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Peat soil as an alternative soil substrate and its effect on balangeran (*Shorea belangeran*) seedling growth

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Abstract

Todays, substrates used for seedling growth are mostly topsoil. The topsoil will one day be difficult to obtain because of forest degradation. Therefore it is necessary to seek for alternative substrates. One of the alternatives is by utilizing peat land which is still of great potential on the island of Borneo. By mixing peat soil with mineral soil in a suitable balance, not only does the physical nature of the soil improve but also the ability of the substrates to hold water also increases. In addition, the only species of Dipterocarpaceae family that grows in wetland habitats is balangeran (*Shorea balangeran*). The existence of the species is almost extinct, so it needs to endeavor for sustainability. The purpose of this study was to analyze the effect of using peat soil and topsoil and their combinations as substrates of the growth of balangeran. The treatments applied were 0% peat soil + 100% topsoil, 25% peat soil + 75% topsoil, 50% peat soil + 50% topsoil, 75% peat soil + 25% topsoil, and 100% peat soil + 0% topsoil. The treatments were analyzed using a completely randomized design. The results showed that the highest increase of the seedling diameter (1.704 cm) was reached using the combination treatment of 25% peat soil + 75% topsoil), but the lowest one was the treatment of 0% peat soil + 100% topsoil) with the increase of the diameter of 0.455 cm. The topsoil should be mixed with peat soil substrates for growing balangeran seedlings in the nursery.

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Introduction

Todays, substrates used for seedling growth are mostly topsoil. As time goes by, the topsoil will one day be difficult to obtain because it is degraded due to the mining industry, land conversion, and uncontrolled forest management and other factors that cause loss of topsoil. Therefore it is necessary to seek for alternative substrates that can be used as a substitute so that the problem of difficulties in obtaining substrates in the future can be resolved. One of them is by utilizing peatland which is still of great potential, including on the island of Borneo.

South Kalimantan Province has 106,272 ha of peatland (Wahyunto *et al*., 2004), which is spread across several districts and cities, namely Banjar Regency, Barito Kuala, and Banjarmasin City. Based on this fact, it seems quite reasonable to explore peat soils for the benefit of forestry commodity production, especially as nursery substrates. Generally, balangeran nursery uses ultisol soil for substrates. Naturally, Ultisol soil has poor chemical and physical properties. These characteristics include acid soil reaction, Cation Exchange Capacity (CEC) and low nutrient content, especially Nitrogen, Phosphorus, Kalium and low organic matter content (Suharto, 1986 as quoted by Permana, 1987). In areas with extensive peatlands, peat soil has the opportunity to be used as a good alternative substrate. By mixing peat soil with mineral soil in a suitable balance, not only does the physical nature of the soil improve but also the ability of the media to hold water also increases. Susilawati and Bastoni (2005) reported that the treatment of peat soil in topsoil substrates with a ratio of 70% of topsoil and 30% of peat soil can increase plant height and the number of leaves of jelutung plants. Therefore, assessing the use of peat soil as an alternative substrate for balangeran seedlings is very important to do. The only species from Dipterocarpaceae family that grows in wetland habitats is balangeran (*Shorea balangeran*) with the condition is almost extinct, so it needs to endeavor for sustainability.

The aim of the study was to analyze the effect of the peat soil and mineral and their combinations on the growth of balangeran seedlings. From the results of this study, it is expected that information on the use of peat soil and mineral/topsoil and their combinations as an alternative substrate will contribute to the development of science in the field of forest cultivation.

Materials and methods

The experimental materials were mature peat soil while the mineral/topsoil used belongs to the order of Ultisols. Balangeran seedlings were obtained from the Banjarbaru Forest Technology Assessment Center and were four months old from the nursery. In addition, also used compound inorganic fertilizers with composition N: P:K, 12:12:17 which was given two weeks after weaning at Shade house. Tools used were analytical scales, ovens, hoes, shovels, calipers, rulers, cameras, polybag and writing instruments.

The research applied a completely randomized design, which consisted of five treatments that were replicated five times so that there were 25 experimental units. The five treatments were G0T4 (0% peat soil + 100% topsoil), G1T3 (peat soil 25 % + 75% topsoil), G2T2 (50% peat soil + 50% topsoil), G3T1 (75% peat soil + 25% topsoil), and G4T0 (100% peat soil + 0% topsoil). The variables observed were plant height (cm), stem diameter (cm), and percentage growth (%).

Statistical analysis

The data obtained were analyzed using variance analysis. If the influence of the treatments is seen in a variable or variables, the analysis is continued by using the Least Significant Difference Test at the level of 1% and 5% (Soemartono, 1977).

Results and discussion

Survival Percentage

Survival percentage of belangeran seedlings was described in Table 1.

Based on the Tabel 1, there was one seedling died from 25 tested seedlings, namely the G0T4 treatment

(0% peat soil and 100% topsoil), so the growth percentage was 96%. This was presumably due to soil physical factors, where the substrate which was not combined with peat soil was less absorbing water. Mixing the topsoil substrates with peat soil helped absorb water and improve soil structure. Peat soils that are indeed rich in organic matter have been able to improve soil properties and chemistry in ways such as stimulating granulation, increasing porosity, increasing the holding capacity of water and changing soil structure into crumbs and loose matter.

Table 1. Survival percentage of balangeran seedlings.

Treatment	Replication					Total	Percentage (%)
	1	2	3	4	5		
GOT4	1	1	-	1	1	4	80
G1T3	1	1	1	1	1	5	100
G2T2	1	1	1	1	1	5	100
G3T1	1	1	1	1	1	5	100
G4TO	1	1	1	1	1	5	100
TOTAL						24	480
Average						96	

Description:
G0T4 = 0% peat soil + 100% topsoil
G1T3 = 25% peat soil + 75% topsoil
G2T2 = 50% peat soil + 50% topsoil
G3T1 = 75% peat soil + 25% topsoil
G4T0 = 100% peat soil + 0% topsoil

In addition, the total soil pore space has also increased with the provision of organic matter from peat soil (Saidi, 1994 which was cited by Hanibal, 2007).

Furthermore, according to Hanibal (2007), based on the results of his research, the nutrient content in the media can be increased through peat treatment.

The increase in stem diameter of the seedling of balangeran

For the average increase in stem diameter of balangeran seedlings in all treatments, the treatments combined with peat soil resulted in greater diameter than the treatment without being combined with peat soil. For more details, the average increase in diameter can be seen in Table 2.

Table 2. The increase in the diameter of balangeran seedlings (cm).

Treatment	Replication					Total	Average
	1	2	3	4	5		
GOT4	0.08	0.04	-	1.30	0.40	1.82	0.455
G1T3	1.82	1.30	1.90	2.40	1.10	8.52	1.704
G2T2	0.32	0.10	1.82	1.30	0.10	3.64	0.728
G3T1	1.70	0.50	0.10	1.50	1.50	5.30	1.060
G4TO	2.60	2.00	0.42	1.50	1.90	8.40	1.684
TOTAL						27.68	1.153

Description:
G0T4 = 0% peat soil + 100% topsoil
G1T3 = 25% peat soil + 75% topsoil
G2T2 = 50% peat soil + 50% topsoil
G3T1 = 75% peat soil + 25% topsoil
G4T0 = 100% peat soil + 0% topsoil

From the results of the normality and homogeneity tests, it is known that the data spread normally and homogeneously. Furthermore, analysis of variance was carried out to determine whether there was an effect of the combination treatments of substrates on the increase in the stem diameter of the seedlings as presented in Table 3.

Table 3. Analysis of variance of the effect of the combination of substrates on the increase in stem diameter of the balangeran seedlings

Source of diversity	Free degree	Number of squares	Middle Squares	F-value	F-table	
					5%	1%
Substrate combination	4	5.823	1.456	4.66**	2.90	4.50
Error	19	5.929	0.312			
Total	23	11.752				

Description: ** = very significant.

Based on Table 3, it is known that F-value is greater than F-table, at the level of confidence of 5% and 1%.

This showed that the combination treatments of substrates had a very significant effect on the average stem diameter increase of the balangeran seedlings. To analyze which treatments that have different effects, further testing was carried out. According to Soemartono (1977), the only comparative test that can be used was LSD (Least Significant Difference Test) because the replication is different and each pair of treatments that are compared will differ in the formula, depending on the magnitude of repetition compared to the results which can be seen in Table 4.

Table 4. Test for LSD comparisons between pairs of treatments for the increase of seedling diameter of balangeran.

Significance	Treatment and Value	Remarks
LSD to.01	G2T2 – G0T4 = 0.728 – 0.455 = 0.27 < 1.07	not significantly different
LSD to.05	G2T2 – G0T4 = 0.728 – 0.455 = 0.27 < 0.78	not significantly different
LSD to.01	G3T1 – G2T2 = 1.060 – 0.728 = 0.33 < 1.01	not significantly different
LSD to.05	G3T1 – G2T2 = 1.060 – 0.728 = 0.33 < 0.74	not significantly different
LSD to.01	G4T0 – G3T1 = 1.684 – 1.060 = 0.62 < 1.01	not significantly different
LSD to.05	G4T0 – G3T1 = 1.684 – 1.060 = 0.62 < 0.74	not significantly different
LSD to.01	G1T3 – G4T0 = 1.704 – 1.684 = 0.02 < 1.01	not significantly different
LSD to.05	G1T3 – G4T0 = 1.704 – 1.684 = 0.02 < 0.74	not significantly different
LSD to.01	G1T3 – G0T4 = 1.704 – 0.455 = 1.25 > 1.07	very significantly different
LSD to.05	G1T3 – G0T4 = 1.704 – 0.455 = 1.25 > 0.78	significantly different
LSD to.01	G4T0 – G0T4 = 1.684 – 0.455 = 1.23 > 1.07	very significantly different
LSD to.05	G4T0 – G0T4 = 1.684 – 0.455 = 1.23 > 0.78	significantly different
LSD to.01	G1T3 – G2T2 = 1.704 – 0.728 = 0.98 < 1.07	not significantly different
LSD to.05	G1T3 – G2T2 = 1.704 – 0.728 = 0.98 > 0.78	significantly different
LSD to.01	G4T0 – G2T2 = 1.684 – 0.728 = 0.96 < 1.07	not significantly different
LSD to.05	G4T0 – G2T2 = 1.684 – 0.728 = 0.96 > 0.78	significantly different
	LSD1% & 5% = 1.07 and 0.78	For the same number of replications
	LSD1% & 5% = 1.01 and 0.74	For the different number of replications

Description:

G0T4 = 0% peat soil + 100% topsoil

G1T3 = 25% peat soil + 75% topsoil

G2T2 = 50% peat soil + 50% topsoil

G3T1 = 75% peat soil + 25% topsoil

G4T0 = 100% peat soil + 0% topsoil

Table 4 about here Based on the results of the LSD test as presented in Table 4, it can be seen that the combination treatments of G1T3 (25% peat soil + topsoil 75%) and G4T0 (100% peat soil + topsoil 0%) substrates provided very significantly different effects on the increase of diameter of balangeran seedlings compared to the treatment of G0T4 (0% peat soil + topsoil 100%) substrate. In addition, they just provided significantly different effects compared to the treatment of G2T2 (50% peat soil + 50% topsoil) substrate. And their effect did not differ from rest other treatments.

Table 5. The increase of seedling height (cm) of balangeran.

Treatment	Replication					Total	Average
	1	2	3	4	5		
GOT4	30.1	27.7	-	54.2	21.3	133.3	33.33
G1T3	27.9	19.7	33.4	24.5	25.3	130.8	26.16
G2T2	13.1	15.8	22.1	30.2	23.2	104.4	20.88
G3T1	12.2	24.5	20.4	30.7	20.2	108.0	21.60
G4TO	27.1	12.5	20.5	21.2	24.2	105.5	21.10
TOTAL						582.0	24.25

Description:
G0T4 = 0% peat soil + 100% topsoil
G1T3 = 25% peat soil + 75% topsoil
G2T2 = 50% peat soil + 50% topsoil
G3T1 = 75% peat soil + 25% topsoil
G4T0 = 100% peat soil + 0% topsoil

The highest increase of seedling diameter was reached with the substrate treatment of G1T3 (25% peat soil + topsoil 75%) i.e. 1.704 cm followed by the substrate treatment of G4T0 (100% peat soil + topsoil 0%) i.e. 1.684 cm; which were significantly different from other substrates. This showed that the utilization of G1T3 or G4T0 substrates produced a relatively better stem diameter growth than other substrates did. In other words, to stimulate the growth of the diameter of the balangeran seedlings, the best way was to use a combination of peat soil and topsoil according to the recommendations from the results of this study. This combination of substrates can improve the physical and chemical properties of the soil such as soil structure, soil porosity, holding of groundwater and adding soil nutrients.

Provision of peat soil guaranteed nutrient availability, improved aeration, and media regeneration. Organic materials found in peatlands tend to increase the amount of water that can be retained in the soil and the amount of water available to plants. Peat soil has a homogeneous content called humus. Humus is a soil organic compound that stores plant nutrients and functions as a buffer in physical, chemical and biological processes that are very important for soil structure improvement (IRRI, 2006). Giving organic material not only adds nutrients to plants but also creates conditions suitable for plants by improving aeration, facilitates root penetration and improves the capacity to hold water and organic matter can increase pH, cation capacity (CEC), nutrient uptake and reduce Al and the soil structure becomes crumbs. Better physical properties of the soil make it easier for plants to absorb nutrients. (Anonim, 1990 in Safuan, 2002).

Growth is related to the development of several specific organs or plant organs as a whole. This growth can be measured through the approach of measuring dry weight, leaf area, plant height, stem diameter and so on (Hakim *et al.*, 1986). One of the environmental factors that affect the growth of seedlings is a substrate whose function is to develop

root organs. According to Novizan (2005) in Kosasih and Haryati (2006), a good substrate has four important functions namely supplying nutrients and as anchoring anchors, providing water and water reservoirs, providing air for breathing roots and growing plants. Whereas Hartmann and Kester (1990) in Juhardi (1995) stated that a good substrate must have criteria which are able to maintain humidity, good aeration and drainage conditions, low salinity and free from pests and diseases. In addition, according to Salisburry and Ross (1992), nutrients have an important role in the process of photosynthesis, energy exchange and protein synthesis and the formation of cell walls in plants.

Table 6. Analysis of the variance of the effect of the combination of weaning media on the average increase in height of the balangeran seedlings.

Source of diversity	Free degree	Number of squares	Middle Squares	F-value	F-table	
					5%	1%
Substrate combination	4	489.172	122.293	1,86^{ns}	2.90	4.50
Error	19	1251.068	65.84			
Total	23	1740.24				

Description: ns = not significantly different.

The results of this study indicated that mixing 25% peat soil media and 75% topsoil produced seedlings with the highest diameter increase, compared to the use of whole substrates using pure soil or topsoil. By adding peat soil to substrates can increase nutrients essential for plant growth such as macronutrients: N, P, K, Ca, and Mg. This was evident from the results of soil analysis, substrates that combined topsoil and peat soil showed higher values of macronutrients than substrates which use topsoil.

Peat soil contains high enough organic material which is easily subjected to weathering and decomposes, so it will improve the physical and chemical properties of the soil. Aeration, drainage and nutrient elements of the media will increase along with decomposition of peat. Indriyanto (2003,) reported that rice husk + bokashi media (2:1) provided relatively better results for cengal nurseries (*Hopea sangal* Korth) than soil and soil + sawdust. Rice husk media can create growing environmental conditions, especially the physical and chemical properties of soil that are better for plant growth because the weathering process is faster, containing nutrients N, P, K, Cl and Mg (Thomas, 1995 in Indriyanto, 2003).

Although based on analysis of variance showed that the treatment of combination of substrates of G1T3 (25% peat soil + topsoil 75%) and G4T0 (100% peat soil + topsoil 0%) had a very significant effect on the increase of balangeran seedling diameter compared to the effect of the substrate treatment of G0T4 (0% peat soil + 100% topsoil), the results of analysis tests showed that the effect of substrate treatments of G1T3 with G4T0 was not significantly different or equally good. This meant that the use of peat soil as a weaning media is very supportive for its use as a substitute media for weaning or mixing with topsoil. The results of this study were similar to the results of the previous Yamani (2017) study, which stated that the combination treatment of 25% peat soil peat media with 75% pure soil (topsoil) could support the growth of agarwood diameter. Likewise, Susilawati and Bastoni (2005) reported that the treatment of peat soil in topsoil planting media with a ratio of 70% of topsoil and 30% of peat soil can increase plant height and the number of leaves of jelutung plants.
Furthermore, according to Yamani (2017), the use of peat soil that was too dominant in weaning media gave the smallest results of stem diameter increase in the agarwood plant, whereas in the results of this present study it showed the opposite. It was suspected that in addition to the different types, the composition of peat that is too dominant in weaning media can affect the physical and chemical properties of the soil, including excessive water absorption so

that soil moisture will be large, soil pore holes will be filled with water which ultimately causes disruption of aeration, soil temperature and the decomposition process that occurs from peat material increases soil acidity. These factors cause the absorption of nutrients needed by plants through plant roots to be disrupted. According to Anonim, 1990 in Sudomo and Santosa (2011), nutrient absorption by plants will be easier if it has good soil physical properties. According to Salisburry and Ross (1992), in addition to the type of planting media, the temperature, humidity, availability of water and nutrients are factors that influence the growth of plant seedlings.

The weaning media or substrates of G0T4 (0% peat soil + 100% topsoil) gave a relatively poor growth in stem diameter compared to other substrates. This is because the soil substrate without a mixture of peat soil is becoming denser and less loose, thus slowing the growth of seedlings. While land which has good water holding and nutrient capacity tends to have poor aeration and drainage. Without a mixture of peat soil, this substrate is relatively nutrient-poor compared to other substrates, as shown in the results of soil analysis data. Novizan (2005) in Kosasih and Heryati (2006) stated that good substrates have four main functions, namely providing nutrients and as a root substrate, providing water and reservoirs, providing air for root respiration and as a place for growing plants.

Increased stem height of balangeran seedlings

Data for the increase in stem height of balangeran seedlings were shown in Table 5.

Based on Table 5, the highest average increase of balangeran seedlings from the substrate treatment of the combination of peat soil and topsoil was the treatment of a combination of G0T4 (0% peat soil + 100% topsoil) and G1T3 (25% peat soil + 75% topsoil). While the average increase in other combination treatments was relatively not much different. Based on the results of the normality and homogeneity tests, the average height increment data of balangeran seedlings spread normally and homogeneously. Furthermore, to determine whether the treatment of a combination of peat soil and topsoil substrates has an effect on the increase in the height of balangeran seedlings, analysis of variance was carried out as shown in Table 6.

Based on the results of the variance analysis (Table 6), it was known that the F-value was less than the value of F-table, which meant that the treatment of peat soil, topsoil, and their combination substrates did not significantly affect the increase in the height of balangeran seedlings. The results of the study were the same as the results of the study conducted by Yamani (2017) stated that the combination treatment of mineral soil (topsoil) and peat soil substrates only had an effect on the increase of stem diameter of gaharu or agarwood (*Aquilaria malaccensis*) - not in the increase in height of seedlings. However, it was different from what was done by Susilawati and Bastoni (2005), where the combination treatments of peat soil and topsoil substrates with a ratio of 70% topsoil and 30% peat soil were able to increase plant height and the number of leaves of jelutung (*Dyera costulate*) seedlings. This was not only caused by differences in plant species but also because of the physical and chemical properties of the soil substrates.

Actually, height growth of seedling is sensitive to shade. Basir (2007) has done research concerning the effect of shade treatment at different levels combined with fertilizing and liming on the height growth of jelutung seedlings. Basir (2007) concluded that the treatment of different levels of shade caused different height growth of jelutung seedlings at a nursery. The present research did not show different height growth because it only used the same level of shade.

Conclusions

The combination treatments of peat soil and topsoil showed a very significant effect on the increase in the stem diameter of the balangeran seedlings, but they did not show any significant effect on the high growth of balangeran seedlings. The treatments of 25% peat soil + 75% topsoil, and the treatments of 100% peat soil + 0% topsoil yielded the increase of stem

diameter of balangeran seedlings that were different very significantly from the results of treatments of 0% peat soil + 100% topsoil in the increase of stem diameter point of view, but their effect only significantly different from the effect of the treatments of peat soil 50% + topsoil 50% in the increase of stem diameter point of view. The highest increase of the seedling diameter of balangeran (1.704 cm) was reached using the combination treatment of 25% peat soil + 75% topsoil), followed by the treatment of 100% peat soil + 0% topsoil) with the increase of the diameter of 1.68 cm. Peat soil was a suitable substrate for growing balangeran seedlings in the nursery.

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