Agroprimatech
Vol. 9 No. 1 April 2025 e-ISSN : 2599-3232

Analysis Of Biomass Of Mucuna Bracteata DC Due To The Provision Of Coffee Skin Waste As An Alternative Fertilizer

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ABSTRACT

Biomass Analysis of Mucuna bracteata DC Due to the Application of Coffee Husk Waste as an Organic Nutrient Source. Mucuna bracteata DC is a cover crop that plays a crucial role in soil conservation and soil fertility improvement. This study aims to analyze the effect of liquid organic fertilizer (LOF) derived from coffee husk waste on the biomass growth of Mucuna bracteata DC, particularly in terms of fresh shoot weight, fresh root weight, dry shoot weight, and dry root weight. The research was conducted at Jalan Kuali No. 50, Medan Petisah District. The experiment was designed using a Completely Randomized Block Design (CRBD) with a single-factor treatment consisting of seven LOF dosage levels: K0 (no treatment), K1 (5 mL/polybag), K2 (10 mL/polybag), K3 (15 mL/polybag), K4 (20 mL/polybag), K5 (25 mL/polybag), and K6 (30 mL/polybag), with four replications, totaling 28 experimental plots. The results showed that the application of coffee husk LOF significantly affected the biomass growth of Mucuna bracteata DC. The highest fresh shoot weight (9.51 g) and dry shoot weight (2.14 g) were recorded in treatment K6 (30 mL/polybag), whereas the highest fresh root weight (2.29 g) and dry root weight (0.32 g) were observed in treatment K5 (25 mL/polybag). Higher LOF doses generally increase plant biomass up to an optimal threshold, beyond which nutrient absorption efficiency by roots declines. Overall, the optimal LOF dosage for maximizing biomass growth in Mucuna bracteata DC ranges between 25–30 mL/polybag. The use of coffee husk waste as an organic nutrient source presents a sustainable alternative for improving plant productivity while reducing dependency on synthetic fertilizers.

Keywords: liquid organic fertilizer, mucuna, bracteata, coffee, waste

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Vol. 9 No. 1 April 2025 e-ISSN : 2599-3232

INTRODUCTION

Mucuna bracteata DC, which belongs to the Fabaceae family, Mucuna bracteata DC is one of the popular ground cover plants in various tropical countries, especially for agroforestry systems and oil palm plantations. Mucuna bracteata DC originates from tropical South Asia and is known for its rapid growth, soil improvement ability, and adaptation to various environmental conditions. In oil palm plantation management, Mucuna bracteata is used to reduce soil erosion, increase organic matter levels, and suppress weed growth which is often a major problem in oil palm production (Agus et al., 2022).

Biomass Mucuna bracteata plays an important role in supporting the sustainability of oil palm plantation systems. High biomass production can contribute significantly to the addition of soil organic matter, which in turn increases the soil's ability to retain moisture and provide nutrients. However, the low success rate of Mucuna bracteata seedlings is a major challenge that must be overcome. Suboptimal seedlings often produce plants with low biomass, which reduces their effectiveness as ground cover plants. The addition of organic fertilizers, such as coffee skin waste, can be a solution to improve the quality of seedlings and encourage higher biomass production (Pratama et al., 2023). In the study by Sitinjak & Pratomo (2019); and Sembiring et al., (2021), the growth of Mucuna cuttings also responded positively to the application of goat urine and shallot extract as a source of natural plant growth regulators.

Mucuna bracteates an extensive root system and the ability to associate with nitrogen-fixing bacteria. In the context of oil palm plantations, this ability not only supports the provision of nitrogen for oil palm plants but also increases overall soil fertility, which can ultimately increase the productivity of oil palm plantations. In addition, the addition of organic materials such as coffee skin waste as a source of organic nutrients can further increase the growth efficiency and biomass production of Mucuna bracteata (Santoso & Wijaya, 2021).

The success of Mucuna bracteata cultivation is currently relatively low. One of the factors that influence the success of Mucuna bracteata cultivation is the condition of the planting medium and the nutrients provided. The nursery phase is a critical stage where the provision of organic nutrients such as coffee skin waste can improve the quality of the seedlings. Coffee skin waste, which is rich in organic matter and essential nutrients, has the potential

to improve the structure of the planting medium and provide the nutrients needed to support the growth of Mucuna bracteata (Pratama et al., 2023). Thus, nutrient management at this phase is very important to ensure the success of Mucuna bracteata.

The use of coffee skin waste as a source of organic nutrients not only provides essential nutrients but also supports sustainable waste management efforts. The combination of Mucuna bracteata and coffee skin waste can improve soil quality and support sustainable agricultural systems in oil palm plantations (Pratama et al., 2023). In addition to its agronomic benefits, Mucuna bracteata also contributes to climate change mitigation through significant carbon dioxide absorption during its growth phase (Irawan & Dewi, 2020). The novelty of this study lies in the use of coffee skin waste as an alternative organic material to improve the quality of Mucuna bracteata seedlings. This approach not only overcomes the challenge of low seedling success but also offers a dual solution in the form of increasing biomass production and contributing to sustainable waste management and climate change mitigation through increasing carbon sequestration in oil palm plantations.

MATERIALS AND METHODS

This research was conducted at Jalan Kuali No.50, Medan Petisah District. The materials used for the research were a large black bucket, Mucuna bracteata DC seeds, 15 liters of coffee washing water, coffee fruit skin, EM4, and brown sugar. The tools used for the research were: 13 cm x 7 cm polybag, hoe, large bucket, ladle, analytical scale, stationery, stirring camera, machete, 8 mesh sieve, dropper, raffia rope, large white plastic, oven, bamboo, topsoil, meter, and watering can.

The research design used a non-factorial randomized block design (RAK) method. The research design was conducted using a non-factorial randomized block design (RAK) method. K0 = 0 mL without treatment K1 = 5 mL of liquid organic fertilizer of coffee fruit skin/polybag K2 = 10 mL of liquid organic fertilizer of coffee fruit skin/polybag K3 = 15 mL of liquid organic fertilizer of coffee fruit skin/polybag K4 = 20 mL of liquid organic fertilizer of coffee fruit skin/polybag K5 = 25 mL of liquid organic fertilizer of coffee fruit skin/polybag K6 = 30 mL of liquid organic fertilizer of coffee fruit skin/polybag. Thus, this

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study has 7 combinations of treatments for administering liquid organic fertilizer of coffee fruit skin with 4 repetitions, so 28 research plots were obtained.

RESULTS AND DISCUSSION

Fresh Weight Header

Table 1. Results of the mean difference test of the effect of providing liquid organic fertilizer from coffee skin waste on the fresh weight of Mucuna bracteata DC shoots.

Treatment	Fresh Weight of Header (gr)	
P0	5.50 g	g
P1	5.77 g	f
P2	6.20 g	e
P3	6.72 g	d
P4	7.50 g	c
P5	8.63 g	b
P6	9.51 g	a

Note: Numbers followed by letters in the same column indicate significant differences based on the DMRT test at the 5% level. P0 (no treatment), P1 (5ml/polybag POC coffee fruit skin), P2 (10ml/polybag POC coffee fruit skin), P3 (15ml/polybag POC coffee fruit skin), P4 (20ml/polybag POC coffee fruit skin), P5 (25ml/polybag POC coffee fruit skin), P6 (30ml/polybag POC coffee fruit skin)

Based on the results of the average fresh weight of the crown, it can be seen in Table 1 that the fresh crown weight of Mucuna bracteata DC with the provision of coffee fruit skin POC, where the best value for fresh shoot weight was in treatment P6 with an average fresh shoot weight of 9.51 gr, however, it was significantly different from treatment P5 with an average fresh shoot weight of 8.63 gr and P4 with an average fresh shoot weight of 7.50 gr, treatment P3 with an average fresh shoot weight of 6.72 gr, treatment P2 with an average weight fresh crown 6.20 g, treatment with an average fresh weight of the crown 5.77 gr, treatment P0 with an average fresh weight of the shoot 5.50 gr. The highest shoot fresh weight was in Mucuna bracteata DC and had a significant effect in the P6 treatment (30 ml/polybag POC

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coffee rind) with an average of 9.51 gr, while the lowest was in the P0 treatment (without treatment) with an average shoot fresh weight of 5.50 gr.

Table 1 shows that the treatment of coffee skin waste affects the fresh weight of Mucuna bracteata. This is due to the nutrient content in coffee skin waste that supports the growth of Mucuna bracteata. Coffee skin waste is known to contain important nutrients such as nitrogen, phosphorus, and potassium which play a role in increasing the vegetative growth of plants (Rahmawati et al., 2021). In the P6 treatment, the optimal nutrient content of coffee skin POC is thought to increase photosynthesis activity and the formation of new tissue in the Mucuna bracteata DC canopy. This is in line with the research results of Fitriani et al. (2020), which reported that liquid organic fertilizer can improve soil structure and increase nutrient absorption by plants, thereby accelerating the growth of vegetative parts. This phenomenon indicates that at a certain dose, the effectiveness of liquid organic fertilizer begins to approach saturation point, as reported by Nurhayati et al. (2022), that excessive accumulation of nutrients can cause nutrient imbalances in the soil and inhibit plant growth. Therefore, the results of this study indicate the importance of managing the right dose of coffee fruit skin POC to achieve optimal growth without causing negative impacts on the environment. The use of coffee fruit skin waste as a raw material for liquid organic fertilizer not only increases agricultural efficiency but also supports sustainable agricultural practices (Putri & Setiawan, 2022).

Fresh Root Weight

Table 2. Results of the mean difference test of the effect of giving coffee skin waste on the growth of Mucuna bracteata DC

Treatment	Average fresh root weight (gr)	
P0	1.15 g	e
P1	1.23 g	e
P2	1.43 g	d
P3	1.71 g	c
P4	2.00 g	b

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P5	2.29 g	a
P6	2.25 g	a

Note: Numbers followed by letters in the same column indicate significant differences based on the DMRT test at the 5% level. P0 (no treatment), P1 (5ml/polybag POC coffee fruit skin), P2 (10ml/polybag POC coffee fruit skin), P3 (15ml/polybag POC coffee fruit skin), P4 (20ml/polybag POC coffee fruit skin), P5 (25ml/polybag POC coffee fruit skin), P6 (30ml/polybag POC coffee fruit skin)

Based on the results of the average fresh root weight in Table 2, the highest treatment was treatment P5 with an average fresh root weight of 2.29 grams, significantly different from treatment P0 with an average fresh root weight of 1.15 grams. P1 with an average fresh root weight of 1.23 grams. P2 with an average fresh root weight of 1.43 grams, P3 with an average fresh root weight of 1.71 grams, and treatment P4 with an average fresh root weight of 2.00 grams.

These findings indicate that a dose of 25 ml of coffee fruit skin POC provides optimal nutrition to support the growth of the root system. The fresh weight of roots in P5 was significantly higher than the control (P0) with an average of 1.15 grams.

The increase in the dose of POC from P1 (5 ml/polybag) to P5 (25 ml/polybag) showed a gradual trend of increasing fresh root weight, by 1.23 grams, 1.43 grams, 1.71 grams, and 2.00 grams, respectively. This finding indicates that the nutritional content in coffee fruit skin POC, such as nitrogen, phosphorus, and potassium, can increase metabolic activity in the roots and encourage the formation of new tissue (Rahmawati et al., 2021). Based on statistical testing in the P6 treatment (30 ml/polybag), the average fresh root weight of 2.25 grams was not significantly different from the P5 treatment.

These results are also consistent with the findings of Yusran et al. (2023), which stated that the use of liquid organic fertilizer at an optimal dose can increase root formation by improving soil structure and nutrient availability. In Mucuna bracteata DC, well-developed roots are very important to support water and nutrient absorption, especially in land with suboptimal conditions. Therefore, the administration of coffee fruit skin POC at a dose of

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25 ml/polybag (P5) is recommended as the optimal dose to increase the fresh weight of Mucuna bracteata DC plant roots. Proper dose management is very important to avoid the negative effects of an overdose of liquid organic fertilizer while supporting the efficient use of sustainable agro-industrial waste (Putri & Setiawan, 2022).

Dry Weight of Header

Table 3. Results of the Mean Difference Test of the Effect of Coffee Skin Waste on the Dry Weight of Mucuna bracteata DC Shoots

Treatment	Average dry weight of crown (gr)	
P0	0.94 g	f
P1	0.99 g	f
P2	1.34 g	e
P3	1.58 g	d
P4	1.75 g	c
P5	1.95 g	b
P6	2.14 g	a

Note: Numbers followed by letters in the same column indicate significant differences based on the DMRT test at the 5% level. P0 (no treatment), P1 (5ml/polybag POC coffee fruit skin), P2 (10ml/polybag POC coffee fruit skin), P3 (15ml/polybag POC coffee fruit skin), P4 (20ml/polybag POC coffee fruit skin), P5 (25ml/polybag POC coffee fruit skin), P6 (30ml/polybag POC coffee fruit skin

The results showed that the provision of liquid organic fertilizer (POC) of coffee berry skin significantly affected the dry weight of the Mucuna bracteata DC canopy. Based on Table 3, the P6 treatment had the highest dry weight of the canopy with an average of 2.14 grams, while the P0 treatment (without treatment) had the lowest dry weight of the canopy at 0.94 grams. The increase in the dose of POC of coffee berry skin from P1 to P6 showed a significant increase in the dry weight of the canopy.

The increase in the dry weight of the canopy is closely related to the nutrient content in coffee fruit skin waste which acts as a source of organic matter and macro and micronutrients needed by plants (Rahmawati et al., 2021). According to Rahmawati et al. (2021), coffee fruit skin waste contains nitrogen (N), phosphorus (P), and potassium (K) which are important for plant vegetative growth. Nitrogen plays a role in the synthesis of proteins and chlorophyll which increase the rate of photosynthesis, thereby accelerating the accumulation of plant biomass (Putri & Setiawan, 2022).

This finding is also supported by research by Yusran et al. (2023) which states that liquid organic fertilizer made from agro-industrial waste can increase the efficiency of photosynthesis and plant metabolism. In Mucuna bracteata DC, the increase in dry weight of the canopy reflects the success of the plant in converting nutrient intake into new, more complex tissues.

However, the difference in dry weight of the shoots between P5 (1.95 gr) and P6 (2.14 gr) was significantly different, indicating that increasing the dose of POC above 25 ml/polybag did not provide a significant increase in shoot biomass. This phenomenon can be caused by the limits of plant nutrient absorption capacity (Nugroho et al., 2023). Nurhayati et al. (2022) stated that excess doses of liquid organic fertilizer can cause antagonistic effects, where excess nutrient accumulation inhibits the absorption of certain nutrients due to ion imbalance in the planting medium.

From an ecophysiological perspective, plant biomass accumulation is greatly influenced by the quality and quantity of available nutrient sources (Wulandari et al., 2021). At P6, sufficient and optimal nutrient intake from coffee fruit skin POC provided maximum growth encouragement to the Mucuna bracteata DC canopy. However, if the provision of POC exceeds the optimum capacity, the plants may not be able to utilize it efficiently and there will only be an accumulation of nutrients in the planting medium (Surya & Indrawati, 2020). Thus, the results of this study indicate that the optimum dose of coffee fruit skin POC to increase the dry weight of Mucuna bracteata DC shoots is in the range of 25–30 ml/polybag. The results of this study reinforce the importance of managing liquid organic fertilizer doses in sustainable agricultural systems to optimize plant growth while maintaining the balance of the soil ecosystem (Sari et al., 2019).

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Root Dry Weight

Table 4. Results of the mean difference test for the effect of giving coffee skin waste on the dry weight of Mucuna bracteata DC roots

Treatment	Average dry weight of roots (gr)	
P0	0.18750 g	e
P1	0.21750 g	d
P2	0.23500 g	CD
P3	0.23000 g	CD
P4	0.25750 g	bc
P5	0.32000 g	a
P6	0.28000 g	b

Note: Numbers followed by letters in the same column indicate significant differences based on the DMRT test at the 5% level. P0 (no treatment), P1 (5ml/polybag POC coffee fruit skin), P2 (10ml/polybag POC coffee fruit skin), P3 (15ml/polybag POC coffee fruit skin), P4 (20ml/polybag POC coffee fruit skin), P5 (25ml/polybag POC coffee fruit skin), P6 (30ml/polybag POC coffee fruit skin

The results of the study showed that the administration of liquid organic fertilizer (POC) from coffee fruit skin affected the dry weight of Mucuna bracteata DC roots. Based on Table 4, the P5 treatment produced the highest dry root weight with an average of 0.32 grams, while the P0 treatment (without treatment) had the lowest dry root weight of 0.18 grams. This difference indicates that coffee fruit skin POC not only acts as a source of nutrition but can also affect the structure and development of the root system. Providing organic fertilizers rich in organic matter can increase the organic carbon content in the planting medium, which has an impact on increasing soil microbial activity (Rahmawati, et al.,

2021). These microbes play a role in accelerating the decomposition of organic matter into nutrients that are more easily absorbed by the roots.

Plant roots have an adaptation mechanism to the availability of nutrients in the surrounding environment. With the availability of sufficient nutrients, the roots will grow longer and branch more to maximize nutrient absorption (Putri & Setiawan, 2022). This can be seen from the increase in root dry weight in the P5 treatment compared to other treatments. However, in P6, where the POC dose was higher, there was a slight decrease in root dry weight, which may be due to nutrient saturation in the planting medium. Nugroho, et al (2023) explained that nutrient saturation can cause ion imbalance, which inhibits nutrient absorption by the roots.

In addition, soil aeration conditions can also be affected by high doses of POC. According to research by Nurhayati, et al (2022), the provision of liquid organic fertilizer in high doses can increase water content in the planting medium and reduce soil porosity, thereby inhibiting root growth. Excessive accumulation of organic matter can cause anaerobic decomposition, producing phytotoxic compounds that harm the root system.

The results of this study also showed that the administration of low doses of coffee fruit skin POC (P1–P3) did not have a significant effect on increasing root dry weight. This indicates that at low doses, the availability of nutrients is not sufficient to stimulate optimal root growth. Wulandari et al (2021) explained that root growth is highly dependent on the balance between available nutrients and plant metabolic needs. If the amount of available nutrients is too low, the plant will allocate more energy to extend the roots to find new nutrient sources, but without a significant increase in biomass.

Thus, the results of this study indicate that the administration of coffee fruit skin POC in an optimal dose (25 ml/polybag) can significantly increase the dry weight of Mucuna bracteata DC roots, but the administration in doses that are too high can harm nutrient balance and root growth. Therefore, the management of liquid organic fertilizer doses must be adjusted so as not to disrupt the soil ecosystem and still support optimal plant growth (Sari, et al., 2019).

CONCLUSION

The results of this study indicate that the provision of coffee fruit skin POC has a significant effect on increasing the biomass of Mucuna bracteata DC, both in the crown and roots. The optimal dose recommended based on the observed parameters is 25–30 ml/polybag, with a dose of 25 ml/polybag showing the best results on root growth, while a dose of 30 ml/polybag is more optimal for crown growth. Therefore, the use of liquid organic fertilizer based on coffee fruit skin waste can be a good alternative in supporting optimal plant growth while still considering the right dose.

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