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Growth Responses of *Acacia mangium* and *Paraserianthes falcataria* Seedlings on Different Soil Origin under Nursery Condition

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Abstract – The objective of the present study was to examine the growth responses of *Acacia mangium* (mangium) and *Paraserianthes falcataria* (sengon) seedlings growing on different soil origin under nursery condition. This study was started in September 2012 and terminated in March 2013. The seedlings were grown from seeds sown in a plastic box filled with sterilized sands. One week after sowing, the seedlings were transplanted into polybags contained sterilized soils originated from secondary forest, *Imperata cylindrica* grassland and ex-coal mining. The number of all seedlings were 180 seedlings consisted of 3 different soils, 2 species of seedlings with 10 seedlings replicated 3 times. Assessment was conducted one week after transplanting, then subsequently monitored every 2 weeks, except dry weighing and counting nodules were performed at the end of the study. A completely randomized design was used in this study. The data was analyzed using Costat software. The study resulted that the different of soil origin influenced on all growth variables of mangium and sengon of 4.5 months old. The survival rate of seedlings, height and diameter increments, dry weight and root nodules were better in both species of seedlings growing on soil originated from secondary forest and *Imperata* grassland compared with the soil from ex-coal mining. But the survival rates of sengon seedlings were higher than that of mangium on these three soils. The highest dry weight of sengon seedlings was achieved on soil originated from secondary forest. In the present study, soil originated from secondary forest increased more in weight of shoot than root, so that the shoot-root ratio was unbalanced more than one. Based on the results of this study, it is recommended that soil from secondary forest and *Imperata* grassland can be used as growing media for mangium and sengon seedlings in the nursery.
Keywords: Mangium; Sengon; Secondary forest; Grassland; Ex-coal mining; Nursery

Introduction

Soil is a very important medium for the growth of vegetation. Soil provides nutrients necessary for growing process of plants and saves the water. Different soil types have different characteristics in terms of physical, chemical and biological. Soil properties determine the nutrients content and the volume of water that can be stored in the soil and root systems of vegetation that reflect the circulation of oxygen and water movement in the soil (Schwab *et al.*, 1993).

Planting of nodulated leguminous plant is expected to increase the speed of coverage of degraded area. *Imperata cylindrica* grassland is one of the largest marginal area in Indonesia. This grass is often growing on various soil fertility levels, from infertile to highly fertile soils, so this species is not classified as nutrient-demanding species (Kathleen *et al.*, 1999). Considering that the width of the critical land as well as the rate of the land degradation are highly increased, then the efforts to restore and to suppress the rate of the critical land have become an urgent requirement. Conservation efforts of soil and water physically, chemistry and biology have often been carried out (Nugroho, 2000; Otsamo, 2001; Nurtjahya *et al.*, 2008; Ilyas, 2012; Asir, 2013), but the results were not yet maximal. The main error prominent of these activities is less coherence of activities and sectors, and not focused the actual problem at its source (Nugroho, 2000). The low result of conservation effort reflects the low level of public awareness in order to overcome critical area, it is characterized by already ongoing recovery efforts, but the other side also takes place the conversion of land use patterns that do not conform with the principles of conservation on a large scale, so that from year to year the condition of critical land in Indonesia continues to grow (Asir, 2013). Another effort should be done such as the utilization of leguminous plants that are believed to be capable to improve soil condition.

Mangium (*Acacia mangium* Willd.) and sengon (*Paraserianthes falcataria* (L.) Nielsen) were chosen as experimental plants model. Both species are leguminous trees that capable form symbiosis with nitrogen-fixing bacteria (*Rhizobium*) and carry out the process of N_2 fixation from the air, so as to meet the needs of N through fixation biologically and reduce reliance on the use of artificial N fertilizer. In addition, mangium also adapted to nutrient-poor soils and is resistant to drought and the wood has a high economic value, the wood has a pretty good quality, especially as a pulp/paper and furniture (Purwaningsih, 2004), while sengon was very adaptable for marginal areas of PT Freeport Indonesia at Timika (Papua) (Ekyastuti, 1998). Sengon is one of the fastest growing multipurpose tree species, and coupled with other positive attributes, it is a suitable species for plantation program and agroforestry in the humid tropics. It has many uses and it is also commonly planted as an ornamental and shade tree. Other uses of the species include alley farming, intercropping in forest plantations and reforestation (CABI, 2014).

Mangium and sengon are usually planted in the project of timber estate as the replacement of natural forest that was cut down, whichever the land was still relatively fertile, whereas planting in the marginal land like the ex-coal mining, *Imperata* grassland and other degraded soil is still rare. Therefore must be carried out by the study about the influence of different soil origin i.e. from secondary forest soil, *Imperata* grassland and ex-coal mining land on the growth of mangium and sengon seedlings in the nursery as an reflection how their capacity of growth on the different soil condition. Hence, the objective of this study was to determine the growth responses of *Acacia mangium* (mangium) and *Paraserianthes falcataria* (sengon) seedlings on different soil origin under nursery nursery condition.

Materials and Methods

This study was carried out for 7 months, from September 2012 to March 2013 at Silviculture and Forest Protection Laboratories of the Faculty of Forestry, Mulawarman University, Samarinda (East Kalimantan). Soil properties analysis were carried out in the Soil Science Laboratory of Agriculture Faculty, Tadulako University, Palu (Central Sulawesi). The seeds of mangium and sengon were purchased from a shop Raja Benih Depok, Sleman, Yogyakarta; the soil of natural secondary forests was taken from the Botanical Garden of Mulawarman University Samarinda, soils of *Imperata* grassland and ex-coal mining were taken from Bengkuring village, Samarinda, East Kalimantan.

This study was designed in two different part of the experiment based on the plant species, mangium and sengon, with a completely randomized design with three treatments as follows: T1 = soil from secondary forest; T2 = soil from *Imperata cylindrica* grassland; T3 = soil from ex-coal mining.

The number of seedlings in each treatment were 30 seedlings with details of the total number of seedlings were 3 soil origin × 2 seedling species × 3 replicates × 10 seedlings = 180 seedlings. Top soil originated from different locations were cleaned from dirt, filled into a polybag measuring 15 × 9.5 cm which had been labeled of each treatment of totally 180 polybags (experimental units). River sands were prepared and sterilized by means of heat and roasted for 2 hours until completely dry. Sterilized sands weres used to sow seeds. Before sowing, seeds of sengon were soaked in cold water for one hour with the aim of selecting good and healthy seeds as well as useful to speed up seed germination. Mangium seeds were poured with boiling water and left to cool for 24 hours for rapid germination.

Untreated soil sample weighed 1 kg each from three locations were sent to Soil Laboratory of Agriculture Faculty, Tadulako University in Palu for chemical content analyzing. Mangium and sengon seeds were sown in plastic boxes containing sterilized river sand. Watering was done once a day in the morning. After the seeds germinate into a young seedlings about 1-week-old, then they were transplanted into a polybag by immersing seedlings in a watered bucket in order to avoid break off at the root when uprooted.

Soils in polybag were perforated in the middle with a piece of wood stick to enter the root of seedling. Each polybag contained one seedling. Seedlings that died just after transplanting were immediately replaced with a new ones. The seedlings laid down under a sheet of sarlon to avoid excess light. The seedlings were watered 2 times in the morning before 09.00 a.m and after 16.00 p.m as required to maintain moisture conducive to seedling growth. The collected data were as follows:

a. Seedling height: measurement started from the base of the stem which was marked by using a marker to the tip of shoot used a ruler. This measurements were done at 1 month after planting and subsequently measured every 2 weeks until seedlings 4.5-months-old, so there were 8 times measurements.

b. Stem diameter: measurements were done at the base of the stem where the measurement of height was done. This measurements were done using a caliper at 1 month after planting. Measurements were then performed every 2 weeks until seedlings 4.5-months-old, so there were 8 times measurements.
c. Number of root nodules: counting was done at 4.5-months-old seedlings. Ten samples of 30 seedlings for each soil origin were counted for their nodules after cleaned with tap water.
d. Seedlings dry weight was assessed at 4.5-months-old seedlings, a total of 10 seedlings as samples were taken from polybag by soaking the seedlings into water until all the soils removed from the root. Furthermore, they were then dried in an oven with a temperature of 50°C for 12 hours. Once dry, the seedlings were weighed following the envelope to determine the dry weight of all parts of the seedling. To determine the weight of the envelope, some empty envelopes were weighed first and then averaged.

The data were analyzed as follows: increment of seedlings height was calculated by subtracting the height at the end of study with the beginning where the seedlings were transplanted to the polybag. Increment of stem diameter was calculated by subtracting the diameter of the stem at the end of the study with the beginning where the seedlings were transplanted to the polybag. Number of root nodule was presented as quantitative data. Seedlings dry weight was obtained from seedlings weighing after drying at the end of the study and shoot-root ratio was calculated as weight of shoot divided by weight of root.

The data was analyzed using the Costat Software. A single factor analysis of variance (one way Anova) was used to test for significant differences in treatments in all observed variables. If the results of F-test showed significantly different or highly significantly different of the observed variables, then they were tested with Duncan's Multiple Range Test (DMRT).

Results and Discussion

Soil properties

Generally, the soil properties obtained from secondary forest was relatively better than from *Imperata* grassland and ex-coal mining (Table 1). Higher percentage of sand and lower clay than other soil possibly the secondary forest soil had more oxygen content and did not become solid. This condition is needed by the roots and microorganisms in rhizosphere, especially root nodule bacteria for respiration. Hence nutrients and other properties needed by plants such as C-organic, N, P, K, Ca, Mg, C/N ratio, cation-exchange capacity and hydrogen ion concentration (pH) were relatively higher in secondary forest soil compared to other soils origin.

Table 1. Soil properties used as growing media originated from different locations

No	Item	Unit	Soil originated from		
			Secondary forest	*Imperata* grassland	Ex-coal mining
1	Sand	%	15.93	0.69	9.20
2	Ash	%	66.38 (silt loam)	76.05	63.32
3	Clay	%	17.68	23.26	27.48
4	C-organic	%	2.30 (moderate)	1.21 (low)	1.15 (low)
5	N-total	%	0.26 (moderate)	0.15 (low)	0.14 (low)
6	C/N ratio		11.79 (moderate)	10,76 (low)	10.95 (low)
7	pH H_2O (1:2.5)		6.42 (rather acid)	5.41 (acid)	5.39 (acid)
8	pH KCl (1:2.5)		5.62	4.52	4,50
9	P_2O_5 (HCl 25%)	mg/100 g	14.52 (low)	12.15 (low)	11.53 (low)
10	P_2O_5 (Bray I)	ppm	23.53 (moderate)	25.05 (moderate)	23.66 (moderate)
11	K_2O (HCl 25%)	mg/100 g	15.29 (low)	12.94 (low)	11.76 (low)
12	Ca	me/100 g	7.20 (moderate)	3.56 (low)	3.54 (low)
13	Mg	me/100 g	0.42 (low)	0.34 (low)	0.33 (low)
14	Na	me/100 g	0.26 (low)	0.24 (low)	0.23 (low)
15	CEC	me/100 g	25.42 (high)	21.32 (moderate)	23.33 (moderate)
16	Base saturation	%	31.51 (low)	19.93 (very low)	18.00 (very low)
17	Al-dd	me/100 g	0.69	0.60	0.85
18	H-dd	me/100 g	0.55	0.45	0.60

Survival Rate of Mangium and Sengon Seedlings

The results showed that there was no mortality of mangium seedlings that grew on the soil originated from secondary forest and *Imperata* grassland, whereas those on soil from ex-coal mining, it was found that 3 seedlings (10%) of 3-months-old were died followed by 13 seedlings (43.3%) of 4-months-old and 7 seedlings (23.3%) of 4.5-months-old (Figure 1). Hence the total mortality of mangium seedlings was 23 seedlings (76.6%). This is meant that soil from ex-coal mining was not good for media of seedling of mangium in the nursery, where the adaptability of this seedling in ex-coal mining was low. The mortality of this seedlings because of aluminium (Al) content in ex-coal mining soil was higher than both other ones (secondary forest 0.69 me/100 g, *Imperata* grassland 0.60 me/100 g and ex-coal mining 0.85 me/100 g), whereas the high Al content was followed by high clay content (27.0%).

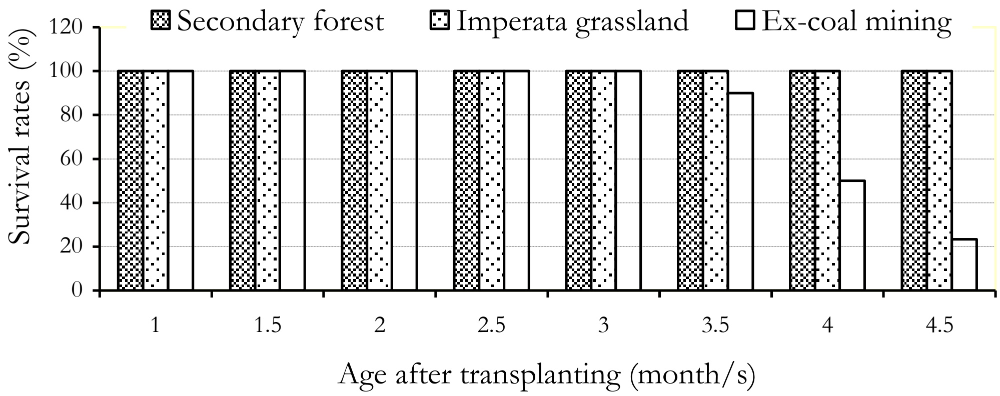

Figure 1. The survival rates of mangium seedlings on different soil origin.
(Average of 30 seedlings of each treatment)

The high contents of Al can also toxic to root causes water and nutrient absorption not maximum and may be cease completely. Aluminium toxicity is one of the major factors that limit plant growth and development in many acid soils; root cells plasma membrane, particularly of the root apex, seems to be a major target of Al toxicity (Mossor-Pietraszewska, 2001). When the disease on plant is caused by physical or chemical environment, then usually the disease become heavier in line with time goes on; the rate of disease development vary according to plant species and pathogen; at a certain physical or chemical condition, a species of plant that at first does not show symptom of disease, at the following ages can be more worst (Hadi, 1986). In the present study, mangium seedlings at 3.5-months-old began to suffer and some were died on the soil originated from ex-coal mining, then the mortality increased until reached 76.7% in line with increasing of age for 4.5 months. It was expected that the mortality would increase when the time of this study longer. The results showed that the survival rates of sengon seedlings on the soil originated from secondary forest, *Imperata* grassland and ex-coal mining at the end of study was 100% (Figure 2).

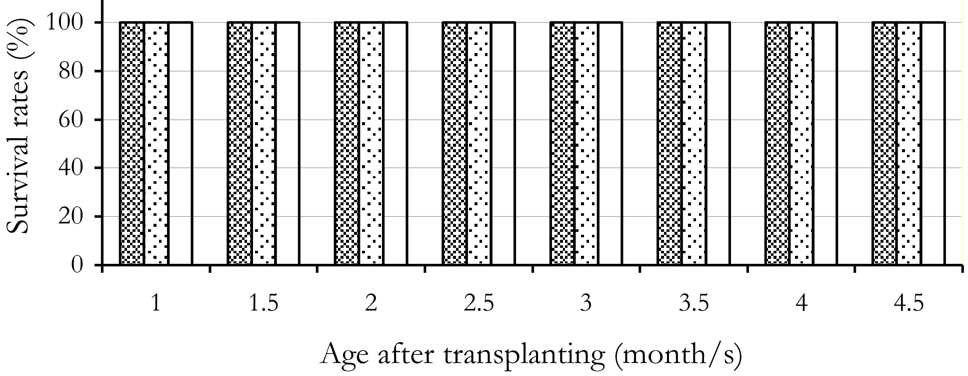

Figure 2. The survival rates of sengon seedlings on different soil origin.
(Average of 30 seedlings of each treatment)

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Sengon seedlings were highly adaptable on the three soils origin. Similar results were earlier obtained by Ekyastuti (1998) who reported that generally the sengon seedlings was more adaptive on sandy soil of ex-gold mining (tailing) at PT Freeport (Papua) compared with mangium seedlings which proved from measurement of all variables (height, diameter, biomass, shoot-root ratio, number and weight of nodules and root infected by mycorrhizal fungus) on sengon seedlings were more than mangium.

For better growth result, it is suggested that soil from secondary forest and *Imperata* grassland can be used for growing media of mangium seedlings. For sengon seedlings it can be used soils from secondary forest, *Imperata* grassland and ex-coal mining.

Height and Stem Diameter of Mangium and Sengon Seedlings

The average height growth of mangium seedlings at the age of 1-month-old after transplanting was 4.5 cm. Then the growth on the soil originated from secondary forest and *Imperata* grassland continued consistently until the end of this study with the height more or less the same, while the growth of seedlings on the soil from ex-coal mining although consistently increased, but the height was lower than on the first both soil origin (Figure 3). Similar result was shown by average diameter growth of mangium seedlings that at the age of 1 month after transplanting was 0.1 cm. The growth of diameter was continuously increased with the diameter of more or less the same on the soil from secondary forest and *Imperata* grassland, while the growth of sengon seedlings in ex-coal mining soil was lower than on the first both soil origin (Figure 4).

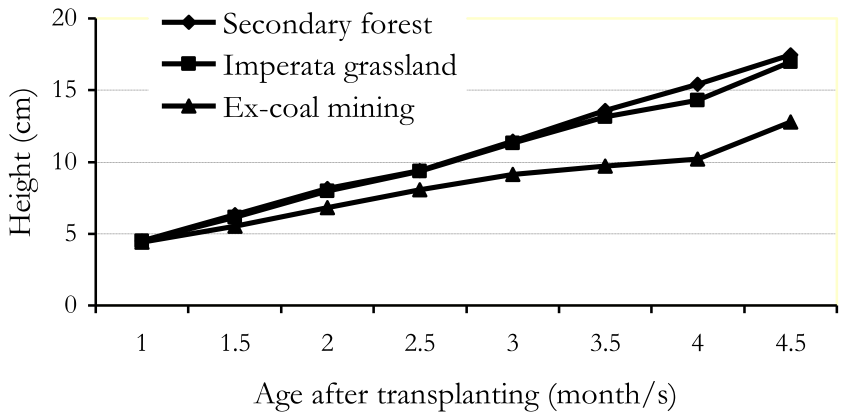

Figure 3. The height of mangium seedlings on different soil origin.
(Average of 30 seedlings of each treatment)

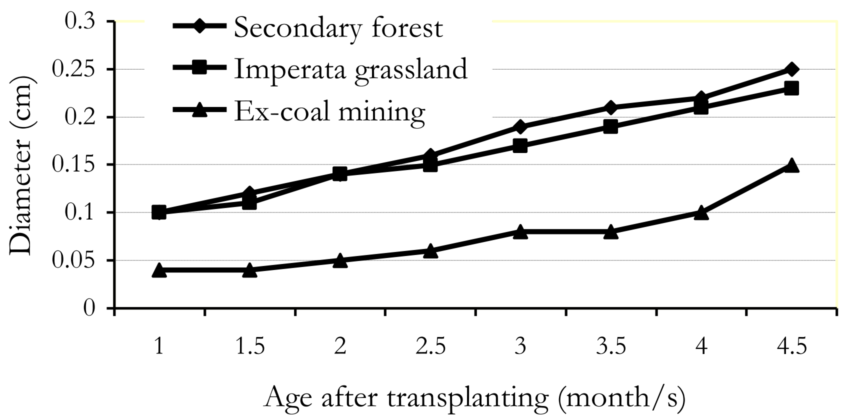

Figure 4. The stem diameter growth of mangium seedlings on different soil origin.
(Average of 30 seedlings of each treatment)

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With the characteristics of such height and diameter, it shows that soil from secondary forest and *Imperata* grassland influenced same good against the growth of mangium seedlings and it means that both soil origin can be used as growing media for this species in the nursery, while the ex-coal mining soil was less good. The growth requirement of mangium was relatively easier, it was able to grow in log-over forest, shifting cultivation, degraded land and in *Imperata* grassland (Retnowati, 1988). The growth of mangium seedlings in ex-coal mining soil became good and significantly difference after adding liquid waste of paper industry (sludge) compared with adding top soil and without treatment (control), where adding sludge in soil could decrease sulphate concentration which act as main polutant in ex-coal mining soil; in addition, this treatment could also decrease micro elements such as Fe, Mn, Zn and Cu which when at a high concentration could toxic to plant (Sormin, 2008).

The average of height growth of sengon seedlings at 1-month-old after transplanting was 6.6 cm. Then the height growth of seedlings on the soil originated from secondary forest and *Imperata* grassland increased consistenly till 4.5-months-old with the same height, while the height of seedlings growing on the soil originated from ex-coal mining eventhough increased consistenly, but the height was lower than on the first both seedlings (Figure 5). A similar result was also shown by stem diameter growth of sengon seedlings, where the average of diameter growth till 4.5-months-old on soil originated from secondary forest and *Imperata* grassland increased consistenly with the same diameter, while the stem diameter of seedlings growing on soil originated from ex-coal mining eventhough increased consistenly, but the diameter was lower than on the first both seedlings (Figure 6).

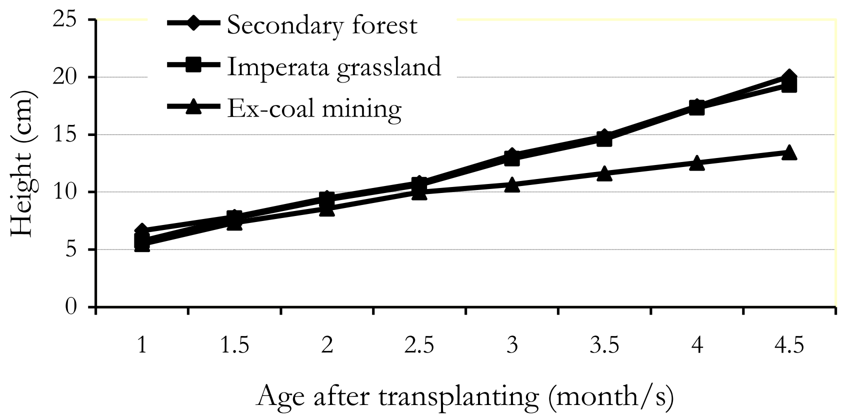

Figure 5. The height of sengon seedlings on different soil origin.
(Average of 30 seedlings of each treatment)

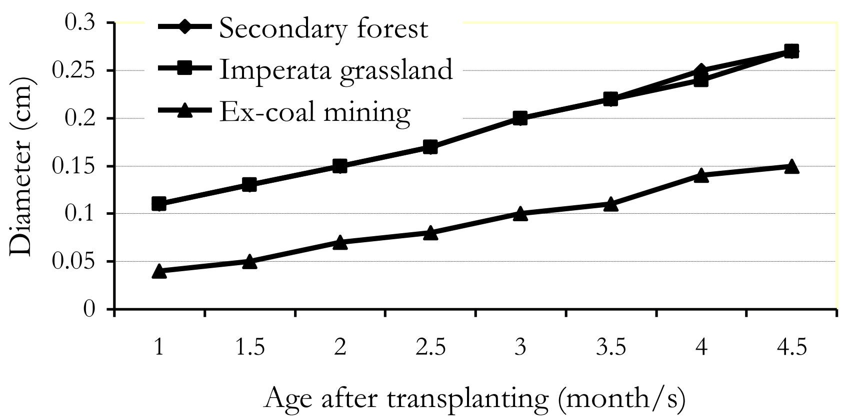

Figure 6. The stem diameter of sengon seedlings on different soil origin.
(Average of 30 seedlings of each treatment)

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With the pattern of such height and diameter growth, it indicated that the soil from secondary forest and *Imperata* grassland had the same good effect against the growth of sengon seedlings, and it is meant that both soil origin can be used as growing media of sengon seedlings in polybag in the nursery, while the soil from ex-coal mining is not recommended. The adaptability of sengon seedlings is higher than mangium, where at PT Freeport Papua, sengon seedlings grew better than mangium in sandy sand ex-gold mining (Ekyastuti, 1998). Similar result was also reported by Setyaningsih *et al.* (2012), where the ability of sengon seedlings to survive in the media contained lead (Pb) of 0.5, 1 and 1.5 mM correlated with cellular metabolic mechanisms, included the production of organic acids secreted by roots or accumulated in the tissues; sengon seedlings secreted or accumulated three kinds of organic acids, oxalic, malic and citric, but the amount of citric acid has the potential to behave in a dominant sensitive to physiological disturbances in sengon, including stress due to heavy metals.

Increments of the Height and Stem Diameter Mangium and Sengon Seedlings

The highest of the height increment of mangium seedlings on soils from secondary forest (12.91 cm), followed by *Imperata* grassland (12.50 cm) and the lowest was the height increment of seedlings on soil from ex-coal mining (1.99 cm). Furthermore, the height increment of sengon seedlings on soils originated from secondary forest was the largest (14.08 cm), followed by *Imperata* grassland (13.55 cm) and the lowest was in the ex-coal mining land (7.98 cm) (Table 2).

Table 2. Average of height and stem diameter increments of mangium and sengon seedlings on different soils origin at 4.5-months old (Average of 30 seedlings of each treatment)

Species	Soil origin	Height increment (cm)	Diameter increment (cm)
Mangium	Secondary forest	12.91[a]	0.14[a]
	Imperata grassland	12.50[a]	0.13[a]
	Ex-coal mining	1.99[b]	0.03[b]
		LSR 95% = 1.28	LSR 95% = 0.016
Sengon	Secondary forest	14.08[a]	0.17[a]
	Imperata grassland	13.55[a]	0.16[a]
	Ex-coal mining	7.98[b]	0.11[b]
		LSR 95% = 1.42	LSR 95% = 0.02

Different letters in the same column for each species of seedling indicate statistical differences between treatments at the 95% confidence level. LSR = least significant range.

There were significant differences in the height increment of mangium and sengon seedlings grew in three soil origins (Table 2). The highest increment of mangium and sengon seedlings height were achieved in the soil originated from secondary forest and followed by soil from *Imperata* grassland, while the lowest height indrement was found in the soil originated from ex-coal mining. Statistical analysis showed that the height increment of mangium and sengon seedlings grew in soil originated from secondary forest did not differ significantly from the soil originated from *Imperata* grassland, but there was significant differences between both soils origin with the soil from ex-coal mining.

The stem diameter increment of mangium seedlings on soil originated from secondary forest was the highest (0.14 cm), followed by *Imperata* grassland (0.13 cm) and the lowest was on soil from ex-coal mining (0.03 cm). The same pattern was also shown by sengon seedlings, that the stem diameter increment of sengon seedlings on soil originated from secondary forest was the highest (0.17 cm), followed by *Imperata* grassland (0.16 cm) and the lowest was on soil from ex-coal mining (0.11 cm). From the Anova test resulted, that the difference of soil origin caused highly significant difference on the diameter increment of mangium and sengon seedlings. From the results of DMRT showed that the stem diameter increment of mangium and sengon seedlings on soil originated from secondary forest did not differ significantly from that from *Imperata* grassland, which meant that the soil from secondary forest and *Imperata* grassland had the same good influence on the diameter increment compared with the soil from ex-coal mining. Soil bulk density affected the height and diameter growth of mangium seedlings for 6 months in greenhouse, where the height and diameter growth increased significantly with decreasing soil bulk density (Jusoff, 1991). The fact in this study that the results of the examination by pressing fingers, soil from ex-coal mining was denser and harder than the two other soils. The results of soil analysis showed that the soil from ex-coal mining contained the highest clay (27.48%) compared with the soil from the secondary forest (17.68%) and *Imperata* grassland (23.26%).

The dense and hard soil are difficult to penetrate by seedlings root, so the root growth is disturbed and cause low absorption of water and nutrients from the soil. In addition, the dense and hard soil have a few cavities, making it difficult to absorb oxygen as well as water needed by root soil properties (Table 1) that the macro elements needed by seedlings such as elements of C-organic, N, P, K, Ca and Mg were higher in secondary forest soil than the others, especially soil from ex-coal mining. Other effects of nutrient deficiency are when K deficiency in soil, it will cause yellowish leaves, there are spots of dead tissue in the middle or along the edges of leaves, height and stem diameter growth and photosynthesis be hampered and the stem become weak. In addition, K is also needed in the preparation of proteins and plays an important role in metabolic processes; this element in plants is found in the form of inorganic salts and found in many parts of the plants that are undergoing the process of growing, such as the tip of stems and roots; lack of Ca causes damage to the tip of roots, tip of plant and branches as well as an abnormal form of young leaves; lack of Ca in the soil also causes excessive absorption of Mg by roots, thus causing toxicity in plants; Ca is also useful for strengthening cell walls, especially in the middle lamella, increasing division of meristem cells, helping nitrate-absorption process and enable a variety of enzymes (Dwidjoseputro, 1986).

The Number of Root Nodules on Mangium and Sengon Seedlings

The number of root nodules of mangium seedlings in the soil originated from secondary forest was the most (12.5), followed by root nodules in the soil from *Imperata* grassland land (10.7) and the least was in the soil from ex-coal mining (2.5). The number of root nodules on sengon seedlings in the soil originated from secondary forest was the most (10.4), followed by root nodules in the soil from *Imperata* grassland (8.7) and the least was in the soil from ex-coal mining (2.5) (Table 3).

Table 3. Number of root nodules of mangium and sengon seedlings on different soils origin after 4.5 months after transplanting

Species	Sample number	Secondary forest	*Imperata* grassland	Ex-coal mining
Mangium	1	10	3	3
	2	13	17	4
	3	16	5	6
	4	9	9	0
	5	7	8	3
	6	15	8	5
	7	18	11	0
	8	8	13	0
	9	12	18	2
	10	17	15	2
	Average	12.5[a]	10.7[a]	2.5[b]
Sengon	1	12	9	2
	2	9	5	3
	3	8	9	2
	4	10	7	2
	5	15	5	3
	6	14	12	4
	7	9	16	2
	8	13	7	3
	9	8	9	2
	10	6	8	2
	Average	10.4[a]	8.7[a]	2.5[b]

Different letters in the same row for each species of seedling indicate statistical differences between treatments at the 95% confidence level. LSR 95% of each species = 2.4.

The results of F-test in Anova indicated that different soil origin caused a very significant difference in the number of root nodules. From DMRT resulted that the number of root nodules on mangium and sengon seedlings in soils originated from secondary forest and *Imperata* grassland were not significantly different but significantly different from ex-coal mining. This indicated that the soils from secondary forest and *Imperata* grassland were better than that from ex-coal mining for the formation of root nodules. There are many factors which affect formation and longevity of nodules in roots of leguminous plants; (i) concentration of inorganic nutrients, (ii) soil temperature (optimum temperature between 25 and 30°C favors nodulation; it is inhibited at cooler and warmer extremes), (iii) light and shading (high light increases nodule numbers, whereas shading depresses nodule weight), (iv) CO_2 concentration (high CO_2 concentration increases nodule numbers), (v) addition of nitrogen (on addition of nitrogen both numbers and weight of nodules are reduced), and (vi) rhizosphere microorganisms (Biocyclopedia, 2012). Among those six factors, which appear different among the three origin of soils had been analyzed in this study was the concentration of inorganic nutrients. From the soil there was a difference between the soil from secondary forest, *Imperata* grassland and ex-coal mining, which is the soil from ex-coal mining contained the lowest N, P_2O_5, K_2O, Ca and Mg (Table 1), so that the root development and the formation of root nodules were retarded.

Effect of Different of Soil Origin on the Dry Weight and Shoot-Root Ratio of Mangium and Sengon Seedlings

The average of dry weight of mangium seedlings growing on soils originated from secondary forest was higher than that from *Imperata* grassland, namely 0.86 g and 0.73 g, respectively, whereas the dry weight of seedlings on soils originated from ex-coal mining was the lowest, namely 0.36 g (Tables 4 and 5). The results of F-test in anova indicated that different soil origin caused a highly significant difference in the dry weight of mangium seedlings. From DMRT resulted that the dry weight of mangium seedlings on soils originated from secondary forest and *Imperata* grassland were not significantly different but significantly different with that from ex-coal mining. This indicated that the soils from secondary forest and *Imperata* grassland were same good influence for dry weight of sengon seedlings compared with that from ex-coal mining. The results of soil analysis in this study showed that there was little difference of soil fertility between secondary forest and *Imperata* grassland, where the soil from secondary forest contained slightly higher of elements required by plant compared with *Imperata* grassland and these differences had not made dry weight of mangium seedlings on both soil origin differed significantly. But the content of elements in the soil of ex-coal mining was lower than the first both soils, this condition caused significant differences in dry weight of the seedlings.

Table 4. Dry weight (g) and shoot-root ratio (S : R) of mangium seedlings on soil from different origin at 4.5 months after transplanting

Sample	Secondary forest				*Imperata* grassland				Ex-coal mining			
number	Shoot	Root	Total	S : R	Shoot	Root	Total	S : R	Shoot	Root	Total	S : R
1	0.5	0.3	0.8	1.67	0.4	0.3	0.7	1.33	0.2	0.3	0.5	0.67
2	0.6	0.2	0.8	3.00	0.4	0.2	0.6	2.00	0.2	0.1	0.3	2.00
3	0.3	0.2	0.5	1.50	0.6	0.2	0.8	3.00	0.1	0.3	0.4	0.33
4	0.7	0.3	1.0	2.33	0.4	0.3	0.7	1.33	0.1	0.1	0.2	1.00
5	0.6	0.4	1.0	1.50	0.7	0.6	1.3	1.17	0.2	0.3	0.5	0.67
6	0.5	0.3	0.8	1.67	0.4	0.2	0.6	2.00	0.2	0.3	0.5	0.67
7	0.8	0.3	1.1	2.67	0.4	0.2	0.6	2.00	0.1	0.1	0.2	1.00
8	0.6	0.3	0.9	2.00	0.3	0.1	0.4	3.00	0.1	0.1	0.2	1.00
9	0.5	0.2	0.7	2.50	0.4	0.3	0.7	1.33	0.1	0.3	0.4	0.33
10	0.6	0.4	1.0	1.50	0.6	0.3	0.9	2.00	0.3	0.1	0.4	3.00
Total	5.7	2.9	8.6	20.34	4.6	2.7	7.3	19.16	1.6	2.0	3.6	10.67
Average			*0.86*[a]	2.03[a]			*0.73*[a]	1.92[a]			*0.36*[b]	1.07[b]

The average figures (italic or regular) followed by different letters in the same variable indicate statistical differences between treatment at the 95% confidence level. LSR 95% of average dry weight = 0.16. LSR 95% of shoot-root ratio = 0.63.

Table 5. Dry weight (gram) and shoot-root ratio (S : R) of sengon seedlings on soil from different origin at 4.5 months after transplanting

Sample number	Secondary forest				*Imperata* grassland				Ex-coal mining			
	Shoot	Root	Total	S : R	Shoot	Root	Total	S : R	Shoot	Root	Total	S : R
1	1.3	0.5	1.8	2.60	0.6	0.6	1.2	1.00	0.6	0.5	1.1	1.20
2	0.8	0.3	1.1	2.67	0.6	0.4	1.0	1.50	0.3	0.1	0.4	3.00
3	0.4	0.5	0.9	0.80	0.5	0.4	0.9	0.25	0.2	0.1	0.3	2.00
4	0.9	0.4	1.3	2.25	0.4	0.6	1.0	0.67	0.3	0.2	0.5	1.50
5	1.0	0.6	1.6	1.67	0.7	0.6	1.3	1.17	0.3	0.2	0.5	1.50
6	0.5	0.3	0.8	1.67	0.8	0.5	1.3	1.60	0.2	0.1	0.3	2.00
7	1.1	0.5	1.6	2.20	0.5	0.4	0.9	1.25	0.3	0.1	0.4	3.00
8	0.8	0.5	1.3	1.60	0.8	0.6	1.4	1.33	0.3	0.1	0.4	3.00
9	1.2	0.6	1.8	2.00	0.5	0.4	0.9	1.25	0.2	0.1	0.3	2.00
10	0.7	0.5	1.2	1.40	0.6	0.3	0.9	2.00	0.2	0.1	0.3	2.00
Total	8.7	4.7	13.4	18.86	6.0	4.8	10.8	12.02	2.9	1.6	4.5	21.20
Average			*1.34*[a]	1.89[a]			*1.08*[b]	1.20[b]			*0.45*[c]	2.12[a]

The average figures (italic or regular) followed by different letters in the same variable indicate statistical differences between treatment at the 95% confidence level. LSR 95% of average dry weight = 0.25. LSR 95% of shoot-root ratio = 0.53.

Similar result occurred also on sengon seedlings, where the average seedlings dry weight of sengon on soils originated from secondary forest was the highest, followed by that from *Imperata* grassland and ex-coal mining, namely 1.34 g, 1.08 g and 0.45 g, respectively. The results of F-test in anova indicated that different soil origin caused a highly significant difference in the dry weight of sengon seedlings. But from DMRT resulted that the dry weight of sengon seedlings on soils originated from secondary forest, *Imperata* grassland and from ex-coal mining were significantly different. This meant that the soil from secondary forest was the best for stimulating dry weight of sengon seedlings compared with that from *Imperata* grassland and ex-coal mining. The difference of soil fertility caused the growth of sengon seedlings differed significantly, where on soils originated from secondary forest were faster than that from two others soil origin.

The average dry weight of shoot of mangium seedlings on the soil originated from ex-coal mining was lower than that of root. It is concluded that ex-coal mining is not suitable for growing medium of mangium seedlings. Soil from ex-coal mining had a pH lower than that from secondary forest and *Imperata* grassland. The lower the pH, the more the bad condition of the plant. It has been determined that most plant nutrients are optimally available to plants within 6.5 to 7.5 pH range (Jensen, 2014; Thapa, 2015). Aluminium is known to exert its primary toxic effect on roots, initial effects including a reduction in root length and damage to cortical cells of the root epidermis near the root tip. Proliferation of root hairs, important for uptake of water, essential nutrients and for infection by N-fixing rhizobia in legumes, is severely reduced by Al at concentrations lower than those that reduce root growth (Atwell *et al.*, 1999).

The average of shoot-root ratio of mangium and sengon seedlings on the soil originated from secondary forest, *Imperata* grassland and ex-coal mining were higher than 1. This indicated that the growth of shoot was faster than root. The results of F-test in anova indicated that different soil origin caused a highly significant difference in the shoot-root ratio of both species of seedlings. From DMRT resulted that the shoot-root ratio of mangium seedlings on soils originated from secondary forest and *Imperata* grassland were not significantly different but significantly different with that from ex-coal mining. Shoot-root ratio of mangium seedlings growing on soils originated from ex-coal mining approached 1.0. However, as they grew in poor soil, then they were in the worst conditions, the development of shoots and roots were not so good.

The different shoot-root ratio occurred on sengon seedlings, where the seedlings on soil originated from secondary forest and ex-coal mining were not significantly different, but they were also more than 1.0. The best shoot-root ratio is when there is a balance of dry weight between shoot and root, then the ratio is 1.0. According to Kennedy (1988), for good survival and early growth, the root system of seedlings should be in balance with the top, otherwise the seedlings will not grow much until the root system becomes established; about a 1:1 shoot-root ratio is generally accepted as standard. In the present study, soil fertility increased more in weight of shoot than root. Nitrogen content (N-total) and cation-exchange capacity might be the soil content that affected to shoot growth, where the N-total and cation-exchange capacity in soil from secondary forest was in the level of moderate (Table 1). Nitrogen is the nutrient that universally deficient, the most visible response is increased shoot growth; for young trees to grow rapidly, they must have increasing amounts of nutrients available, among others is the soil having a high cation-exchange capacity (Harris, 1992).

Conclusions

The different of soil origin influenced on all growth variables of mangium and sengon seedlings of 4.5-months-old, they were rate of survival of seedlings, seedlings growth, height increment, stem diameter increment, dry weight, nodulation and shoot-root ratio, where the soil originated from secondary forest and *Imperata* grassland had the same good influence, while the soil from ex-coal mining was not so good influence for all growth variables of mangium seedlings. But the soil originated from secondary forest had made the highest dry weight of sengon seedlings followed by that from *Imperata* grassland and the lowest was from ex-coal mining. Soil fertility increased more in weight of shoot than root, then the shoot-root ratio was more than one. Based on the higher rate of survival of sengon seedlings, then it is concluded that sengon seedlings were more adaptive than mangium on those three soil origin.

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