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Pig Farm Liquid Waste Processing Technology and Its Utilization in Cacao Plants

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Abstract - Pig farm liquid waste can pollute the environment. Therefore, an innovation of technology is needed to process it so that it can be beneficial for plants. The main objective of this study is to apply a technology to process pig farm liquid waste and its utilization for fertilizing cocoa plants. The study was conducted in a farmer group at Petang Village, Badung Regency, Bali Province, Indonesia. The methods used were counseling, training, and application of the use of pig farm liquid waste processing results (bio-urine) at various doses to obtain the best dose for cocoa plant growth. The results of the study found that almost 90% of farmers were familiar with the fermentation technology for processing pig farm liquid waste into organic fertilizer (bio-urine). A bio-urine dose of 600 cc/L of water is found to be the best dose for cocoa plant growth. This study confirmed the benefit of processing pig farm liquid waste using fermentation technology into bio-urine which can be used as fertilizer for cocoa plants. By the end of the study the 90% farmers have succeeded in making bio-urine from pig liquid waste. Applying this technology will minimize environmental pollution and support sustainable farming and animal husbandry.

Keywords: Biourine, Cocoa, Fermentation, Pig Farms, Technology

1 Introduction

Pig farming can be a highly promising venture when managed professionally [1]. From a market perspective, the demand for pork in Badung Regency, Bali, has shown a tendency to rise in line with the increasing population in the area. Pork consumption in Badung is higher compared to beef, with many restaurants in the region offering pork as a main dish, featuring a variety of processed products such as lawar, satay, and suckling pig. Additionally, pork demand remains significant for Hindu rituals in Badung. This growing demand encourages pig farming groups to expand their operations. However, these groups still face challenges, particularly in managing livestock waste, feces and urine which has not been handled properly. The waste produced is approximately 3 kg per head per day of feces and 3 liters per head per day of urine, but it has not been optimally utilized, either as organic fertilizer (compost) or biourine for biopesticides. The waste produces unpleasant odors, which are often complained about by local communities. Therefore, there is a need to process this waste into compost and biourine through fermentation technology.

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Bio urine, a term widely recognized in organic farming, refers to livestock urine, particularly from ruminants, that is first fermented before use. Bio urine is produced through anaerobic fermentation technology, where livestock liquid waste (urine) undergoes fermentation with the addition of nitrogen-binding microbes and other decomposer microbes. As a result, the nitrogen content in bio urine is higher than in regular urine. The benefits of bio urine include its more economical use compared to solid organic fertilizers, its ease of application whether by spraying or watering and its ability to increase nutrient content, particularly nitrogen.

Bio urine can be applied to plantations, including cocoa plants. Cocoa is a significant export commodity in the plantation sector, ranking as the third-largest contributor to foreign exchange earnings in Indonesia, following palm oil and rubber [2], [3]. Additionally, cocoa occupies the fourth-largest plantation area in Indonesia, after palm oil, coconut, and rubber. This shows that cocoa is a very important commodity for the Indonesian economy. Almost all cocoa plantations at the research location, namely in Petang Village, Badung Regency, are mixed with various commodities including coffee, bananas, durian, and mangosteen. Farmers use simple cultivation technology (especially fertilization) and the sun light below optimum (shaded by other trees) so that productivity and quality are low. Efforts to overcome low light intensity for plants can be through planting arrangements (planting distance and manipulation of shade canopies) or compensation for the addition of nitrogen (N). Nitrogen, in addition to playing a role in providing nutrients for plants, also functions to form and increase the amount of chlorophyll. Low light intensity requires higher chlorophyll b as a light-capturing antenna [4].

According to research by Utami, R. R., et al. (2018), nitrogen fertilization can enhance the physical and chemical quality of Punung Pacitan cocoa beans. The optimal dose of N (urea) fertilizer for improving the physical quality of cocoa beans is 870 grams per tree per year, while for chemical quality, the optimal dose is 820 grams per tree per year [5]. The results of research by Sacita, A. S., & Naim, M. at Tarobok Village, Beabunta District, Luwu Regency, routine fertilization can increase cocoa plant production [6]. The results of research by Sukmawati, S., et al. (2024) in Parenring Village, Lilirilau District, Soppeng Regency, the provision of NPK fertilizer using biochar from corn cobs on cocoa plants can increase plant productivity[7].

This study aims to utilize the technique of processing pig liquid waste into biourine as a source of nitrogen (N) and the effect of increasing the use of biourine on the growth of cocoa plants. In addition to that this study also aims to increase the farmers knowledge about the pig farm liquid waste management.

2 Research Method

The method employed in this study integrated a series of activities including counseling, training, and mentoring, specifically designed for members of the pig farming group in Petang Village, Badung Regency. The primary goal of this community-based intervention was to enhance farmers' knowledge, skills, and independence in managing pig farming waste particularly liquid waste in an environmentally friendly manner by converting it into biourine, a nutrient-rich liquid organic fertilizer. The overall aim was to support the development of sustainable agricultural practices by utilizing livestock waste to improve soil fertility and crop productivity, especially for cocoa plants. The first phase of the program began with counseling sessions that introduced the concept and

benefits of organic farming, the environmental risks of unmanaged livestock waste, and the economic opportunities offered by organic fertilizer production. These sessions were followed by hands-on mentoring focused on the practical techniques for producing biourine.

In the biourine production process, farmers were guided to collect fresh and clean pig urine, which was then filtered when necessary to remove any impurities or suspended solids. A standard mixture was prepared by combining 18 liters of pig urine with 5 milliliters of EM4 (Effective Microorganism 4), a commercial microbial starter culture, and 5 milliliters of molasses, which serves as a carbohydrate source to support microbial activity during fermentation. The solution was placed in a sealed plastic container or barrel to undergo anaerobic fermentation for a period of 21 days. This method was selected for its practicality and low energy requirement, in contrast to more complex techniques such as continuous aeration systems that require electricity to reduce ammonia content. To ensure long-term sustainability and reduce dependence on external inputs, farmers were also introduced to the use of local microorganisms (MOL), which can be produced independently using readily available organic materials such as overripe fruits and vegetable waste.

The second phase involved comprehensive training and technical assistance on the application of biourine to cocoa plants, which are widely cultivated in the village. Biourine was applied to one-year-old cocoa plants by pouring the solution directly into the soil in a circular pattern under the canopy, targeting the root zone to maximize nutrient uptake. The effectiveness of the fertilizer was tested through a field experiment using a Completely Randomized Design (CRD), consisting of six different treatments based on the concentration of liquid pig urine fertilizer: B0 = 0 cc/L (control), B1 = 150 cc/L, B2 = 300 cc/L, B3 = 450 cc/L, B4 = 600 cc/L, and B5 = 750 cc/L. Each treatment was replicated and randomly assigned to experimental plots to minimize bias. Observations were conducted one month after fertilizer application, focusing on two important growth variables: plant height (in cm) and leaf area (in cm^2), as indicators of vegetative growth performance.

The data collected from field observations were statistically analyzed using Analysis of Variance (ANOVA) to determine whether the differences between treatments were statistically significant. If significant differences were found, further analysis was carried out using Duncan's New Multiple Range Test (DNMRT) at a 5% level of significance to identify which treatment groups differed from each other and to determine the optimal concentration of biourine for promoting cocoa growth. The research was guided by the hypothesis that the application of pig urine-derived biourine at different concentrations would produce a significant positive effect on cocoa plant growth, particularly in terms of height and leaf area, with an optimal dosage level outperforming the control group that received no biourine application. The findings of this study were expected to support the widespread adoption of biourine as an effective, economical, and environmentally sustainable fertilizer option for smallholder farmers in tropical regions.

3 Results and Discussion

3.1 Pig Farm Liquid Waste Processing Technology

At present, the "Go Green" initiative is gaining momentum especially in Bali, which has been declared a Clean and Green Province encouraging the shift toward organic products, particularly those intended for human consumption. Agriculture and animal husbandry, as the largest contributors to food production, are increasingly associated with the concept of "organic." Livestock waste, once

discarded and environmentally harmful, is now being repurposed in line with this trend. Waste materials in solid, liquid, and gaseous forms are being utilized by livestock farmers at various scales, from smallholder operations to commercial enterprises.

Through the application of appropriate technology, livestock waste can be transformed into organic fertilizers. These fertilizers offer dual benefits: not only are they advantageous for plant growth, but they also help improve soil nutrients in ways that chemical fertilizers cannot, thereby supporting long-term soil fertility. Given the rising prices of inorganic fertilizers on the market, manure-based fertilizers represent a promising business opportunity with commercial value.

Recognizing this potential, many individuals are now turning to organic practices by converting various waste types into organic fertilizers. These fertilizers have proven effective in increasing yields of both perennial and annual crops. Additionally, they are well-suited to tropical environments, as they do not leave harmful residues in the soil and promote a looser, healthier soil structure. In contrast, chemical residues that accumulate over time can degrade soil nutrients, leading to hardened and compacted soils.

In Petang Village, pig urine is now being utilized by farmers as a liquid organic fertilizer (bio urine), as illustrated in Figure 2, and applied to cocoa plants through irrigation. Bio urine presents several advantages: it is more efficient in volume use compared to solid organic fertilizers, its application is simple either through spraying or watering and its nutrient content, especially nitrogen, can be enhanced through fermentation processes.

Arumingtiyas (2017) found that the use of bio urine significantly improved rice plant growth and yield using the 4:1 legowo planting method. Improvements were observed in plant height, number of tillers, leaf count, leaf area, leaf area index, number of panicles per clump, grains per panicle, 1000-grain weight, dry grain weight per clump, and overall harvest yield in tons per hectare [8].

Bio urine has become a widely known term among organic farming practitioners. It refers to livestock urine—especially from ruminants—that undergoes fermentation before use. This anaerobic fermentation process includes the addition of nutrients and microbes, such as nitrogen-fixing and decomposer microorganisms, thereby increasing the nitrogen content of the bio urine. The key benefits of this liquid organic fertilizer include: (1) A higher concentration of nitrogen, phosphorus, potassium, and moisture compared to solid manure; (2) The presence of growth stimulants that can function as natural plant growth regulators; (3) A characteristic livestock odor that can help repel various crop pests.

Research has shown that nearly 90% of farmers are now familiar with the techniques for processing livestock urine into bio urine, indicating a strong grassroots adoption of this sustainable agricultural practice. The technology for making biourine from pig urine is shown in **Fig. 1**, making biourine starts from (1) taking clean urine or if necessary filtering it first (2) mixing 18 liters of urine with 5 ml of EM4 and 5 ml of molasses, (3) then putting it in a barrel and fermenting it for 21 days, using this method is much more practical and can be easily implemented by farmers, compared to using an aerator which then has to be turned on for 24 hours to remove the ammonia content in pig urine. Furthermore, the results of the study to replace the EM4 decomposter, farmers can use local microorganisms which can be produced by farmers by utilizing vegetable or fruit waste.

Fig. 1. Technology for processing pig liquid waste into biourine

3.2 Application of biourine use on Cocoa plants

Petang Village has a cocoa plantation, the plants are less fertile, due to lack of fertilizer, and biourine from processing pig farm liquid waste is applied as fertilizer to one-year-old cocoa plants. Biourine is given by pouring it in a circle under the tree along the plant canopy. With the treatment given are several concentrations of pig urine liquid fertilizer, namely: B0 = 0 cc / L of water, B1 = 150 cc / L of water, B2 = 300 cc / L of water, B3 = 450 cc / L of water, B4 = 600 cc / L of water, and B5 = 750 cc / L of water. After one month of observation of plant height, the results of the observations are shown in Figure 2.

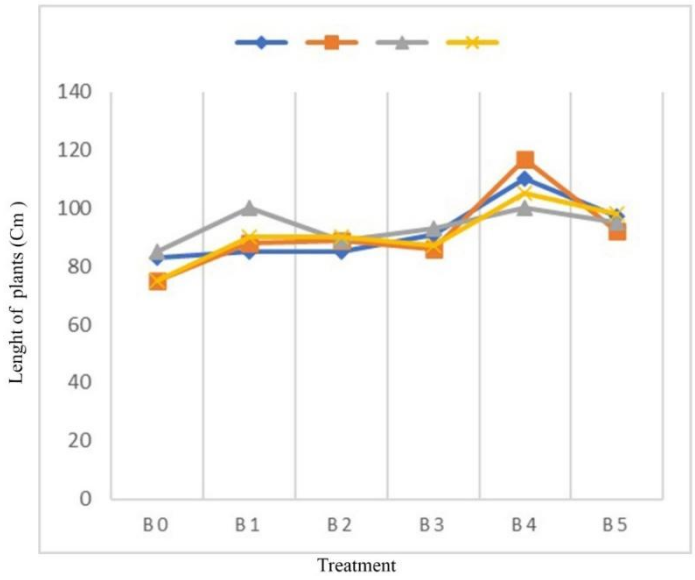

Fig. 2. Cocoa Plant Height (Cm)

Based on **Fig. 2**, the average height of cocoa plants observed after one month of treatment, it appears that the B4 = 600 cc/L water treatment showed that the plant height reached 108.00 cm, which was the highest when compared to the plant height of treatments B0, B1, B2, B3 and B5, and the lowest was B0 without the administration of biourine.

Table 1. Duncan Test Results of BioUrine Treatment on Plant Height (cm) in one-year-old cocoa plants

Treatment	Volume	Average

B0	0 cc per liter water	79,5 ± 5,26[a]
B1	150 cc per liter water	90,75 ± 6,5[b]
B2	300 cc per liter water	88,25 ± 2,22 [b]
B3	450 cc per liter water	89,25 ± 3,3 [b]
B4	600 cc per liter water	108 ± 7,26 [c]
B5	750 cc per liter water	95,5 ± 2,65 [b]

Description: Treatments with the same superscript show no significant difference, conversely treatments with different superscripts show significant differences.

The F-count value of the BioUrine treatment of 13.182 is greater than the F-count value at a real level of 5% or F-critical 5% which is 2.901. Based on the Duncan Test using the SPSS version 25 application, it shows that the best concentration of pig urine liquid fertilizer is in the B4 treatment = 600 cc / L of water with a plant height (cm) reaching 108 ± 7.26 c.

The results of observations of the effect of biourine administration on the leaf area of cocoa plants are the second variable to determine the effect of biourine use on the growth of cocoa plants. The results of the observations are presented in Figure 2. The largest average leaf area was achieved in the B5 treatment, reaching 369.00 cm2.

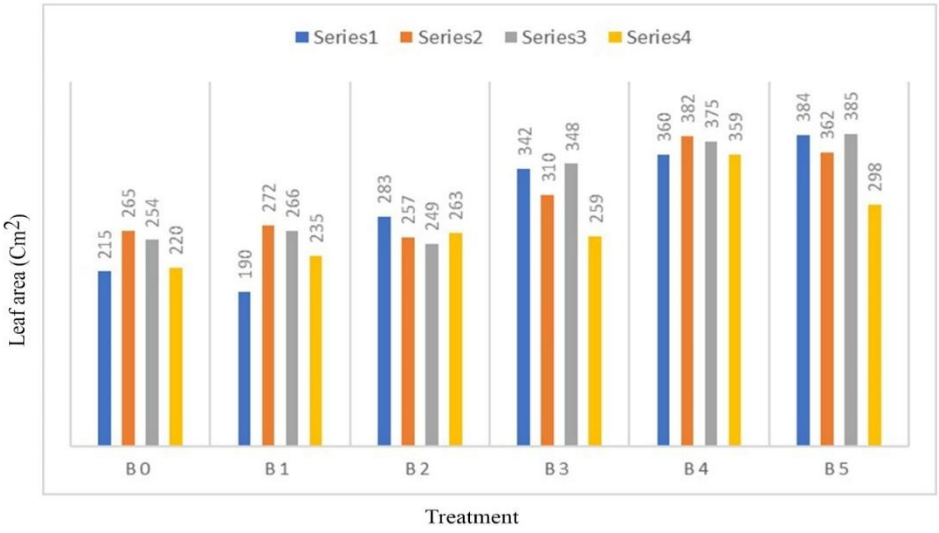

Fig. 3. Area of Cocoa Plant Leaves (Cm^2)

Table 2. Duncan Test Results of BioUrine Treatment on Leaf Area (cm^2) per Cocoa Plant Branch

Treatment	Volume	Average
B0	0 cc per liter water	238,5 ± 24,475[a]
B1	150 cc per liter water	240,75 ± 37,518[a]
B2	300 cc per liter water	263 ± 14,514[a]
B3	450 cc per liter water	314,75 ± 40,738 [b]
B4	600 cc per liter water	369 ± 11,343 [c]
B5	750 cc per liter water	357,25 ± 40,901 [c]

Description: Treatments with the same superscript show no significant difference, conversely treatments with different superscripts show significant differences.

The F-count value of the BioUrine treatment of 18.101 is greater than the F-count value at a real level of 5% or F-critical 5% which is 2.901. Based on the Duncan Test using the SPSS version 25 application, it shows that the best concentration of pig urine liquid fertilizer is in the B4 = 600 cc/L water treatment with an average leaf area (cm2) per branch reaching 369 ± 11.343 c.

4 Conclusion

The application of biourine, a liquid organic fertilizer derived from fermented pig urine, has demonstrated significant potential in enhancing the growth of cocoa plants. The biourine production process, involving a simple anaerobic fermentation using EM4 and molasses for 21 days, is practical, cost-effective, and easily adopted by farmers, with the possibility of substituting EM4 with local microorganisms from organic waste. Field experiments conducted in Petang Village showed that the application of biourine at a concentration of 600 cc per liter of water resulted in the greatest improvement in plant height (108 cm) and leaf area (369 cm^2), outperforming other treatments. Statistical analysis using ANOVA and Duncan's test confirmed that the B4 treatment had a significantly positive effect on plant growth parameters. By the end of the study, 90% of farmers had successfully produced biourine from pig liquid waste, indicating strong adoption and potential for broader implementation. Overall, biourine from pig urine offers an environmentally friendly and sustainable solution for organic fertilization, particularly beneficial in areas facing limited access to chemical fertilizers, and supports the broader movement toward green and organic agriculture.

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