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RESEARCH ARTICLE

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Bioassay the Composition of the Organic Pot as a Container Media for Balsa (*Ocrhoma bicolor* Rowlee) Growth in Nursery

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ABSTRACT

Forestry plant seedling production uses non-eco-friendly polybags. Organic pots are a solution that can be applied. This research aimed to analyze the composition and size of raw materials in organic pots for balsa growth and to examine the composition of raw materials in organic pots appropriate for balsa growth. This study used a factorial complete randomized design (CRD). There are two factors: the organic pot composition factor (A) and the mesh size factor (M). The observed parameters included the C/N ratio of organic pots, height, diameter, biomass, and plant chlorophyll content. The results showed that the highest percentage decrease in the C/N ratio was found in the A3M2 treatment. The highest average value of balsa plant growth was found in the A3M2 treatment (15% newspaper, 80% goat manure, 5% cocopeat, and ten mesh material size). The highest chlorophyll content was found in A3M1 treatments (15% newspaper, 80% goat manure, 5% cocopeat, five mesh material size). Organic pots with low C/N ratio values had higher average increases in height and diameter of plants compared to organic pots with high C/N ratio values. The optimal composition of the organic pot in this study was the A3M2 treatment.

Introduction

Indonesia is a country that has a large forest area, around 125,795.31 thousand ha [1]. However, forest areas decline almost every year due to the damage to forests and land, both natural and human actions. Between 1950 and 2017, deforestation impacted 35% of the national territory, totaling over 66 million ha with an average loss of 985,200 ha/year [2]. The decrease in forest area is due to land conversion and changes in forest uses caused by humans [3]. That leads to deforestation and forest degradation. Deforestation that occurs due to changes in land use reduces the area of vegetation cover and reduces the quality and density of forests [4,5]. Deforestation also causes loss of nutrient content in the soil, change soil properties, and can disrupt ecosystem structure by changing vegetation cover [6]; when forest cover, structure, and composition change, it shifts in biophysical processes such as water and energy balances may amplify or reduce the climate impacts of carbon released from forest above ground biomass and deforestation can cause global warming [7].

On the other hand, indirect forest degradation is also determined by a change in a partial reduction in tree density on forest land and a reduction in the function or capacity of the forest [8], and forest degradation also influences climate change [9]. Based on the negative impacts of deforestation and forest degradation, it is necessary to take action to improve forests and land through rehabilitation activities. Forest and land rehabilitation aims to restore, maintain, and improve the function of forests and land (*Undang-Undang 41 tentang 1999 Kehutanan*). The government is forced to rehabilitate forests and land an average of 200.000 hectares per year [10]. The objective of rehabilitation is to provide a continuous supply of economically important woody and non-woody products and restore the deforested area to its initial or original state [11].

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One factor that determines the success of forest rehabilitation is the selection of the right plant types and the availability of seeds in large quantities. The species that can be used in forest and land rehabilitation is balsa [12]. Balsa (*Ochroma bicolor* Rowlee) belongs to the Malvaceae. This species grows quickly and has great potential to be used as a plant for forest and land rehabilitation [13]. Thus, the seed of this species might be required in large quantities. The number of seeds used for rehabilitation is directly proportional to the number of polybags needed. However, using polybags in large quantities will become waste and pollute the environment because they are made from plastic. The environmental impact of plastic pollution is one of the major problems for ecosystems on earth [14]. Plastic has properties that are not easily destroyed in various weather conditions and cannot be broken down by soil microorganisms that cause the accumulation of plastic waste. One solution that can be applied to overcome this problem is to use containers for growing plants made from organic materials because they are easily decomposed and environmentally friendly [15].

Organic pots can be made from newspaper, fertilizer, cocopeat, or other organic materials. Based on a previous study [16], an organic pot can be mixed with newspaper, sawdust waste, clusters, different types of compost, and natural adhesives. The use of organic materials is good for plant growth. Organic materials slowly release essential plant nutrients and reduce their leaching to groundwater [17]. Organic pots can also streamline planting time when seedlings are planted in the field [18]. In relation to those cases, the research aims to analyze the composition and size of organic pot materials on the growth of balsa plants, as well as examining the composition of organic pot materials that are appropriate for the growth of these plants.

Materials and Methods

Location and Period

This research was conducted in a greenhouse of the Silviculture Department, Faculty of Forestry and Environment, IPB. Goat manure and organic pot analysis were carried out at the Indonesian Center for Biodiversity and Biotechnology (ICBB) Laboratory. It was conducted from August to December 2022.

Tools and Materials

The tools and materials used were organic pot printing equipment, hammer, sieve shaker (size 5 mesh and 10 mesh), pot tray, sand sieve, blender, sprout tub, SPAD-502, digital scales, digital caliper, ruler, oven, stationery, newspaper, goat manure (decomposed), cocopeat, topsoil, and balsa seed.

Collecting Data Method

Data collection uses a quantitative method that measures several parameters through trials or experiments. The parameters tested included the C/N ratio of the organic pots, plant height and diameter, plant biomass, and chlorophyll content of plant leaves.

Organic Pot Making

The newspaper was cut into small pieces and soaked in water. Then the newspaper was crushed by using a blender until it became like paper pulp and filtered. Goat manure and cocopeat were prepared by filtering these materials using a multi-level sieve with sizes of 5 mesh and 10 mesh. The prepared material is printed according to the specified composition. The composition consists of 1) 70% newspaper, 30% goat manure, 0% cocopeat; 2) 35% newspaper, 60% goat manure, 5% cocopeat; 3) 15% newspaper, 80% goat manure; cocopeat 5%. Each composition is molded into an organic pot with compost and cocopeat sizes of 5 mesh and 10 mesh. The printed organic pots were dried in an oven at 85 °C for 24 hours.

Seedling Growth Trial

Balsa seedlings were obtained from IPB Permanent Nursery. The planting media was topsoil obtained from Dramaga Sub-district, Bogor Regency. The topsoil was filtered using a sand sieve with a hole size of 2 x 2 mm, then mixed with a composition ratio of 1 kg of topsoil and 50 g of compost. After that, the ingredients were stirred until evenly mixed. The well-mixed media is ready to be used for weaning balsa seedlings. Weaning of seedlings was carried out in a greenhouse in the afternoon. Weaning the seedlings by making a hole in the planting medium in an organic pot, then the seedling roots (up to the base) were inserted into the hole and covered with the planting medium. Maintenance was carried out by watering every day in the morning and evening, depending on the humidity of the media.

Chemical Analysis of Goat Manure

The sample 100 g of goat manure was analyzed at ICBB.

Variables of Growth

C/N Ratio of Organic Pot

Organic pot samples were tested for C/N ratio and analyzed at the ICBB Laboratory.

Plant Height and Diameter

Plant height and diameter were measured every two weeks during observations. The plant height was measured from the base of the trunk to the tip of the plant. Plant height was measured using a ruler. The plant diameter was measured 1 cm from the soil surface or at the bottom of the seedling—diameter measurement using digital calipers.

Plant Biomass

Biomass measurements were carried out after the plant seeds were harvested. Seedling biomass was calculated based on the dry weight of the roots and shoots. Dried using an oven at a temperature of 80 °C for 48 hours. Biomass is weighted using a digital scale.

Chlorophyll Content

The chlorophyll content of each treatment was calculated using a SPAD chlorophyll meter. The chlorophyll content was measured three times to obtain an average value. A leaf sample was clamped on the sensor part of the SPAD-502.

Data Analysis Method

The data analysis method used was a factorial randomized design (CRD). The research used two factors: the organic pot composition factor (A) and the mesh size factor of the organic pot base material (M). Each factor had three levels and two levels. Each level of factor A (A1: 70% newspaper, 30% goat manure, 0% cocopeat; A2: 35% newspaper, 60% goat manure, 5% cocopeat; A3: 15% newspaper, 80% goat manure, 5% cocopeat) and level of factor M (M1: 5 mesh; M2: 10 mesh) is combined to obtain six treatments. Each treatment is repeated six times. A total of 36 experimental units are used for this research. The combinations of treatments tested are as follows (Table 1).

Table 1. Combination of research treatments.

Level	A1	A2	A3
M1	A1M1	A2M1	A3M1
M2	A1M2	A2M2	A3M2

Description: **A1M1**:70% newspaper, 30% goat manure, 0% cocopeat, material size 5 mesh. **A1M2**:70% newspaper, 30% goat manure, 0% cocopeat, material size 10 mesh. **A2M1**:35% newspaper, 60% goat manure, 5% cocopeat, material size 5 mesh. **A2M2**:35% newspaper, 60% goat manure, 5% cocopeat, material size 10 mesh. **A3M1**:15% newspaper, 80% goat manure, 5% cocopeat, material size 5 mesh. **A3M2**:15% newspaper, 80% goat manure, 5% cocopeat, material size 10 mesh.

Statistical Analysis

Data processing was performed using Microsoft Excel and SAS 9.0. The effect of treatment on the variables was observed using the ANOVA test at the α = 5% level. Further tests were carried out using Duncan's Multiple Range Test (DMRT) using SAS 9.0 Software.

Results and Discussion

Chemical Analysis of Goat Manure

Goat manure can provide sufficient nutrients for plant growth and improve soil chemical properties. Chemical analysis of goat manure shows that it contains high nutrient elements, especially N, P, and C. The results of this study's chemical analysis of goat manure are shown in Table 2.

Table 2. Chemical analysis of goat manure.

Parameter	Result	^Criteria
C-Organic (%)	36.85	Very high
N-Total (%)	1.88	Very high
P_2O_2 Total (%)	1.37	Very high
K_2O Total (%)	0.79	Low

^Eviati and Sulaeman [19].

Variance Analysis Towards Parameters

The recapitulation of variance analysis on balsa growth parameters shows differences in the influence of the composition, size, and interaction between the composition and size of the organic material. The results of the analysis are presented in Table 3.

Table 3. Results of variance analysis towards parameters.

No	Parameter	A	M	A x M
1	Diameter (mm)	*	*	*
2	Height (cm)	*	*	*
3	Biomass (g)	*	Ns	Ns
4	Chlorophyll content (μg/cm²)	*	Ns	Ns
5	C/N ratio of organic pot	*	Ns	Ns

A: Pot material composition, M: Size of organic material (mesh), Ns: No significant effect (P > 0.05); *: Significant effect (P < 0.05).

C/N Ratio of Organic Pot

The C/N ratio of the organic pots is the ratio of the amount of organic carbon (C) to nitrogen (N) in the organic pots. The C/N ratio indicates the ease with which microorganisms can decompose organic matter and the nutrient content in organic pots [13,20]. The C/N ratio indicates the maturity level of the decomposed organic matter (fertilizer). The decomposition process requires C as a source of energy and growth and N as a source of protein for the development of metabolic cells. Microorganisms can break down C compounds as an energy source, whereas N is used to synthesize proteins. If the C/N ratio is high, the activity of microorganisms in the organic material decreases, whereas if the C/N ratio is very low, excess nitrogen cannot be assimilated and disappears [21]. The results of C/N ratio analysis of the organic pots are shown in Figure 1.

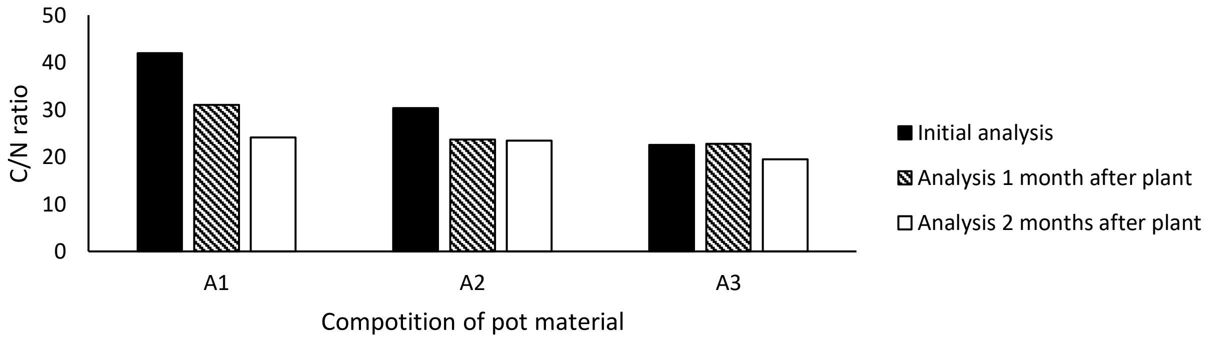

Figure 1. C/N ratio analysis of organic pots 2 months after planting (A1: 70% newspaper, 30% goat manure, 0% cocopeat; A2: 35% newspaper, 60% goat manure, 5% cocopeat; A3: 15% newspaper, 80% goat manure, 5% cocopeat).

The results of variance analysis (Table 3) show that single factor of organic matter composition has a significantly different effect on the C/N ratio of organic pots. Meanwhile, the single factor, of pot material size and interaction between material composition and organic pot material size, were not significant effect on C/N ratio. The results of organic C/N ratio test showed that each treatment decreased when the plants were harvested every month within 2 months. The decrease of organic pot C/N ratio indicated the decomposition of organic pot. Figure 1 shows the highest average C/N ratio value was found in A1 from initial to final analysis with the average value from 41.99 to 24.09, while the lowest average C/N ratio value was found in A3 with the average value from 22.29 to 19.45. This might happen due to the influence of the composition of organic pot matter. The organic pots of A1 did not decompose easily compared to A3 which had a higher organic material content.

High organic matter content might cause the presence of soil microorganisms that help in decomposing organic pots. At the end of the observation period, organic pots with a high content of organic materials especially goat manure were found to be brittle. This indicates that pots with high organic content can decompose more effectively, likely due to the presence of microorganisms utilizing these organic materials for their biological activities. Previous study [22] showed that during the decomposition process of organic matter, the availability of carbon (C) has a function as an energy source for the survival of microorganisms, and nitrogen (N) has a role in the formation of the microorganisms themselves. Also, the decomposition process will cause CO_2 to evaporate so that carbon content decreases and nitrogen content increases. This causes C/N ratio content to decrease. According to Tsai and Chang [23], more nutrients are added to support plant growth when fertilizer is applied at a higher rate. As a result, the plant might have acquired more N, which led to an increase in N concentration and a decrease in the C/N ratio.

Balsa Plant Growth Test

Plant growth is an increase in plant size, which can be measured by increasing the diameter, plant height, biomass, number of leaves, etc. Plant growth occurs because of division and an increase in the number of cells in the plant. The results of the balsa plant growth tests are presented in Table 4.

Table 4. Increase in balsa growth parameters (16 weeks after planting / WAP).

Treatment	Diameter increase (mm)	Height increase (cm)	Biomass (g)	Chlorophyll content (μg/cm²)
A1M1	0.82 ± 0.07^{c}	2.23 ± 0.06^{d}	0.19 ± 0.08^{c}	19.07 ± 2.04^{bc}
A1M2	1.58 ± 0.52^{b}	3.60 ± 0.26^{c}	0.28 ± 0.04^{c}	17.87 ± 1.33^{c}
A2M1	2.15 ± 0.06^{ab}	4.47 ± 0.31^{b}	0.83 ± 0.24^{ab}	21.77 ± 1.39^{ab}
A2M2	1.84 ± 0.06^{b}	4.43 ± 0.55^{b}	0.48 ± 0.15^{bc}	19.47 ± 1.99^{bc}
A3M1	1.92 ± 0.37^{ab}	4.37 ± 0.29^{b}	0.99 ± 0.53^{a}	23.93 ± 1.59^{a}
A3M2	2.51 ± 0.44^{a}	6.00 ± 0.36^{a}	1.07 ± 0.07^{a}	22.30 ± 1.91^{ab}

Notes: The number followed by the same letters in the same column indicate no real difference based on Duncan’s analysis at levels of α 5%.

The results of variance analysis (Table 3) show that the single factor of organic pot material and size of organic pot material have significantly different effects on plant diameter and height parameters. Meanwhile, biomass, chlorophyll content, and C/N ratio of organic pots had a significant difference in organic material composition. Statistical analysis (ANOVA) showed that the interaction between the organic material composition factors and the size of the organic pot material was significantly different ($f_{count} < 0.05$) on the increase of plant height and diameter. According to a Novita et al. studies [24], organic material size treatment had a significantly different effect on plant vegetative growth.

The analysis of plant growth parameters on plant diameter and height (Table 4) showed that the A3M2 treatment had the highest average plant diameter and height increase. It has a value of 2.51 mm and 6.00 cm compared to the A1M1 treatment which has an average value, the lowest increase in diameter and height with respective values of 0.82 mm and 2.23 cm. Increasing plant height and diameter also increases plant biomass. The results showed that increasing plant diameter and height was directly proportional to the increase in biomass (Table 4). The highest plant biomass occurred in the A3M2 treatment, with an average biomass value of 1.07 g, compared to the A1M1 treatment, with an average biomass value of 0.19 g. This shows that adding 15% newspaper, 80% goat manure, 5% cocopeat, and a pot material size of 10 mesh in the A3M2 treatment can increase the growth of balsa plants better than the other treatments.

This is thought to be because 80% of goat manure contains organic material supporting plant growth and development. Based on the chemical analysis of goat manure (Table 2) shows that goat manure contains high levels of nutrients such as N, P, and C. The presence of these nutrients can enhance plant growth, as proven by the treatment with 80% goat manure, which can increase the growth of balsa more optimally than other treatments. This finding is consistent with Hariadi et al. studies [25], which show that goat manure can increase plant growth. Goat manure provides nutrients sufficient for plant growth and development, especially in the metabolic process of photosynthesis [26]. Providing high amounts of goat manure can increase the C-organic content of soil [27]. C-organic plays a role in soil fertility because the weathering of organic material can bind the nutrients in goat manure so that nutrients such as N, P, and K are not easily lost due to leaching of nutrients by water and cause plants to absorb these nutrients optimally [28].

In addition to the high application of goat manure, treatment A3M2, which showed the highest average values for several plant growth parameters, also received an additional 5% cocopeat. At the end of the observation period, organic pots supplemented with 5% cocopeat exhibited more extensive and longer plant roots. This enabled the plants to absorb and access nutrients more optimally than other treatments. Additionally, providing cocopeat as an organic material can help pots withstand water absorption because cocopeat has fibers that retain the water needed for plant growth. Therefore, the addition of cocopeat played an important role in plant growth. According to Wasis and Fitriani [29], cocopeat plays a role in improving the physical properties of soil, such as soil structure and increasing water-holding capacity, so that plant roots can grow well.

The difference factor in the size of organic material shows a significant difference in the growth of height and diameter of balsa plants. The size of the organic pot material with a size of 10 mesh produces better plant height and diameter growth compared to the size of 5 mesh. This is thought to be caused by the smaller size of the material that can expand the organic pot's absorption area and increase water absorption capacity. This causes organic pots with a material size of 10 mesh to be more optimal in absorbing water than organic pots with a material size of 5 mesh. According to Guo et al. and Imelda et al. studies [30,31], the smaller the particle size, the higher the absorption capacity because a wider surface area supports it.

Increased plant growth is due to the plant metabolic process called photosynthesis. Photosynthesis can be interpreted as changing light energy into chemical energy accompanied by releasing oxygen into the air [32]. Photosynthesis is the main determinant of growth results. Plant photosynthesis begins with plants capturing sunlight and converting carbon dioxide and water into plant biomass [33]. This photosynthesis process plays a role in the chlorophyll content in leaves [34]. The research results showed that the highest chlorophyll content was found in the A3M1 treatment, which had an average value of 22.30 μg/cm², compared to the A1M2 treatment, which had an average chlorophyll content value of 17.87 μg/cm² (Table 4). The organic material content influences this in the pot.

The A3M1 treatment has a higher percentage of organic material, especially goat manure, with a percentage value of 80%, compared to the A1M2 treatment, with a percentage value of 30%. High organic matter affects the nutrients plants absorb, which are used for photosynthesis. Based on the chemical analysis of goat manure (Table 2), goat manure contains high levels of nutrients, especially N, which can help plants prepare and increase chlorophyll content. Organic matter affects the chlorophyll content in leaves. Leaves obtain nutrients from plant roots; older leaves have more nutrients, so the chlorophyll content increases and causes the leaf color to become greener [35]. A previous study [36] stated that increasing N fertilizer is helpful in increasing the chlorophyll content and photosynthetic rate of leaves.

A Correlation between C/N Ratio with Height and Diameter of Plant

The result of the correlation analysis between the C/N ratio and the height and diameter of the plant shows a strong negative correlation. This indicates that as the C/N ratio decreases, the height and diameter of the plant increase. The correlation between the C/N ratio and the height and diameter of the plant is illustrated in Figure 2.

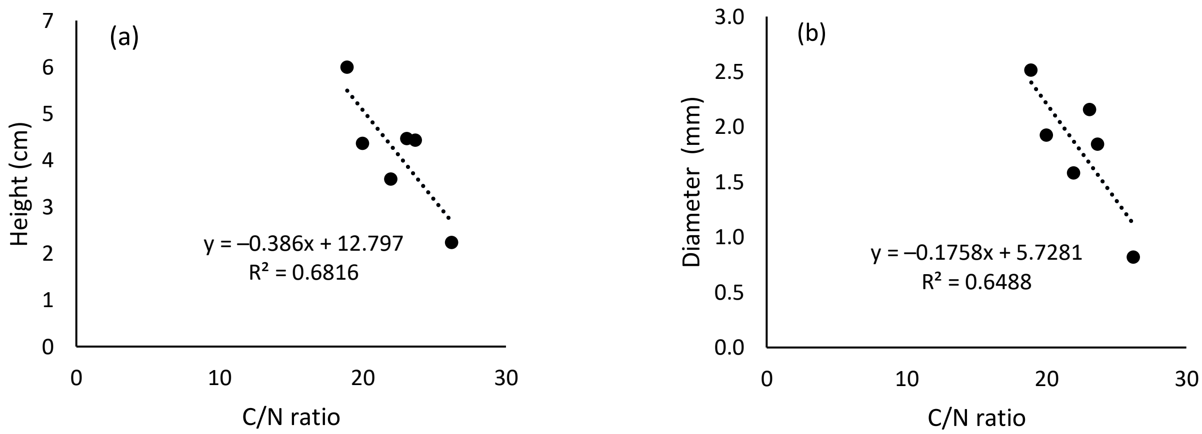

Figure 2. Correlation between the C/N ratio with (a) height and (b) diameter of plant.

Based on the correlation of the C/N ratio with the height and diameter of the plant (Figure 2), it shows that plant growth increases inversely with the C/N ratio of the organic pot. At the end of the observation period, organic pots with low C/N ratio values had higher average increases in height and diameter of plant compared to organic pots with high C/N ratio values. This is likely because organic pots with low C/N ratio decompose or break down easily, thus providing nutrients needed for more optimal plant growth. A low C/N ratio indicates active microorganisms that break down organic materials into compounds or elements required by plants. A previous study [37] also stated that plant biomass decreases with increasing C/N ratio and vice versa. Plant biomass decreased when applying amendments with C/N ratio above 20 but increased when applying C/N ratio of 10.

Conclusions

The composition and size of organic materials influence balsa's growth. The highest average value of balsa plant growth parameters was observed in an A3M2 treatment with 15% newspaper, 80% goat manure, and 5% cocopeat.

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