dose compared to the control. These results indicate that LOF has a positive influence on the growth of leguminous plant height.

In Indonesia, liquid organic fertilizer based on agricultural waste also increased the height of leguminous plants, mainly due to its nitrogen content, which supports vegetative growth [23][24]. Liquid organic fertilizer can accelerate the development of leguminous plants, including Indigofera, by providing more nitrogen available to plants than chemical fertilizers [24][25]. This finding is relevant to the current study, where the increase in plant height in Indigofera was in line with the increase in the dose of LOF applied.

Nitrogen-rich liquid organic fertilizers, such as LOF, can increase the height of leguminous plants due to their nitrogen content, which supports vegetative growth [23]. The use of liquid organic fertilizer also increases the growth of leguminous plants, especially in terms of plant height, because these plants utilize nitrogen more efficiently than non-leguminous plants [15]. Leguminous plants that get enough nitrogen experience a significant increase in height and biomass growth [18].

### Number of Nodules on Indigofera Legume

The number of nodules formed on the roots of Indigofera legumes also increased significantly as the LOF dose increased. In the control, the average number of nodules was 13.50, while at doses of 10 ml and 20 ml, the number of nodules increased to 40.50 and 25.25. The most significant increase occurred at the 30 ml dose, where the number of nodules reached 153.50. The higher number of nodules at larger doses indicates that LOF can increase nitrogen fixation activity by nitrogen-fixing bacteria in legume roots.

The increase in the number of nodules in legumes, including Indigofera, is strongly influenced by the availability of nitrogen in the soil, which is enhanced by applying liquid organic fertilizer [25][26]. These nodules are essential for the nitrogen fixation process, which helps provide nutrients to the plant and supports vegetative growth. Applying LOF rich in nitrogen enhanced the symbiosis between leguminous plants and nitrogen-fixing bacteria, which increased the number of nodules in the plants [25][27]. This is in line with the results of this study, where LOF provided a significant increase in the number of nodules formed on Indigofera.

The liquid organic fertilizer promoted nodule formation on leguminous roots by increasing nitrogen availability in the soil, which is essential for the symbiosis between nitrogen-fixing bacteria and plants [27][28]. The increase in the number of nodules correlated positively with the plant's enhanced ability to fix nitrogen, which is crucial for leguminous growth [21] [22]. Research also indicated that a higher number of nodules improved the efficiency of leguminous plants in utilizing atmospheric nitrogen to support their vegetative growth [22].

### Chlorophyll Content of Indigofera Legume

The chlorophyll content in the leaves of Indigofera legumes significantly increased with the application of LOF. In the control group, the chlorophyll content measured 31.00 units, while the 10 ml dose resulted in 48.50 units, the 20 ml dose produced 53.50 units, and the 30 ml dose yielded 57.00 units. This increase suggests that LOF enhances photosynthetic activity in Indigofera, as indicated by the rise in chlorophyll content.

The increase in chlorophyll content in Indigofera was also significant with applying LOF, especially at a dose of 30 ml, which produced the highest chlorophyll content of 57.00 units. His research in Indonesia showed that livestock waste-based liquid organic fertilizer can increase chlorophyll content in leguminous plants due to nutrient content, especially nitrogen, which helps improve photosynthesis [27].

An increase in chlorophyll is closely related to a rise in plants' photosynthetic capacity, directly impacting plant productivity [28]. The increase in chlorophyll content in Indigofera indicates that LOF increases the plant's efficiency in absorbing light and converting it into energy for growth.

According to Liang et al. [19], the increase in chlorophyll content in legume plants treated with liquid organic fertilizer results from the enhanced availability of nitrogen, a key component of chlorophyll and essential for photosynthesis. Sulistiyani and Napoleon [29] also found that liquid organic fertilizer can improve photosynthetic efficiency in forage crops by increasing chlorophyll content, allowing plants to utilize light energy more effectively. Abdullah [30] showed that higher chlorophyll content is associated with increased photosynthetic capacity, which subsequently boosts crop productivity.

Overall, using LOF on Indigofera legumes positively influenced all measured parameters, including plant height, nodule number, and chlorophyll content. The significant results at the 30 ml dose indicated that the higher LOF dosage improved the plant's ability to fix nitrogen through nodule formation and increased its photosynthetic capacity via elevated chlorophyll levels. Research by Sulistiyani and Napoleon [29] demonstrated that liquid organic fertilizers with high nitrogen content, such as LOF, have substantial potential to foster leguminous growth, particularly in nutrient-poor soil conditions. Abdullah [30] also noted that liquid organic fertilizers can enhance leguminous growth by improving soil health and nutrient absorption efficiency. This aligns with research by [19], which found that regular use of organic fertilizers boosted crop yields and enhanced soil quality for long-term plant growth.

## CONCLUSIONS

Liquid organic fertilizer (LOF) made from agricultural and livestock waste improved various plant growth parameters, particularly in the legume Indigofera. LOF significantly increased plant height, nodule count, and chlorophyll content, especially at the 30 ml dose. While the effects on elephant grass were less pronounced regarding plant height and tiller count, LOFs demonstrated the capacity to enhance chlorophyll content, which aids photosynthesis. Overall, LOFs hold significant promise for enhancing soil fertility and promoting sustainable agriculture.

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