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Coal Post-Mining Reclamation Using *Pterocarpus indicus*

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ABSTRACT

Coal mining is generally carried out through open pit mining methods which have an impact and become an obstacle to changes in the chemical, physical, and biological properties of the soil. Revegetation of reclaimed land is a priority in restoring ecosystems disrupted by mining activities. This study aims to assess the success of the direct planting method in accelerating the growth of *Pterocarpus indicus* plants in coal mining reclamation areas. Field data and observations are used to evaluate the growth of plants directly planted in reclaimed post-mining land. The growth parameters observed include plant height, stem diameter, and leaf count using both seedling and stem-cutting planting materials. The research results indicate that the direct planting method has a significant impact on accelerating the growth of *Pterocarpus indicus* plants. The plant height, diameter, and leaf count growth from the ANOVA test results showed a significant effect or significance at $p<0.05$ for the interaction between planting material, fertilizer, and dosage. The Duncan test results for the average plant height, stem diameter, and leaf count indicate the optimal use of bokashi fertilizer. The effective bokashi fertilizer dosage for each variable is 3 kg/planting hole, resulting in a plant height of 102.31 cm; 3 kg/planting hole, resulting in a stem diameter of 24.26 cm; and 5 kg/planting hole, resulting in a leaf count of 41.32.

Keywords: revegetation, dirict planting, adaptif plant, bokashi and coal fertilizer.

INTRODUCTION

Coal mining reclamation includes closing the mine accompanied by the rearrangement of land contours and revegetation of land that has been destabilized [Albert, 2015]. Reclamation activities involve land arrangement, topsoil spreading, erosion control, acid mine drainage management, and revegetation to support successful plant growth, reduce runoff, prevent landslides, and accelerate canopy closure [Frouz, 2020]. Long periods of soil reclamation [Feng et al., 2019] and post-coal mining are not well established yet and need more research regarding the necessary time to restore ecosystem functions and the development of new ecosystems [Kompała-Bąba et al., 2020]. The general approach used in many nations to improve the mine soil profile quality has been revegetation with various plant species [Ahirwal et al., 2018; Zhang et al., 2020].

Revegetation is an effort or activity of replanting on former mining lands. In its implementation, reclamation activities on post-mining lands often face challenges such as compacted soil conditions, low nutrient content, potential mineral toxicity, and a lack of organic matter. These factors contribute to poor plant growth and low success rates of reclamation, necessitating efforts to improve the land and select suitable plant species [Albert, 2015]. The selection of tree species is an important part of reclamation activities. Three types of plants can be gradually planted on former mining lands, such as cover crops, main or fast-growing trees, and companion plants [Delgado et al., 2021].

Plants that have been used for reclamation in post-mining coal areas include *Gliricidia sepium,* *Senna siamea, Leucaena leucocephala*, and *Acacia magnum* [Singh and Kumar, 2022; Festin et al., 2019], *Ipomoea* sp, *Azolla*, and *Limnocharis flava, Mikania cordata* and *Azolla* [Soendjoto et al., 2015], *Swetenia Mahagoni, Terminalia catapa, Anthocephalus chinensis*, *Cassia siamea*, *Vitex pubescens*, *Pterocarpus indicus, Paraserianthus falcataria*, and *Gmelina arborea* [Noor et al., 2021]. The *Pterocarpus indicus* tree, also known as *sonokembang*, belongs to the Fabaceae (*Leguminosae*) family, the legume family. This plant is a deciduous tree species that grows tall, reaching heights of 30–40 meters, with a trunk diameter of over 2 meters. *Pterocarpus indicus* is an adaptive plant that thrives in open areas with direct sunlight and well-drained soil. It is commonly propagated through seeds or stem and branch cuttings. However, propagation through cuttings is often preferred due to its ease and relatively fast growth [Saputra et al, 2018].

The ameliorative approach to land reclamation is one of the methods that can be used to improve physical, chemical, and biological soil properties. One approach that can be applied is the application of fertilizers aimed at improving soil fertility and nutrient availability for plants, as well as helping to restore the damaged soil structure caused by mining activities into a productive and sustainable state [Navarro-Ramos et al., 2022]. The method of applying treatments by providing coal and bokashi fertilizers is one of the efforts that can be carried out to improve the quality of reclaimed soil. Coal and bokashi fertilizers contain macro and micronutrients such as nitrogen (N), phosphorus (P), and potassium (K) that can enhance plant productivity if applied correctly [Gashua et al., 2022; Liu et al., 2017]. However, fertilization must be done accurately by providing appropriate doses to improve soil conditions.

The methods for plant application in reclamation consist of cuttings and seedlings. Cutting method have applied for reclaiming post-mining coal lands, such as Gamal (*Gliricidia sepium*), Sengon (*Albizia chinensis*), Mahogany (*Swetenia Mahagoni*), Waru (*Hibiscus tiliaceus*), and Trembesi (*Samanea Saman*). However, research involving cutting and seedling methods in a single study is very limited, especially with direct planting on post-mining lands. To the best of our knowledge, *Pterocarpus indicus* is rarely used for post-mining land reclamation purposes. However, in addition to being adaptive to critical land conditions, *Pterocarpus indicus* is also a high-quality wood drought tolerant [Thomson, 2006; Flores et al., 2021]. The comparison of planting tests between *Pterocarpus indicus* cuttings and seedlings through direct planting for the reclamation of post-mining coal lands is being conducted for the first time in this study, especially using coal fertilizer and bokashi. Therefore, this study aims to evaluate the application of *Pterocarpus indicus* and assess the effects of planting methods on the reclamation of post-mining coal lands. The growth acceleration of *Pterocarpus indicus* in post-mining lands is also determined by using coal fertilizer with bokashi.

MATERIALS AND METHODS

Study area

The study was conducted in the coal mine reclamation area in Pit 3 Barat IUP Banko Barat, PT. Bukit Asam, Tbk., Tanjung Enim, South Sumatra, Indonesia with coordinate point of 3°44’ 39,703” (Latitude) and 103°48’ 44,071” (Longitude) (Figure 1). PT. Bukit Asam, a coal mining industry,

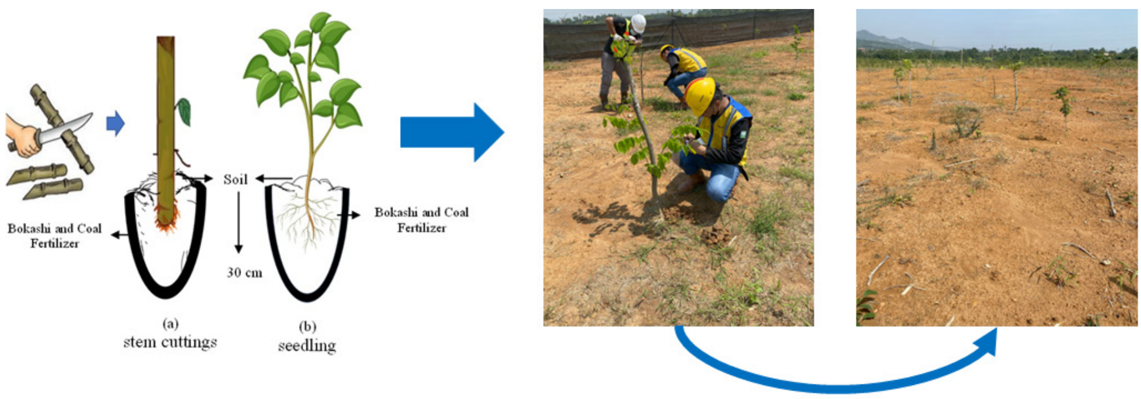

Figure 1. Study and the soil sampling area in Banko Barat

implements open-pit mining for producing coal. The initial mining process involves clearing the concession land to be mined and removing the soil from the overburden. To preserve the soil's quality, the soil is stacked separately. Additionally, the exposed land can be directly spread in the mine reclamation area after it has been recontoured to restore and repair the former mining land for its environmental function.

The soil types in the study area include grumosol, Mediterranean, podzolic, reddish-yellow regosol, and organosol. The pH soil of this region ranges from 6.0 to 8.2, with increasing alkalinity as the soil depth increases. Grumosol soil contains Ca and Mg and is characterized by wet saturation. The Mediterranean land contains K and Mg, while the regosol contains P and K. The vegetation in this area consists of secondary natural forests that are ecologically unstable due to smallholder plantations, Imperata grass, and shrubs. Common types of vegetation found include *Oplismenus burmannii*, *Pithecelobium jiringa*, *Leea indica*, *Eurya acuminata*, *Scleria sumatrana*, *Melastoma walichii*, *Havea brasiliensis*, and *Schima walichii*.

Soil sampling and analysis

Soil samples were collected using purposeful sampling at 0–30 cm depth. The soil samples were taken using an aerator and a ring soil sampler. Afterward, the collected soil samples were air-dried and combined using a 0.5'×0.5' wire mesh, then thoroughly mixed by hand to homogenize the merged samples. This process removed stones and other debris while gathering finer soil particles. The detail physical and chemical analysis of the soil includes were summarized in Table 1.

Table 1. Physical and chemical properties of the mine soil and the score used to calculate the soil quality index

Parameter	Level					References
pH H_2O	<4.5	4.5–5.5	5.5–6.5	6.5–7.5	7.5–8.5	ICSR (1983) Brandy (1984)
	(Extreme acidity)	(Strong acidity)	(Slight acidity)	(Neutral)	(Slight alkalinity)	
Score	0	1	2	2	1	
Organic C (%)	<1				>5	ICSR (1983)
	(Very low)	(Low)	(Moderate)	(High)	(Very high)	
Score	0	1	1	2	2	
Total N (%)	<0.1	0.1–0.2	0.21–0.50	0.51–0.75	>0.75	
	(Very low)	(Low)	(Moderate)	(High)	(Very high)	
Score	0	1	1	2	2	
Exch Ca (cmol$_c$ kg^{-1})	<2	2-5	6–10	11–20	>20	Dierolf et al. (2001)
	(Very low)	(Low)	(Moderate)	(High)	(Very high)	
Score	0	1	2	2	2	
Exch Na (cmol$_c$ kg^{-1})	<0.1	0.1–0.3	0.4–0.7	0.8–1.0	>10	ICSR (1983)
	(Very low)	(Low)	(Moderate)	(High)	(Very high)	
Score	0	1	2	2	2	
Exch K (cmol$_c$ kg^{-1})	<0.1	0.1–0.3	0.4–0.5	0.6–1.0	>10	Dierolf et al. (2001)
	(Very low)	(Low)	(Moderate)	(High)	(Very high)	
Score	0	1	2	2	2	
Al-saturation (%)	<35	35–50	50–70	>70		
	Low	Moderate	High	Very high		
Score	2	1	1	0		
Base saturation (%)	<20	20–40	41–60	61–80	>80	ICSR (1983)
	(Very low)	(Low)	(Moderate)	(High)	(Very high)	
Score	0	1	2	2	2	
Bulk density (g cm^{-1})	<1.1	1.1–1.6	>1.6			
	(Normal)	(High)	(Very high)			
Score	2	1	0			
Cation exchange capacity (cmol$_c$ kg)	<5	5–16	17–24	25–40	>40	
	(Very low)	(Low)	(Moderate)	(High)	(Very high)	
Mg (cmol$_c$ kg)	<0.4	0.4–1.0	1.1–2.0	2.1–8.0	>8.0	
	(Very low)	(Low)	(Moderate)	(High)	(Very high)	

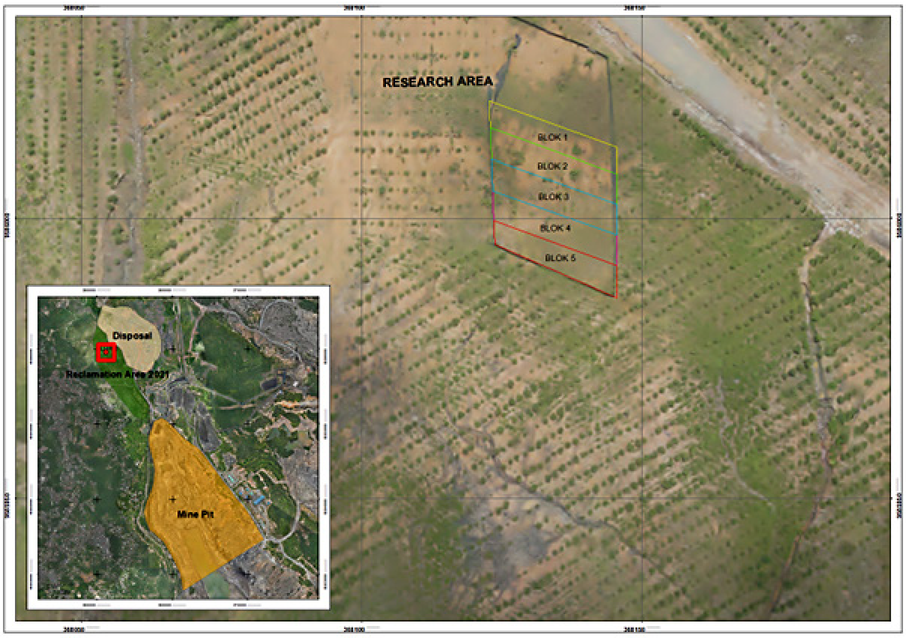

Figure 2. The schematic diagram of direct planting in coal post-mining reclamation area

Plant sample preparation and data collection

The research was performed on reclaimed land finalized with a research site area of 630 m^2 over three months. A vegetation inventory was used to evaluate and measure plant growth. Data inventory was obtained by creating square plots measuring 22.5×28 m for five plots. The placement and determination of the planted seeds (generative and vegetative) in the plots were randomly using bokashi and coal fertilizer. The coal fertilizer used consisted of variations of 1–3 kg/planting hole. The bokashi fertilizer had three dosage variations of 3, 5, and 7 kg/planting hole (the fertilizer would undergo incubation before use). The distance between plots was 5 m, with a planting distance of 3×3 m. The schematic diagram of direct planting in coal post-mining reclamation area is presented in Figure 2. The sampling method was carried out using a grid with a random start. The parameters observed are planted seeds (generative or vegetative), the amount of fertilizer dose, plant diameter, plant height, and the growth of shoots and leaves. The height and diameter of the plant are measured using a roll meter. Observations on leaf count were conducted over three months with 33 observation intervals for both *Pterocarpus indicus* seedlings and cuttings. The calculation of leaf count is done in units of individual leaves. Each sample is henceforth named and abbreviated as control stem cuttings (CSC), control seedlings (CS), bokashi fertilizer 3 kg (BF3), bokashi fertilizer 5 kg (BF5), bokashi fertilizer 7 kg (BF7), coal fertilizer 1 kg (CF1), coal fertilizer 2 kg (CF2), and coal fertilizer 3 kg (CF3).

Statistical analysis

Descriptive statistics (i.e., means ± standard deviation) were calculated for all tested parameters. Before further analysis, the data were checked for normality assumptions (Shapiro-Wilk test) and variance homogeneity and log-transformed if necessary (using SPSS Statistics v20.0). The differences among treatments affecting the direct planting of *Pterocarpus indicus* trees, including the treatment of planting material, type of fertilizer used, and fertilizer dosage, were analyzed using a one-way analysis of variance (ANOVA). The basis for concluding the ANOVA test is that if the significance value (Sig.) is $> p = 0.05$, then there is no significant difference in the growth of the planting material when using two different treatments of fertilizer type and dose. If the significance value (Sig.) is $< p = 0.05$, then there is a significant difference in the growth of *Pterocarpus indicus* planting material when using two different treatments of fertilizer type and dose. The mean effects and interaction factors were separated using the Duncan test at $P < 0.05$. The Duncan test analysis was conducted to determine the significance of the difference in homogeneity. This analysis helps in rejecting the null hypothesis and accepting the alternative hypothesis.

RESULTS AND DISCUSSION

Characteristic of soil from coal post-mining

The physical observation and morphology of the post-mining soil have a lateritic structure with a dust storage soil texture with a base saturation rate of less than 50%. The soil originates from new layered deposits whose organic quantity is significantly reduced. The detailed chemical and physical properties of soil from coal post-mining are presented in Table 2. The clay content affected by sand content (28.6%), and the brownish-grey to bright red color of the soil was generally oxidized and contaminated processes to a certain extent [Pérez-Lizasuain et al., 2022; Sukarman and Gani, 2020]. These soils have a low pH, are less fertile, contain organic material at a certain level, and are more susceptible to physical corrosion [Pérez-Lizasuain et al. 2022]. The soil has a bulk density value of 1.24 g/cc, categorized high to reduce root penetration into the soil. The porosity of the soil has a value of 43.21%, which can cause soil permeability to accelerate. The ideal soil condition is when 50% of the soil pores consist of macropores to facilitate water movement due to gravity, and the other 50% consist of micropores to retain water against the gravitational pull [Gu et al. 2019].

Table 2. Chemical and physical characteristics of coal mining

Soil parameters	Results	Normal range
Chemistry		
Organic C (%)	0.25	Very low
Total N (%)	0.03	Very low
C/N ratio	9	Lowly
pH H_2O (1:1)	3.64	Acidity
pH KCL (1:1)	3.38	Acidity
Cation exchange capacity (cmol/kg)	15.23	Lowly
Bulk density g/cm^3	1.24	High is
Base saturation (%)	17.8	Very low
Exchangeable K (cmol/kg)	0.26	Rendah
Available P (mg/kg)	3.45	Very low
Ca (cmol/kg)	1.71	Very low
Mg (cmol/kg)	3.09	High
Na (cmol/kg)	0.41	Very low
H (cmol/kg)	1.91	Very low
Al (cmol/kg)	8.90	Very low
Physics		
Textures		Sandy clay
Sand %	28.6	
Dust %	22.2	
Clay %	49.2	
Permeability (cm/h)	2.84	
Porosity (%)	53.21	

Regardless of the overburden type used, the results of this study showed that the pH value of H_2O is 3.64, and the pH of KCL is 3.38, or with a highly acidic criterion. The high acidity of the soil is caused by the low amount of cation exchange capacity and changes in rock fragments, in which rocks containing pyrite minerals (FeS_2) are oxidized into sulfate acid (H_2SO_4). The low potential hydrogen (pH) level affects the availability of macronutrients P and K, reducing availability in the soil, namely 3.45 mg/kg and 0.26 cmol/kg. Similarly, the availability of nutrients Ca and Mg also decreases with the decreasing soil acidity level by the conditions of post-mining soil, namely 1.71 cmol/kg (very low) and 3.09 cmol/kg (high). Soil reaction or soil potential hydrogen is one of the important chemical properties in the growth process of plants that reflects the availability of macro and micro elements for growth [Meetei et al., 2020]. The result of the analysis of the value of the cation exchange capacity on the post-mining soil is low at 15.23 cmol/kg. The low cation exchange capacity is due to decreased organic carbon concentration in the soil and the mixing of lower soil horizons, and the colloid surface area of dust fractions is small and clay-textured [Nešić et al. 2015]. When this is connected with the physical nature of the soil, it appears that there are changes, especially in the porosity of the land, where the content of sand and clay is reduced while the dust content is increased [Helling et al., 1964; Purnamasari et al., 2021].

Characteristics of coal and bokashi fertilizer

The characteristics of fertilizer summarized in the Table 3. The analysis results of the coal and bokashi fertilizer content show that the pH of coal fertilizers was already within the standard range of fertilizer quality as specified in Regulation of the Indonesian Minister of Agriculture No. 70 of 2011. However, it was different with the nitrogen (N), phosphorus (P), and potassium (K) values. The pH values of coal and bokashi fertilizers affected the alkaline and did not have the potential to cause a decrease in soil pH when applied. The macro element value of N, P, and K in coal fertilizer are N 0.413%, P 0.044%, and K 0.125%. The N value

Table 3. Properties of bokashi and coal fertilizers

Parameters	Squad	Results		Fertilizer quality standards
		Coal fertilizer	Bokashi fertilizer	
pH H_2O	-	6.97	7.46	4-9
Nitrogen	%	0.413	1.149	> 4
Phosphorus	%	0.044	0.471	> 4
Potassium	%	0.125	0.375	> 4

in bokashi fertilizer is 1.149%, P 0.471%, and K 0.375%. The low values of N, P, and K in coal and bokashi fertilizers are due to the low composition of the raw materials, resulting in low nutrient.

Results of growth and diversity analysis on soil reclamation

The randomized block design (RBD) was applied, including several treatments, such as direct planting of *Pterocarpus indicus* trees, treatment of planting material, and type and dose fertilizer. The results obtained from the variance analysis showed that applying coal fertilizer and bokashi significantly influenced the observations of plant height, plant diameter, number of shoots, and number of leaves produced.

Plant height is one aspect of plant development vertically and undergoes daily changes caused by complex physiological, biochemical, and biophysical processes [Sembdner and Parthier 1993]. The growth of *Pterocarpus indicus* tree height using the direct planting method in post-mining reclamation land experienced an increase as the age of the plants increased (Figure 3). The height growth of *Pterocarpus indicus* trees

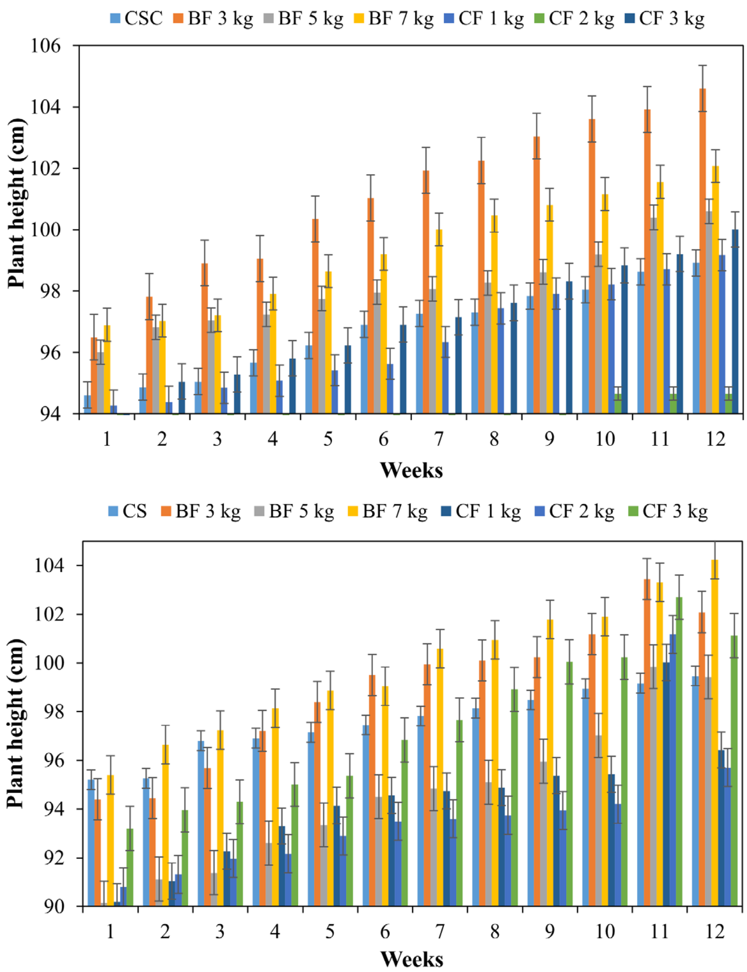

Figure 3. The average growth of *Pterocarpus indicus* tree height with (a) stem-cutting and (b) seedlings in response to the type and dose of fertilizer. Error bar means data variation

using both seed and stem-cutting methods was increased. In treating coal and bokashi fertilizers at a dose of 3 kg per planting hole, there was a rapid increase in plant height from 1 to 12 weeks after planting, similar to other doses. The increase in plant height, whether through stem cuttings or seedlings, indicated that the macronutrients contained in the fertilizer could decompose effectively. Meanwhile, a static trend was observed in the stem growth of the stem-cutting with 1 kg of coal fertilizer (F1).

The plant growth process requires macronutrients such as nitrogen (N). Nitrogen can stimulate overall plant growth, particularly in stem, branch, and leaf development [Almeida Neta et al. 2020]. The low nitrogen concentration in the soil did not affect the height growth. This is due to plant roots can develop efficient mechanisms for absorption and utilization, allowing plants to grow well. There is a possibility that plants have undergone adaptation processes to cope with nutrient deficiencies [Chemutai et al. 2019].

The average stem diameter growth of *Pterocarpus indicus* increased from the initial to the final treatment condition for each planting material, as depicted in Figure 4. The average stem diameter of the stem-cutting planting material increased in the second week. Then, the average diameter growth tends to remain stable until the twelfth week after planting. According to Taiz et al [2018], the assimilates produced through photosynthesis are transported from the leaves to other organs, such as roots, stems, and reproductive organs, through the phloem vessels. The transportation process through the stem leads to an increase in stem diameter growth.

Leaf count is one of the characteristics of a plant undergoing vegetative growth. During the vegetative growth, plants produce new shoots, which develop into leaves. The number of leaves in plants can be affected by various factors, including the availability of nutrients and the environment [Wahba et al., 2016]. According to Bahmanyar and Mashaee [2010], nitrogen promotes

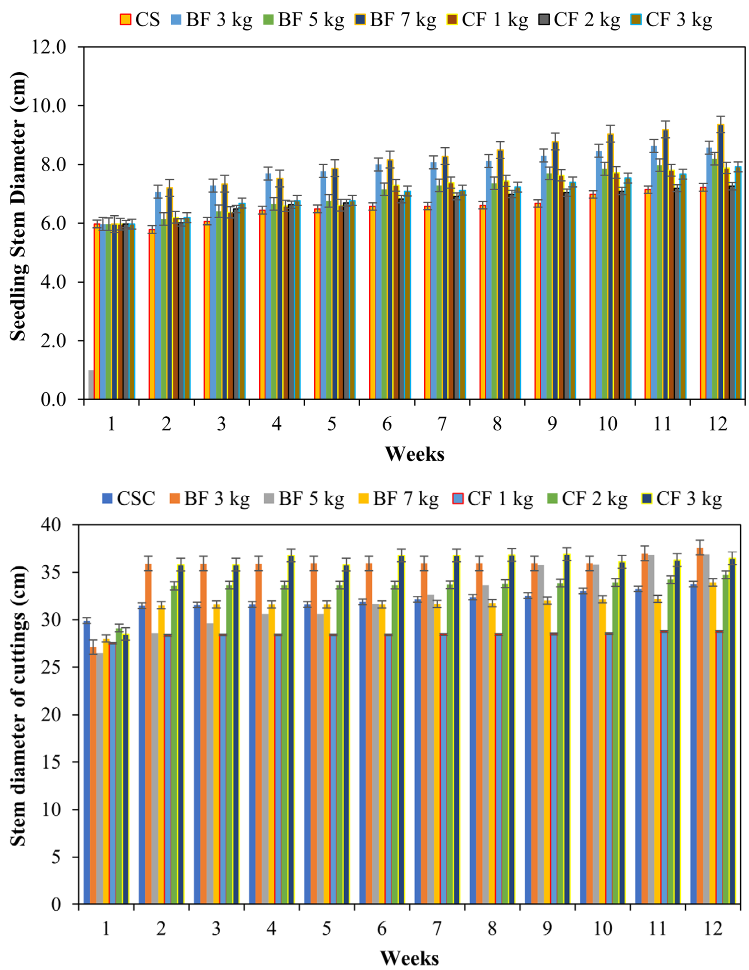

Figure 4. Average growth of *Pterocarpus indicus* tree with (a) seedling and (b) stem diameter to fertilizer type and doses. Error bar means data variation.

the growth of organs involved in photosynthesis, such as leaves, and component of all proteins and nucleic acids, as well as the overall composition of protoplasm. The leaf growth of *Pterocarpus indicus* plants treated with bokashi fertilizer showed normal growth with a higher quantity of leaves than the control treatment. At the beginning of the treatment, the *Pterocarpus indicus* leaves appeared fresh and green, but the plants showed necrosis and chlorosis overtime after one to two weeks (Figure 5). Bronzing and necrosis can occur due to environmental conditions that do not support plant growth, leading to the death of cells or tissues due to nutritional deficiencies or excess [Sawyer, 2004]. This is caused by the disruption of plant activity and metabolism, which affects key physiological and biochemical processes [Singh et al., 2016].

ANOVA and Duncan test for *Pterocarpus indicus* growth

The results of ANOVA test on the effect between treatments received by *Pterocarpus indicus* plants on plant height, diameter, number of leaves are summarised in Table 4. The three factors affect the resulting plant height. Interpretation of the interaction test results between variables on the height, diameter and number of leaves *Pterocarpus indicus* has a significant value or $p < 0.05$. The treatment of planting materials and doses has a significant effect on the height, diameter, and number of leaves of the plants produced. The treatment can increase the binding of soil bases, increase the availability of nutrients for plants and support better plant growth [Choudhary et al., 2018].

The influence of all variables cannot be separated due to the interaction between these three factors. Therefore, Duncan Multiple Range Test (DMRT) is required (Table 5). The highest plant height is found in the bokashi fertilizer treatment at 99.84 cm. The differences in dosage affected the presence of macronutrients in the fertilizer, which influence generative and vegetative plant growth. Carvajal et al. [2023] revealed that plants would grow vigorously if the required nutrients were available in a balanced proportion, especially N, P, and K. The Duncan analysis results indicated that the interaction between *Pterocarpus indicus*

Table 4. ANOVA test results for *Pterocarpus indicus* plant height, diameter, and number of leaves

No.	Variable	Height		Diameter		Number of leaves	
		F-count	Significance	F-count	Significance	F-count	Significance
1	Plant material	18.679	0.009^{+}	1270.360	0.000^{+}	1937.570	0.000
2	Fertilizer	30.499	0.001^{+}	2.632	0.105^{++}	144.449	0.000
3	Dose	47.710	0.000^{+}	4.487	0.001^{+}	14.213	0.000
4	Plant material × fertilizer × dose	7.312	0.017^{+}	2.997	0.006^{+}	9.333	0.000

Note: $^{++}$ not significant or $^{+}$ significant at $P < 0.05$, $P < 0.01$, analysis of variance

Figure 5. Bronzing and necrosis of *Pterocarpus indicus* plants

Table 5. Advanced Duncan test results on the effect of treatment application on the growth of *Pterocarpus indicus*

Behavioral factors	Average height (cm)	Average diameter (cm)	Average number of leaves (blade)
Control	90.01^{a}	19.38^{a}	35.53^{a}
Coal fertilizer	97.31^{b}	20.21^{a}	34.53^{a}
Bokashi fertilizer	99.84^{c}	22.08^{ab}	42.61^{b}
Fertilizer factor/planting hole (dose in kg)	Observed variables average height (cm)	Observed variables average diameter (cm)	Observed variables average number of leaves (blade)
0 (control)	90.01^{a}	19.38^{a}	35.53^{a}
1	94.77^{b}	21.55^{ab}	34.93^{a}
2	92.13^{a}	19.34^{a}	35.77^{a}
3	102.31^{c}	24.26^{c}	41.32^{b}
5	99.33^{b}	22.42^{bc}	41.50^{b}
7	100.61^{b}	20.01^{ab}	37.13^{a}

Note: Plant height: a, b, and c show the type of fertilizer that affects plant height, and c shows the best fertilizer dose; Average diameter: ab shows the greater influence of bokashi fertilizer. ab and bc show that the fertilizer dose has an effect on stem diameter, while c shows the best fertilizer dose; Average number of leaves: a and b show a real influence on the average number of leaves.

plants and bokashi fertilizer tends to produce a higher number of leaves than other interactions, with an average value of 42.6. The fertilizer dose that resulted in the highest number of leaves was 5 kg per planting hole, with an average number of leaves of 41.50. Applying a dosage of 5 kg per planting hole with the same fertilization timing before grafting resulted in a higher number of leaf blades than other dosage treatments.

The Duncan test results for plant stem diameter in all treatments, both bokashi and coal fertilizer, did not show significant differences. The effectiveness of coal fertilizer in supporting stem diameter growth is low. Although coal fertilizer contains nutrients needed by plants, other factors such as nutrient composition, nutrient availability, and the ability of coal fertilizer to interact with soil can affect its effectiveness in optimally increasing stem diameter growth. Seedlings as planting materials exhibit better leaf growth compared to stem cuttings. This is due to their higher genetic potential, as they originate from seeds or tissue cultures that inherit desired traits from their parent plants. Seedlings also have sufficient energy reserves in the seeds or tissue cultures used during early growth, and the genetic diversity in seedlings provides adaptability to environmental changes and resistance to pest and disease attacks.

Planting material for cuttings treated with bokashi fertilizer is more optimal or effective in the direct planting method of post-coal mining reclaimed land. However, it is necessary to conduct further research on the growth of *Pterocarpus indicus*, especially on cuttings planting material with the appropriate type and dose of fertilizer and a longer research time. Furthermore, it is necessary to carry out additional treatments periodically so that a more comprehensive understanding of the effect of fertilizer on the growth of *Pterocarpus indicus* needs to be carried out on planting materials cuttings. The results of this research will provide more specific recommendations that can be applied practically in supporting the growth of *Pterocarpus indicus* on post-coal mining reclaimed land.

CONCLUSIONS

The experimental results show that the direct planting method significantly accelerated the growth of *Pterocarpus indicus* plants in reclaimed coal mining areas. The acceleration of *Pterocarpus indicus* plant growth, given the dosage and treatment of bokashi and coal fertilizers, resulted in a 100% growth rate for seedling planting materials. The growth acceleration in cutting planting materials at each dosage and treatment of bokashi and coal fertilizers resulted in varied growth acceleration. The results of the ANOVA test indicate that the interaction between planting material, fertilizer, and dosage has a significant effect with a significance level of $p<0.05$. The Duncan test results for the average plant height, stem diameter, and leaf count indicate the optimal use of bokashi fertilizer. The effective bokashi fertilizer dosage for each variable is 3 kg/planting hole, resulting in a plant height of 102.31 cm; 3

kg/planting hole, resulting in a stem diameter of 24.26 cm; and 5 kg/planting hole, resulting in a leaf count of 41.32.

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