

Optimizing groundnut seedling growth on post-tin mining soil by adding organic growing media

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ABSTRACT

Soils from post-tin mining soil typically exhibit suboptimal conditions for plant growth due to low organic matter content, sandy texture, and the presence of heavy metal wastes. Groundnuts (*Arachis hypogaea* L.) are a highly nutritious food crop of significant economic importance, rich in protein and fat. Enhancing the quality and fertility of old tin mine soils can be accomplished by adding organic growing media to facilitate optimal groundnut cultivation. This study aims to enhance groundnut growth by the addition of organic planting media and determining of the optimal dosage. This study used a Completely Randomized Design (CRD) using organic planting media with four treatment levels: P0 = control (no organic planting media), P1 = 85% post-tin mining soil + 15% organic growing media, P2 = 75% post-tin mining soil + 25% organic growing media, P3 = 60% post-tin mining soil + 40% organic growing media. Each treatment was replicated five times, giving a total of 20 experimental units. Data were evaluated utilizing Analysis of Variance (ANOVA) succeeded by Duncan's Test at the 5% significance level. The addition of organic growing media into post-tin mining soil influenced root biomass in groundnut plants, showing a tendency to enhance leaf count and canopy biomass, however this effect was not statistically significant. This study found no significant effect on plant height.

Keywords: *Arachis hypogaea* L, Organic Planting Media, Post-tin Mining Soil, *Tailing* Soils

INTRODUCTION

The Bangka Belitung Islands are recognized for their rich natural resources, especially as the main producer of tin (Wardani et al., 2022). Current tin mining operations have resulted in significant environmental damage, including land loss, reduced soil quality, and reduced agricultural output (Hartini et al., 2023). The open-mine tin mining technique generally disrupts soil structure, eliminates topsoil, and pollutes the soil with mining byproducts, adversely affecting soil fertility. These former mining sites typically lack organic matter, exhibit low porosity and water retention, and suffer from nutrient and soil microflora imbalances, which are crucial for sustaining soil biological activity. Consequently, these areas are challenging to effectively repurpose for agricultural operations without suitable rehabilitation initiatives (Sukarman and Rachmat., 2017).

Utilizing former tin mining land for agricultural purposes is a strategic measure to meet food requirements and mitigate the decrease of fertile land repurposed for non-agricultural uses. Transforming ex-tin mining soil into productive agricultural land necessitates prior enhancement of the land's fertility and quality (Asmarhansyah., 2017). A potential alternative is to use organic growing media to enhance soil fertility and structure, hence facilitating optimal plant growth (Harahap., 2016). Organic growth media is thought to enhance the physical, chemical, and

biological properties of ex-mining soil, including increasing organic matter content, cation exchange capacity, and microbial activity (Gusventi et al., 2021; Yunanda et al., 2022).

The repurposing of former tin mining areas can facilitate the cultivation of food crops, including groundnut (*Arachis hypogaea* L.) (Muchtadin et al., 2020). According to the Belitung Regency Food Security and Agriculture Service, groundnut productivity in Bangka Belitung in 2023 was approximately 1.68 tons per hectare, significantly lower than the national average of 13.82 tons per hectare. Enhancing the quality of this planting medium is anticipated to promote the growth of groundnut plants (*Arachis hypogaea* L), a valuable commodity known for its nitrogen-fixing properties that benefit the soil (Gulo et al., 2025). Moreover, groundnuts are classified as a *legume cover crop* (LCC) that enhances soil fertility and ameliorates the microclimate in ex-tin mining areas (Asmarhansyah., 2017). Suryani and Dariah (2012) reported that leguminous cover crops could yield approximately 2-3 tons of organic matter per hectare after 3 months, increasing to 3-6 tons per hectare after 6 months of growth. Consequently, cultivating groundnuts on post-tin mine land not only yields products but also enhances the soil's quality. Research by Jaenudin et al., (2018) indicates that integrating compost, an organic planting medium, into former mining land at a ratio of 12 kg of mining land to 3 kg of compost (4:1) enhances plant height, stem diameter, leaf area index, nitrogen, phosphorus, and potassium absorption, as well as the cob length, the cob weight, and dry shell weight. This study proposes to investigate the impact of organic planting media on groundnut growth in former tin mining ground, specifically analyzing leaf count, plant height, root biomass, and canopy biomass from week 1 to week 6. The study's findings are anticipated to provide insights for the rehabilitation and utilization of former mining land to enhance groundnut productivity and promote sustainable land improvement.

MATERIALS AND METHODS

This research was conducted from August to September 2025 at the Greenhouse of the State Manufacturing Polytechnic of Bangka Belitung. The materials and tools used in this study included post-tin mining soil, organic planting media composed of tea leaves, fertile soil, manure, compost, growth-promoting bacteria, and groundnut seeds. The equipment used consisted of polybags, an analytical balance, a ruler, a watering can, research labels, a notebook, and documentation tools.

The study employed a Completely Randomized Design (CRD) with treatments involving the addition of organic planting media at four levels, namely:

- P0 (control) : Post-tin mining soil without organic planting media
- P1 (85:15) : 85% post-tin mining soil + 15% organic planting media
- P2 (75:25) : 75% post-tin mining soil + 25% organic planting media
- P3 (60:40) : 60% post-tin mining soil + 40% organic planting media

Each treatment was replicated five times, resulting in 20 experimental units. Data were analyzed using Analysis of Variance (ANOVA) followed by Duncan's Multiple Range Test at a 5% significance level. The observed parameters included leaf number (week 1 to week 6), plant height (week 1 to week 6), root biomass, and shoot biomass.

RESULTS AND DISCUSSION

Leaf Number and Plant Height

The ANOVA results indicate that the treatment with organic planting medium did not significantly affect leaf number from week 1 to week 6, as illustrated in Figure 1. The P2 (75:25) treatment exhibited the greatest average leaf count during the six weeks, totalling 8 leaves, with a weekly average increase of 2.32 leaves.

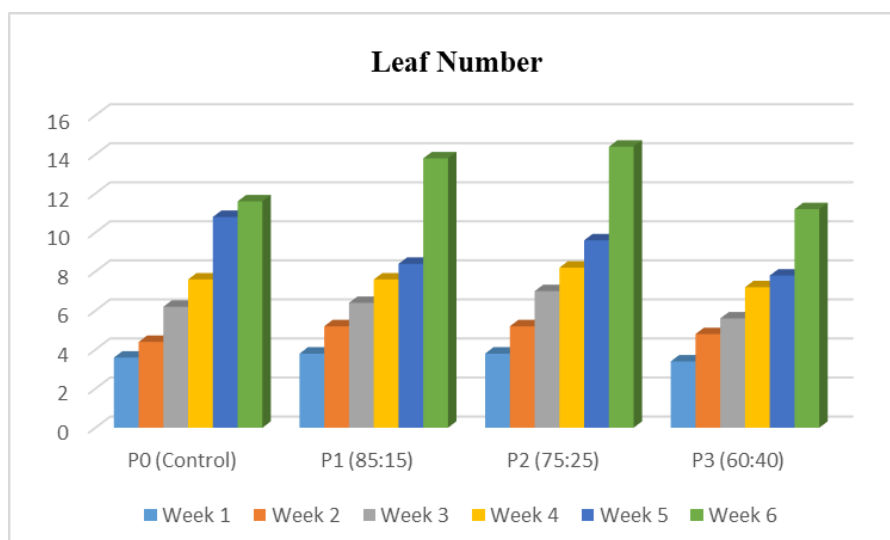


Figure 1. ANOVA results for the leaf number parameter

The ANOVA outcomes for plant height from week 1 to week 6 is presented in Figure 2. Based on the ANOVA results in Figure 2, the addition of organic growing media at the treatment levels P0, P1, P2, and P3 did not have a significant effect on plant height at any observation period from week 1 to week 6.

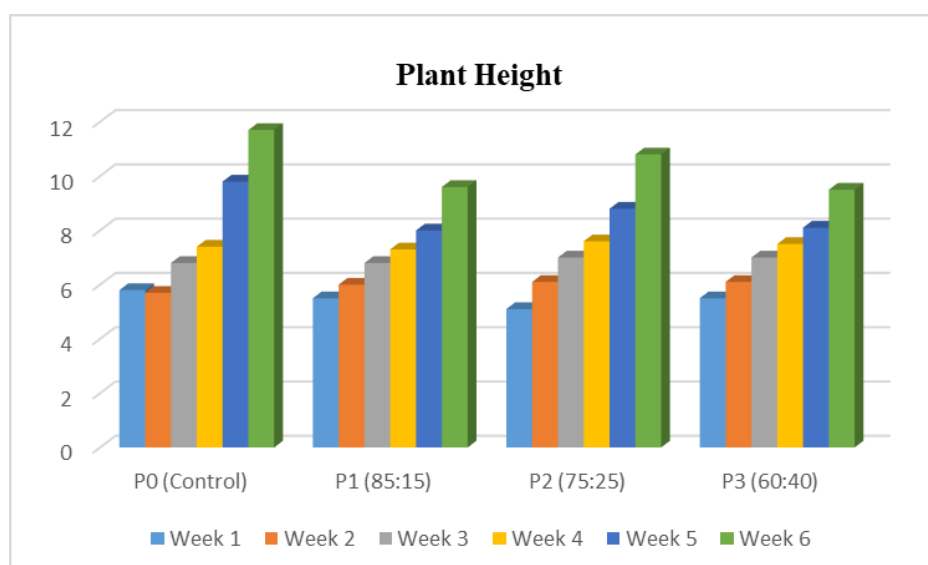


Figure 2. ANOVA results for the plant height parameter

Root Biomass and Shoot Biomass

The ANOVA outcomes for root biomass and shoot biomass are presented in Table 1. Based on the ANOVA results in Table 1, the addition of organic growing media at the various treatment levels (P1, P2, and P3) had a significant effect on root biomass compared to P0 (control), with the highest mean value observed in treatment P2 (75:25), which is 3.54 g. For shoot biomass, although there was a tendency to increase with the application of treatments, P1 (3.29), P2 (3.54), and P3 (2.99) did not show significant differences. The highest mean shoot biomass was also observed in treatment P2 (75:25), at 4.82 g.

Table 1. ANOVA results for root biomass and shoot biomass

Treatments	Parameters	
	Root biomass (gr)	Shoot biomass (gr)
P0 (control)	1.19 a	2.61 a
P1 (85:15)	3.29 b	4.72 a
P2 (75:25)	3.54 b	4.82 a
P3 (60:40)	2.99 b	3.55 a

Note: Numbers followed by the same letter within the same column are not significantly different according to Duncan's Multiple Range Test at a 5% significance level.

Discussion

The amount of marginal land on Bangka Island is expanding as a result of tin mining operations. Poor soil quality limits the effective use of previously mined land. Mining operations also result in extensive areas characterized by clay, humic, and sand tailings (Gayatri et al., 2022). Sand tailings are the residual byproducts of the leaching process in mining, mainly consisting of sand particles. Approximately 80–90% of tin tailings consist of sandy tailings, with the remainder consisting of slime tailings. This tailings material contains 87–94% sand fraction, a little clay fraction (under 3%), and low organic matter content (below 1.5%). Moreover, tailings have a low water retention capacity and high water permeability (Mustikarini et al., 2025). Mining activities degrade soil quality, affecting its physical, chemical, and biological properties (Nurtjahya et al., 2023). The soil used in this study was sourced from post-tin mining ground situated at coordinates 1°55'14.48"S and 106°7'37.65"E on Jalan Pattimura, Air Kenanga Village, Sungailiat District, Bangka Regency, Bangka Belitung Islands Province. Figure 3 shows the locations of the soil samples. The addition of organic planting media, such as compost or manure, is expected to enhance soil physical properties (Haryati et al., 2019). The addition of compost can enhance soil physical characteristics, including soil structure, water retention capacity, aeration, and drainage. Moreover, soil chemical characteristics can be enhanced by increasing the availability of key nutrients, such as Nitrogen (N), Phosphorus (P), and Potassium (K), which are critical for seedling development (Hajar et al., 2025).

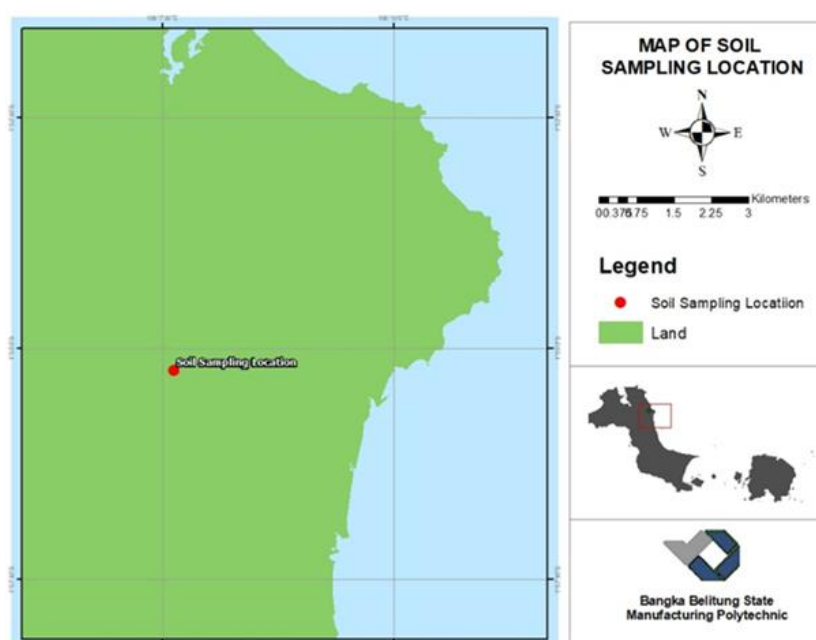


Figure 3. Map of the soil sampling locations

The findings of this study demonstrate that of the four parameters examined, leaf number, plant height, root biomass, and shoot biomass, only root biomass had a significant effect on the organic planting media addition treatment. The remaining parameters, while showing an upward trend relative to the control (post-tin mining soil without the addition of an organic planting medium), did not reach statistical significance.

In terms of leaf numbers, treatments P1 and P2 tend to show an increase compared to P0 (control). The elevated levels of nutrients, particularly nitrogen and potassium, in the compost within the organic planting media are considered the primary factor promoting leaf development (Gulo et al., 2025). Nonetheless, while the addition of organic planting medium can enhance nutrient availability for leaf development, the plant's response to post-mining soil conditions remains limited (Gusventi et al., 2021). It depends on the properties of the post-mining soil and the specific medium used (Rahman et al. 2021). Soil resulting from tin mining typically has a coarse texture, is predominantly sand, and has significantly reduced fertility due to nutrient and organic matter leaching during mining operations. This soil texture results in significantly reduced water and nutrient retention, making the soil vulnerable to drought and challenging for optimal plant growth. Furthermore, the soil from former tin mines exhibits suboptimal chemical properties, characterized by an acidic pH and markedly low organic carbon content, both of which significantly influence soil microbial activity and overall soil fertility. Soil from former tin mine sites contains several hazardous heavy metals that might adversely affect the ecosystem and inhibit the establishment of groundnut plants (Indriani et al., 2017).

Besides leaf number, the insignificant plant height is due to insufficient nutrient absorption by the plants, despite the incorporation of organic planting media. The movement of nutrients and soil dynamics in sandy land post-tin mining is significantly affected by water flow within the soil, with soil permeability rate serving as a key indicator. Analysis of soil physical parameters from nine previous tin mine sites indicates that soil permeability varies from 9 to 17 cm/hour, with an average above 12.5 cm/hour. This permeability rate is categorized as rapid to extremely rapid. At a velocity of approximately 12.5 cm/hour, water in the 0–20 cm layer of the root zone will readily percolate into the lower layer, resulting in the nutrients-rich water exiting the root area within approximately 2 hours (Sutono et al., 2019). Sutono et al (2018) asserts that the predominant sand fraction in the former tin mining area results in high soil permeability, rapid drainage, and substantial porosity, alongside low organic matter content that promotes nutrient leaching. This leaching facilitates the migration of nutrients to deeper soil layers. Despite phosphate (PO_4) generally exhibiting low solubility in sandy soils resulting from tin mining, this nutrient can be transported from a depth of 0–20 cm within the root zone to deeper strata, hence impeding accessibility for plant roots. This suggests that whereas organic growing media enhances soil conditions, additional factors in post-mining soils continue to restrict optimal vegetative growth (Rahman et al., 2021).

The largest variation was observed in the root biomass parameter, where the addition of organic growth media substantially increased root biomass in groundnut plants. The physical properties of the growth medium will affect root development (Inonu et al., 2021). Prananda et al (2014) state that one environmental factor affecting plant growth is the soil in which roots grow. The addition of organic growing media rich in organic matter and nutrients enhances soil structure and nutrient distribution, facilitating optimal root development. Lestari et al (2020) asserted that increasing soil organic matter content reduces soil density, thereby facilitating the unrestricted growth of plant roots and the development of a strong root system. Conversely, enhanced root biomass serves as a plant adaptation for acquiring resources under suboptimal conditions. The increased root biomass may enhance the plant's capacity to take up water and nutrients, which are essential for the rehabilitation of post-mining soil (Rusdiyanto et al., 2025). The treatment containing organic growth material exhibited a considerably higher root biomass.

This aligns with the findings of Laia et al (2025) and Basyaruddin (2025), who indicated that organic material content enhances soil structure, hence facilitating optimal root development as a strategy of plant adaptation.

Although a trend of enhancement with the addition of organic growing material was observed, canopy biomass production did not differ substantially from the control. The canopy biomass is significantly influenced by complex environmental and nutritional factors, making the impact of organic growing media alone insufficient to achieve significant increases. Canopy biomass indicates the water content present in plant tissue. The water content in this tissue is determined by the plant's capacity to absorb water from its surroundings and the environmental conditions that facilitate this absorption process (Lestari et al., 2020). Limited water absorption by plants may inhibit vegetative growth and, consequently, canopy development (Wahono et al., 2018). Soils from former tin mining typically possess a sand component reaching 95%, exhibit moderate to rapid permeability, have a loose texture, and demonstrate minimal nutrient and water retention capacity, leading to suboptimal plant development (Rajiman et al., 2008).

The addition of organic growing media to post-tin mining soil markedly enhanced groundnut root development, whereas other vegetative parameters showed gains that were not statistically significant. These findings emphasize the need to prioritize management of the growth medium to enhance the efficacy of post-mining land restoration by adopting a strategy that regulates the plant's capacity to acclimate to adverse environmental conditions.

CONCLUSIONS

Based on the results of this study, among the four treatments of growing media (P0, P1, P2, and P3), root biomass showed a significant effect on plant growth. In contrast, other parameters, such as leaf number, plant height, and shoot biomass, did not show significant differences among the treatments. This indicates that the applied growing media composition optimized root system development but did not significantly affect other vegetative growth aspects. Therefore, further research is recommended to investigate the addition of organic materials or soil microorganisms to enhance the overall vegetative growth of the plants.

CONFLICT OF INTEREST

There is no conflict of interest with any party regarding the material discussed in the article, funding, and differences of opinion between the authors.

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