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Research Paper

# Community Involvement and the Use of Coffee Exocarp as a Growth Medium for Cajuput Plantation in Post-Mining Land Reclamation in PT Bukit Asam Tbk (PTBA)

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**Abstract**
The cajuput plant (*Melaleuca cajuputi*) is valued for its essential oil production and its ability to thrive in challenging environments, including post-mining lands. PT Bukit Asam Tbk (PTBA) has cultivated this plant extensively to supply seeds for reclamation projects on former mine sites, along with the provision of location-specific fertilizers. This study aims to identify the new alternative organic materials, determining the optimal formula for plant growth media and also to measure the tangible and intangible impacts of the community involvement. Following the implementation of statistical testing involving the analysis of variance model (ANOVA) and subsequent test, which is the least significant difference (LSD) test, definitive findings reveal that incorporating coffee exocarp as a growth medium significantly impacts the elevation of plant height and the augmentation of Cajuput leaf count. The most efficacious treatment is delineated as P2, characterized by a 1:1 composition of coffee exocarp and soil. The involvement of the local community has precipitated several advantageous outcomes, encompassing the creation of employment opportunities, the facilitation of economic equilibrium, and the development of smallholder forestry enterprises within the local community.

**Keywords**
Community Involvement, Coffee Exocarp, Growth Medium

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## 1. INTRODUCTION

PT Bukit Asam Tbk, referred to as PTBA, stands as one of the State-Owned Enterprises under Indonesia Mining Industry Holding (MIND ID) specializing in coal mining through the implementation of an open-pit mining system. PTBA is situated in Tanjung Enim, Lawang Kidul Subdistrict, Muara Enim Regency, South Sumatra Province.

On the one hand, the implementation of an open-pit mining methodology has the potential to instigate significant environmental modifications. From a chemical perspective, these alterations exert a direct influence on both groundwater and surface water dynamics. Furthermore, they engender notable physical adjustments in landscape morphology and topographic features. In addition to the aforementioned chemical and physical ramifications, environmental shifts can precipitate microclimatic alterations, impacting wind patterns, disturbing biodiversity, and giving rise to exposed land areas that adversely affect soil fertility (Kodir et al., 2016).

On the other hand, post-mining land reclamation has an ample potential to be optimized for other business sectors, such as forestry and tourism sectors. When undertaking reforestation endeavors involving planting and nurturing vegetation in post-mining land reclamation, it is crucial to ensure that the seeds are in optimal conditions to facilitate the successful growth of reclamation plants as per planned objectives. To meet the necessary nutrient demands crucial for the growth of plants, the substrate utilized during seeding should integrate topsoil along with organic substances such as compost fertilizers or rice husks (Mohd et al., 2013). Therefore, the use of coffee exocarp for Cajuput (Melaleuca cajuput) plant growth media will help mining companies to utilize their post-mining land reclamation.

Cajuput represents a versatile tree species renowned for its production of non-timber forest products of considerable economic significance (Prayitno and Sutapa, 2013). Among its diverse utility, this species stands out for its capacity to yield essential oils highly valued in the cosmetic and pharmaceutical sectors (Budiadi and Ishii, 2010). Presently, the demand for cajuput oil shows a persistent upward trend, driven by the emergence of the Covid-19 pandemic in Indonesia and the expanding utilization of cajuput oil across various industries. Cajuput oil is esteemed for its multifaceted properties, serving as an antiviral, antimicrobial, and respiratory therapeutic agent.

Muara Enim Regency stands out as a major coffee-producing region in Indonesia, generating a substantial amount of coffee fruit skin. Despite its significant potential as a raw material for organic fertilizer, farmers in the area have yet to fully exploit this resource. Given the abundance and potential of coffee fruit skin residue, it is envisaged to serve as a viable substitute for rice husks or other organic materials in the creation of compost or planting media for nurseries (Oliveira and Franca, 2015).

The use of organic materials to enrich planting media is necessary because of the abundance of coffee fruit skins, which can be beneficial as soil treatment in post-mining reclamation. On the other hand, the application of organic fertilizers alone and in combination with lime and chemical fertilizers has surpassed all the treatments mentioned above in terms of improving crop yields and restoring soil health parameters. Therefore, the application of organic fertilizers alone could be a sustainable management practice to enhance crop production and restore degraded post-mining land (Shinde et al., 2017).

The composition of coffee pulp makes it an interesting by-product for research and development for multiple uses, one of them is agronomy and forest research. The use of coffee pulp as a substrate for earthworms has been studied, and found to improve the plant growth and improve soil qualities (Senthilkumar P., 2015).

In light of the foregoing, this study aims to investigate the impact of incorporating coffee fruit skin into the planting media on the growth rate of Cajuput seedlings in favor of identifying the new alternative organic materials and determining the optimal formula for plant growth media in post-mining land reclamation. Furthermore, this study also aims to measure the tangible and intangible impacts of the community involvement.

## 2. EXPERIMENTAL SECTION

### 2.1 Materials

The equipment employed in the study includes PTBA's Sustainability Report 2022, a fixed station, tally sheet, camera, ruler, drill, small shovel, and a set of scales. In terms of materials, the research utilized seeds of Cajuput plant seedlings, water, polybags, soil, coffee exocarp, and labels.

### 2.2 Methods

The research was conducted at the Nursery site of PTBA's Tanjung Enim Mining Unit during the period of June and August 2023. It was separated into two different researches, which were the study of community involvement using secondary data and the study of cajuput plant using primary data.

The investigated treatment for the study of cajuput plant involved a complete composition of growth medium totaling 5 kg. It was designed by using a Randomized Complete Block Design (RCBD) with five treatments and five repetitions, resulting in a total of 25 experimental units. The research design is outlined in the Figure 1.

| | | | | |
|---|---|---|---|---|
| P4U1 | P1U1 | KU1 | P2U1 | P3U1 |
| | | | | |
| KU2 | P4U2 | P2U2 | P3U2 | P1U2 |
| | | | | |
| P3U3 | P2U3 | P1U3 | KU3 | P4U3 |
| | | | | |
| P2U4 | P3U4 | P4U4 | P1U4 | KU4 |
| | | | | |
| P1U5 | KU5 | P3U5 | P4U5 | P2U5 |

**Figure 1.** The Outline of Research Design

The research procedures outlined in this study are detailed in the following explanation: (1) Seedling Preparation, Cajuput (*Melaleuca cajuputi*) seedlings, approximately ±3 cm in height, originated from seeds planted in the nursery section; (2) Planting Media Preparation, planting media employed in the research consist of a combination of coffee exocarp and soil, the composition of which aligns with the prescribed treatment method; (3) Adding Coffee Exocarp, Coffee Exocarp is incorporated into the soil in accordance with the specified dosage for each treatment; (4) Plantation, Cajuput (*Melaleuca cajuputi*) seedlings, ready for transplantation, exhibit a height of ±3 cm and are approximately 2 weeks old; (5) Plant Care and Maintenance, these activities in this research include watering and manual weed removal. Watering is conducted during periods of little or no rain in the morning or evening. Manual removal of weeds around the plants or in the planting media is performed; (6) Observation, the observation phase commences with an assessment of the physical and chemical properties of the initial soil, including pH scale, temperature, and nutrient content, and after that, the focus shifts to monitoring the height and leaf count growth of Cajuput plants over a period of 4 weeks or 28 days; and, (7) Variables, the study will scrutinize plant height from the root collar to the tip, number of new leaves, and physical and chemical properties of the soil.

## 3. RESULT AND DISCUSSION

### 3.1 Examination of Soil's Physical and Chemical Characteristics

Based on the analysis of the physical and chemical properties outlined in Table 1, the findings reveal a soil texture

**Table 1.** Physical and Chemical Soil Properties

| Soil Properties | Unit | Result | Criteria |
|---|---|---|---|
| Texture Class | - | - | Sandy clay |
| Soil Fractions | | | |
| Sand | % | 56.40 | |
| Dust | % | 18.00 | |
| Clay | % | 25.60 | |
| N-total | % | 0.10 | Very low |
| P-exist ($P_2O_5$) | mg $kg^{-1}$ | 11.60 | High |
| K-exist ($K_2O$) | cmol $kg^{-1}$ | 0.13 | Very low |
| Mn | mg $kg^{-1}$ | 12.00 | Low |
| Temperature | $^oC$ | 29.00 | Fine |
| pH | - | 4.83 | Acidic |

characterized as sandy clay. The breakdown indicates a composition of 56.4% sand, 18% dust, and 25.6% clay. Soil texture stands as a pivotal factor influencing soil fertility (Baver, 1972). Soil texture is indicative of the coarseness or fineness of soil particles, determined by the relative proportions of sand, silt, and clay. Soil classification encompasses five main texture classes: coarse (e.g., sand, sandy clay), moderately coarse (e.g., sandy loam, fine sandy clay), medium (e.g., loam, silty clay, silt), moderately fine (e.g., clay loam, sandy clay loam, silty clay loam), and fine (e.g., sandy clay, clay) (Willson et al., 2001).

The soil texture in post-coal mining land is predominantly characterized by clay and silt. Soils dominated by clay and silt have the ability to retain water well but struggle to absorb it. Additionally, high levels of clay and silt cause the soil to become compacted, thereby disturbing the growth of plant roots. Sandy clay soils have advantages in every component of soil texture. Clay soil has the potential to be rich in plant nutrients; however, due to poor drainage, these nutrients are often unavailable to plants. Sandy soils have good air circulation, are lightweight, and are easy to work with. They allow viable seeds to germinate easily and roots to penetrate easily, but they have the disadvantage of being nutrient-poor, as nutrients are easily washed away by drainage. Therefore, a combination of sandy clay soil textures can provide sufficient nutrient requirements with adequate drainage (Abdulazeez, 2017).

Cajuput demonstrates resilience in colonizing ex-mining reclamation sites owing to its pioneer status, remarkable adaptability, rapid growth rate, and capacity to enhance physical, chemical, and biological soil properties (Buta et al., 2019). Moreover, its cultivation offers both ecological and socio-economic advantages, alongside the valuable production of essential oils.

### 3.2 Plant Height

Height measurements of Cajuput plants were conducted weekly, spanning from the initial planting phase to the fourth week thereafter. The research involved 25 experimental units encompassing five treatments with five repetitions each. Delta data, representing the changes in plant height from the commencement of planting to the fourth week, were utilized in the analysis. The data aimed to discern significant increases in plant height, considering the inherent daily variations in vertical growth. Notably, treatment P2 exhibited the highest plant growth, with Cajuput plants experiencing approximately a 17.02 cm growth over the four-week period. The comparison of the heights of the cajuput trees at the beginning of observation with the fourth week of observation can be seen in Figure 2.

**Figure 2.** The Condition of the Cajuput Trees at the Beginning and at the end of Observation

According to ANOVA results, it becomes evident that the F value exceeds the F($\alpha$;k-1;k(n-1)) or F table (F value $>$ F table : 108.808 $>$ 3.06). This means that the null hypothesis (H0) is rejected and showing a tangible impact resulting from the inclusion of coffee fruit skin as a growth medium for Cajuput plants. These results are in accordance with the research conducted by Fatmawati et al. (2022), demonstrating that different concentrations of coffee fruit peel compost have a discernible impact on the growth height of chili plants in comparison to a control group devoid of coffee fruit peel compost.

The LSD test was conducted to assess the impact of incorporating coffee exocarp as a growth medium for Cajuput plants. The results of the LSD test demonstrate notable differences in test values between various treatments. Notably, treatment P2 emerged as the most optimal treatment to increase the plant height. According to (Hartini, 2011), substantial outcomes in the height growth of coffee seedlings are facilitated by the availability of necessary nutrients, ensuring unhindered and maximized plant growth. Additionally, plants which supplied by adequate levels of nitrogen (N) nutrients typically will manifest tall stature and broad foliage (Murtinah and Komara, 2021).

### 3.3 Number of Leaves

Weekly measurements of Cajuput plant height were conducted from the initial planting phase to the fourth week, involving 25 experimental units across five treatments with five repetitions each. This research utilized data tracking changes in the number of plant leaves from the outset of planting to the fourth week. The analysis aimed to ascertain if there was a significant increase in the number of leaves resulting from the treatment. Treatment P2 demonstrated the highest impact, leading to an increase of approximately 19 leaves over the four-week period. The comparison of the number of leaves of the cajuput trees at the beginning of observation with the fourth week of observation can be seen in Figure 2.

Soil condition emerges as a significant factor affecting the fluctuation in plant leaf counts (Mensah, 2015). The dosage treatment, as per the results where F value > F table (27.856 > 3.06), significantly influences the number of leaves. According to (Carmen et al., 2020), the use of coffee exocarp has many advantages in implementation for environmental aspects, for example, inoculating mycorrhiza and managing soil treatment, which can be beneficial for root growth, affect the photosynthetic process, and improve the number of leaves.

The examination of the impact of introducing coffee exocarp as a growth medium for Cajuput plants involved the implementation of the LSD test. The outcomes of this test show reasonable differences in test values between various treatments. As well as the results of the LSD test of plant height variable, treatment P2 has become the most optimal to help the leaves to grow.

### 3.4 Soil's Chemical Properties (pH, Temperature, and Nutrient)

The assessment of soil pH values was conducted using composite soil samples from five treatments and five repetitions. Soil pH measurements were taken once, at the conclusion of the four-week observation period. The comparison of soil pH values across the treatments is presented in Table 2.

The soil pH level, denoting the degree of acidity or alkalinity within a range from 0 to 14, holds significant importance in modulating the accessibility of nutrients essential for fulfilling plant nutritional needs (Rondon et al., 2007). This parameter exerts an indirect influence on plant developmental processes by affecting both the availability of nutrients and the behavior of soil-dwelling organisms. (Henriksen and Breland, 1999). Soil with higher pH levels typically holds plenty of macro nutrients, while more acidic soil tends to have fewer macro nutrients and may trigger the release of potentially harmful metals like aluminum, iron, and manganese, which can adversely affect plant growth (Willson et al., 2001). Using limestone fertilizers presents a solution to increase soil pH, thereby maintaining optimal nutrient levels for plants, given that nutrient availability depends greatly on soil pH. Consistently checking soil pH is crucial to confirm its suitability for plant growth (De Neve et al., 2004).

Cajuput has a number of advantages in reclamation land. Cajuput thrives in marginal lands, swamps, and puddles. In the Maluku Islands, it flourishes under diverse environmental conditions, whether in high or low plains adjacent to coastal forests, or as a sole crop. Cajuput exhibits resilience to poorly-drained soils, fire resistance, and the ability to endure both low and high soil salinity. Melaleuca cajuputi subsp. cajuputi is utilized for cajuput oil production by distilling its leaves and terminal buds (Kodir et al., 2016).

Coal mining operations exert substantial consequences on ecological sustainability, notably through the depletion of essential primary macronutrients critical for plant growth as a result of the process of topsoil removal (Speight, 2015). Corresponding research by (Hagen-Thorn et al., 2006) highlights the importance of the upper layer as a significant source for nutrient storage and exchange, influencing plant growth through nutrient availability.

### 3.5 Community Involvement

The ex-mining lands present an opportunity for the advancement of cajuput agroforestry systems, particularly in non-forest areas (Kodir et al., 2016). Agroforestry, a land-use approach integrating agricultural and forestry components, facilitates diversified production while ensuring ecological and social safeguards (Cardinael et al., 2017; Kaur et al., 2017; Tarigan et al., 2019). Cajuput's inherent adaptability makes it well-suited for integration into agroforestry models, thus bolstering initiatives aimed at enhancing food security (Suryanto et al., 2017).

Align with the process of post-mining reclamation, PTBA actively engages local communities in the activities of seedling, planting, and the upkeep of Cajuput plants. During the period spanning from 2017 to 2022, PTBA established collaborative endeavors with eight farmer groups, each comprising ten individuals. The collaborative framework adopted by PTBA entails a contractual work package, wherein these farmer groups receive monthly remuneration for the contracted services. The aggregate monthly compensation for all farmer groups is approximately IDR 560 million, translating to an annual sum of IDR 5,7 billion (Corporate-Secretary, 2022). This underscores PTBA's role in not only creating employment opportunities but also fostering economic equilibrium within the local community.

Moreover, the issue of inadequate skills and experience among local communities is mitigated through this collaboration, as PTBA consistently provides systematic technical guidance and aids in the establishment of business entities. As a result, local communities are poised to autonomously establish enterprises within the forestry domain, thereby nurturing self-reliance and promoting synergistic relationships with external business entities (Husodo et al., 2021).

**Table 2.** Soil Nutrients, Temperature and pH Values

| Treatments | N (%) | P (mg $kg^{-1}$) | K (cmol kg-1) | Mn (mg $kg^{-1}$) | Temp. ($^o$C) | pH |
|---|---|---|---|---|---|---|
| P1 (1:3) | 0.10 | 14.18 | 0.32 | 14.01 | 32 | 4.9 |
| P2 (1:1) | 0.14 | 14.20 | 0.53 | 8.51 | 33 | 5.0 |
| P3 (3:1) | 0.12 | 14.56 | 0.64 | 9.32 | 34 | 5.0 |
| P4 (100% treatment) | 0.18 | 14.71 | 0.72 | 7.81 | 33 | 5.0 |
| K (100% soil) | 0.11 | 13.97 | 0.18 | 14.41 | 30 | 4.9 |

## 4. CONCLUSIONS

Based on the research findings pertaining to community involvement in the use of coffee exocarp as a growth substrate for Cajuput plants in post-mining land reclamation PT Bukit Asam Tbk, the conclusion that can be deduced is the composition of the growth substrate significantly influences the height and leaf count of Cajuput (*Melaleuca cajuputi*) seedlings, with an optimal ratio of 1:1 soil to coffee exocarp maximizing plant height and leaf count. The treatment also effectively improves the physical and chemical properties of the soil, enhancing soil porosity, pH levels, and the availability of essential elements such as Nitrogen, Phosphorus, and Potassium within the planting medium. Other than that, community involvement has yielded positive outcomes for the local community, including the generation of employment opportunities, the promotion of economic stability, and the advancement of smallholder forestry enterprises.

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