NUSANTARA BIOSCIENCE
Vol. 8, No. 1, pp. 39-44
May 2016

ISSN: 2087-3948
E-ISSN: 2087-3956
DOI: 10.13057/nusbiosci/n080108

The effect of biochar, cocopeat and saw dust compost on the growth of two dipterocarps seedlings

MARJENAH♥, KISWANTO, SRI PURWANTI, FENNY PUTRI MARIANI SOFYAN
Silviculture Laboratory, Faculty of Forestry, University of Mulawarman. Kampus Gunung Kelua Jl. Ki Hajar Dewantara P.O. Box 1013 Samarinda-75116, East Kalimantan, Indonesia. Tel.: +62-541-735 089, 749 068; Fax.: +62-541-735 379; ♥email: marjenah_umar@yahoo.com

Manuscript received: 24 December 2015. Revision accepted: 24 March 2016.

Abstract. *Marjenah, Kiswanto, Purwanti S, Sofyan FPM. 2016. The effect of biochar, cocopeat and saw dust compost on the growth of two dipterocarps seedlings. Nusantara Bioscience 8: 39-44.* Good growing media contains enough nutrients, light textured, and have the capacity to hold water to create conditions that can support plant growth. The growing media used for propagation has several requirements, that is firm and dense to enhance the growth of stems, has the capability to hold water, guarantee the plant life, and moderate humidity. This study attempts to evaluate the effect of biochar, cocopeat, and saw dust compost on the growth of *Dryobalanops aromatica* and *Shorea balangeran* seedlings. An experiment was conducted by using completely randomized block design (CRBD) in factorial with two factors, namely growing media (top soil 100%; top soil 80% + saw dust compost 20%; top soil 80% + biochar 20%, top soil 80% + 20% coco peat) and two species of dipterocarps seedlings (*D. aromatica* and *S. balangeran*). The experiment was carried out in a Forestry Faculty nursery during 3 months. To determine the best growth media, the vegetative parameters of seedlings were measured and the data were statistically analyzed. Survival rates of both of seedlings showed good specification in all types of growing media. The survival rates of *D. aromatica* for 100% top soil (control); 80% top soil+ 20% sawdust compost; 80% topsoil + 20% biochar; 80% top soil + 20% cocopeat are 100%; 100%; 97.78% and 97.78%; respectively. *S. balangeran* are 93.33%; 100%; 100%; 97.78%. Quality Index of *D. aromatica* 100% top soil (control); 80% top soil+ 20% sawdust compost; 80% topsoil + 20% biochar; 80% top soil + 20% cocopeat that are 0.15; 0.14; 0.10; and 0.10; and for *S. balangeran* 0.09; 0.38; 0.05 and 0.07 respectively.

Key words: growing media, biochar, coco peat, saw dust compost, growth response

INTRODUCTION

Growing media is a substance or combination of materials used to grow the plants either originating from generative and vegetative propagation. It provides a place for anchoring the plant roots, provides air space which enables the respiration, maintains the water available is sufficient to allow the growth of plants. Growing media which has been commonly used in nursery is top soil. The use of top soil as growing media in the nursery will gradually cause the loss of the main layers of the forest soil. Take out top soil will damage the layer of the forest soil. To avoid that, it is necessary to look for materials to substitute top soil to decrease the usage of top soil.

Biochar is form of charcoal made from the heating of natural organic materials (crop and other waste, wood chips, rice husk, manure, etc.) in a high temperature, in the absence of oxygen or with limited air (low oxygen) process known as pyrolysis. Biochar particles have large surface areas that can absorb nutrients and promote the growth of bacteria or fungi which result in vastly improved plant growth.

The use of biochar (rice husk) as the media mix for forest plant nurseries has been investigated by several researchers, including Mori and Marjenah (1994) and Marjenah (1998). The results showed that the best dosages for the growth of some dipterocarps are 20% biochar (rice husk) and 80% top soil. Biochar (from rice husk) is not only a trigger of mycorrhizal inoculation, but also as a material that improves the physical properties of the soil by increasing the air permeability and water percolation. Biochar have content phosphorus which have an advantageous effect on the growth of plants. It is suspected that there is a close relationship between mycorrhizal fungi and soil bacteria that affect plant growth Dipterocarpaceae (Mori and Marjenah 1993).

Since the last few years, cocopeat has been considered as a substitute for the use of renewable sphagnum peat in horticulture. Cocopeat has good physical properties, many pore space, high water content, low shrinkage, low bulk density and slow biodegradation. Cocopeat find, use in germination of seeds, nursery raising, cutting rooting and other vegetative plant propagation methods, hydroponic systems of plant cultivation, cultivation of glass house plants, soil conditioning, etc. (Basirat 2011).

Composting is the biological decomposition of organic components of the organic waste material under controlled conditions and converted into a product to be use as a soil conditioner and organic fertilizer. During this process, carbon from organic molecules will be converted into carbon dioxide, which results in the bulkiness reduction of the organic forms, which can be absorbed directly by plants. Composting rate depends on a great extent of C/N ratio, lignin and polyphenol contents, the presence or absence of suitable microbial agents of decomposition etc. (Wilson 1989; Prabhu and Thomas 2002).

Sawdust was used as the bulking agent to provide additional carbon and to increase the porosity of the substrate. Sawdust compost is rich of plant nutrients, it can supply various nutrient needs of plants, depending on the amount used and where the plants grow, on the ground or in containers. The use of those materials provides environmental benefits as ecosystem damage caused by soil or peat extraction can be avoided and the impact of residue accumulation is minimized and economically beneficial because of use the residues it means lower cost than those of conventional material (Apaolaza et al. 2005).

Refers to the above description, it is necessary to look for a combination of other substrates that can be used for plant nurseries. The materials are relatively innocuous, inexpensive, and readily available. In this study, the material used as a growing media is a combination of rice husk charcoal (biochar), composted sawdust and cocopeat. Doses used refers to the doses used for husk charcoal (biochar) is 20%. This study aim to evaluate the survival rate and 6 months old seedling growth of *Dryobalanops aromatica* and *Shorea balangeran* in variation of growing media between top soil and rice husk charcoal (biochar), top soil and sawdust compost, top soil and cocopeat.

MATERIALS AND METHODS

The study was carried out in nursery area belongs to Faculty of Forestry University of Mulawarman at Gunung Kelua, Samarinda, East Kalimantan, Indonesia. The time required for this study ± 6 months, including seedbed preparation activities, preparation of plant material, transplanting seedling from small polybag with old growing media to bigger polybag with combination growing media, new arrangement of plants, numbering plants, observations of grow seedlings (for 3 months), laboratory analysis, data processing, and writing paper.

The materials used in this study was the topsoil, sawdust compost, rice husk, coco peat, consumable materials such as labels for marking the nursery, polybag size of 20 cm x 15 cm. The tools used in this study were a micro caliper to measure the diameter of seedlings, wooden ruler to measure the height of seedlings, camera and stationery; and tools related to the activities in the nursery. The object of this research was *Dryobalanops aromatica* and *Shorea balangeran*, 6 months old seedling.

This study was prepared in Factorial Experimental Design following the randomized block design (Randomized Completely Block Design). Consists of two factors, namely A Factor (growing media with combination of different compositions substrate which consists of four levels, A0 = 100% top soil (control); A1 = 80% top soil + 20% sawdust compost; A2 = 80% topsoil + 20% biochar; A3 = 80% top soil + 20% cocopeat. B Factor (plant species) using two species of plants, namely: B1 = *Dryobalanops aromatica*; and B2 = *Shorea balangeran*.

Growing media (A factor), which composed of four compositions was combined with B factors, so that there were 8 combinations of treatments. Every combination of treatment was 3 replications, so there were 24 treatment units. Each treatment unit of 15 seedlings planted, so the total number of seedlings was 360 seedlings. The main parameters observed in this study were the survival of seedlings (%), height (cm), diameter (mm), and the Seedling Quality Index.

Calculation of survival rates were performed at the end of the study using a simple formula, as follows:

$$\text{Survival rate} = \frac{\text{Number of seedling live}}{\text{Number of seedling planted}} \times 100\ \%$$

The Dickson quality index - DQI (DICKSON et al. 1960 in Binotto, et al. 2010) was a tool to evaluate seedling quality as a function of total dry matter (TDM), shoot height (SH), stem base diameter (SBD), shoot dry matter (SDM)-sum of stem base dry matter and leaf dry matter-and root dry matter (RDM), and is given by the expression:

$$DQI = \frac{TDM\ (g)}{\frac{SH\ (cm)}{SBD\ (mm)} + \frac{SDM\ (g)}{RDM\ (g)}}$$

Seedling Quality was the ratio between the total dry weight with the robustness of the seedling and the root shoot ratio. Seedling Quality can be used as a parameter because it can describe the morphological and physiological properties of seedling.

The statistical significance of the results obtained was assessed by ANOVA (F test and Duncan's Multiple Range Test) with a probability level of 95%.

RESULTS AND DISCUSSION

Plant growth and development is the result of an interaction between genetic factors, internal factors which integrates a variety of cells, tissues and organs into one unified structural and functional, as well environmental factors. The factors that determine the success of growing the plants are soil conditions. As improved soil fertility, the growth of plants will increase.

Plant quality is one aspect that was increasingly recognized as contributing factor to better growth. For the successful seedling establishment in the field, it was necessary to understand how nursery practices affect seedling quality, which in turn was influenced by a complex system of plant morphological and physiological conditions and which was studied through quality attributes.

The survival rates

In order to achieve the first objective, several growing media with different combination were tested. The survival rates were interpreted as an indicator of the success of planting. The determination of successful planting was seen based on survival rates of plants refers to the guidelines issued by the success of planting Reforestation according to the Directorate of the Directorate General of Reforestation

Table 1. Survival rate of *D. aromatica* and *S. balangeran* seedlings on variation of growing media

Variation of growing media	Number of seedling	Number of life seedlings	Survival rate (%)
S. aromatica			
100% top soil (control)	45	45	100
80% top soil + 20% sawdust compost	45	45	100
80% top soil + 20% *biochar*	45	44	97.78
80% top soil + 20% *coco peat*	45	44	97.78
S. balangeran			
100% top soil (control)	45	42	93.33
80% top soil + 20% compost	45	45	100
80% top soil + 20% *biochar*	45	45	100
80% top soil + 20% *coco peat*	45	44	97.78

and Land Rehabilitation, Ministry of Forestry for 1 year seedling which categorized as follows: (i) successfully (> 65%); (ii) moderately successful (55-64%); and (iii) failure (<54%) (Nirawati et al. 2013).

The calculation results of the seedling survival rates of *D. aromatica* and *S. balangeran* planted in growing media with different combination shown in Table 1. Both types of plants grow in all growing media showed a healthy performance throughout the study.

Survival rates of both types of plants indicate that very good criteria, because it has a survival rate of > 65% (Nirawati et al. 2013). These results indicate that all of the growing media combination that used in this study can be categorized as a good growing media for seedlings preparation of *D. aromatica* and *S. balangeran.* For seedling can survive, the root system must be viable and able to grow faster to maintain the contact with the soil moisture supply. Survival and growth are usually increased because of intensive contact between the roots with soil, and the nutrients and water holding capacity of the container media.

The result showed that the variation of growing media with the highest survival rate was a combination of 80% top soil and 20% biochar; and 80% top soil and 20% sawdust compost that was 100%. Biochar increases the ability of soil to hold the water, having its greatest effect in soil with poor water holding ability such as sandy soils. Biochar improves the nutrients soil availability, increases the amount of nutrients that can be absorbed by plants from the soil. Biochar reduces acidity of soil, which improves the ability of plants to absorb most nutrients. Furthermore, by improving water retention, biochar could provide an opportunity for nutrient ions to move from mineral into water where plants can absorb those (Brakels et al. 2010).

Biochar isn't a fertilizer, or food source for plants or microbes. Understanding its action is a paradigm shift from chemical views to biological insight to soil fertility and food webs. New research shows biochar has several effects in soil, namely: increase water infiltration and water holding capacity, improve soil structure, tilth and stability, adsorb ammonium, phosphate and calcium ions, enhance nutrient retention capacity, better root development, increase soil pH and buffering, increase cation exchange capacity, and also anions, increase fertility and nutrient retention more than conventional soil organic matter, increase soil biological activity and diversity, creating conditions described as a "microbial reef", reduce fertilizer runoff, especially nitrate and phosphorus, 50-80% decrease in nitrous oxide emissions from soil, reduces total fertilizer requirements, mitigates climate and environmental impact impact of cropland, reduces phosphorus runoff into surface water, reduces nitrogen leaching into groundwater (Mori and Marjenah 1994; Marjenah 1998; Warnock et al. 2007; Laird 2008 Hunt et al. 2010).

Plant growth

Plant growth is the irreversible, quantitative increase in size, mass, and/or volume of a plant or its parts. It occurs with an expenditure of metabolic energy. Therefore, the events lead to leaf formation and the increase in height of a plant growth, but the increase in volume of a seed due to uptake of water or imbibition is not growth (Moore et al. 2003). Plant growth is shown by the increasing size and dry weight of plants with increasing of time, and is not able to return. Plant growth is a complex process from every part of the plant cells which are closely related to one another. Growth is not only determined by the minerals absorbed but also influenced by the environment, the nature of the plant itself and the competition with other plants.

Plant growth and development will form different organs, generally consists of a plant organ vegetative and generative. Roots, stems, and leaves are classified as vegetative organs, while flowers, fruits and seeds are classified as generative organs. Vegetative organs will be formed early, when compared to the generative organs. Growth is divided into two, are: (i) the primary growth; are growth which caused by the activities of the primary growing point located on the tip of the roots and stems that have begin to form since the plant is still in the form of embryo, where the embryo of plants will form roots, stems and leaves, (ii) the secondary growth; is caused by the growth of cambium activity, so that the secondary growth only occurs in dicotyledonous plants and gymnosperms.

Table 2. Duncan- test ofheight and diameter Increment of *D. aromatica* and *S. balangeran* seedlings

Species	Variation of growing media	Height increment (cm)	Diameter increment (mm)
D. aromatica	100% top soil (control)	6.22 a	0.85 a
	80% top soil + 20% saw dust compost	9.14 b	1.14 b
	80% top soil + 20% *biochar*	**10.68** c	**1.17** b
	80% top soil + 20% *coco peat*	8.59 b	1.15b
S. balangeran	100% top soil (control)	6.21 b	**0.15** c
	80% top soil + 20% saw dust compost	6.01 b	0.12ab
	80% top soil + 20% *biochar*	5.21 a	0.10a
	80% top soil + 20% *coco peat*	**6.87** c	0.13bc

Note: The value in the same column followed by the same letter are not significantly different at the 5% according to Duncans- test

The calculation of height and diameter seedling increment of *D. aromatica* and *S. balangeran*) in growth media with different mixtures for 3 months observation, as well as the test results shown in Table 2.

Plant growth against the media combination on both of observed seedlings indicates different response. *D. aromatica*, the best increment height and diameter on the combination of 80% top soil + 20% biochar. The optimum application rate for biochar depends on the specific soil type and crop management. Informal observations of crops growth after biochar applications between 5-20% by soil volume have consistently yielded positive and noticeable results (Glaser et al. 2002). Biochar can also applied for timber plantation in the field it is suggested 1 kg biochar per square meter (Brakels 2010). While, for *S. balangeran*, the best height increment on the combination of 80% top soil + 20% coco peat; the best of diameter increment on the 100% top soil.

The difference in growth response of *D. aromatica* and can be caused by: (i) differences in the size of the plant since the beginning of the study; (ii) differences in the age of the plant; (iii) differences in a genus of plants (the same genus will have different growth rate, despite coming from the same family).

Dickson Quality Index

For successful seedling establishment in the field, it is necessary to understand how nursery practices affect seedling quality, which in turn is influenced by a complex system of plant morphological and physiological conditions and which is studied through quality attributes (Luis et al. 2004)

The Dickson quality index (DQI) reflects the overall quality of the seedling. The highest QI (0.375) was found in 80% top soil and 20% compost on *S. balangeran* seedlings. Plant growth is simply considered as the accumulation of biomass, without considering the chemical composition of the constructed biomass. Growth may compete with survival for common substrates.

Several variables are used to evaluate seedling quality, including shoot height, root configuration, stem base diameter, ratio of shoot to root, ratio of stem base diameter to shoot height, dry and fresh matter weight of shoot and root, shoot stiffness and nutritional aspects. This indicates that, in order to verify the degree of seedling quality, stem base diameter is the best non- destructive testing variable that expresses this characteristic, in other words, the larger diameter, the greater the shoot dry matter volume and the higher the DQI value, indicating better quality.

The growth of shoot height and stem diameter is the most common measures used for growing and grading standards in forest nurseries. There are many additional morphological parameters that can be assessed as well. Morphological standards vary greatly by species, seed zone, and stocktype. No single factor has been shown to provide a perfect prediction of the success of the planting, but each of them has been linked with seedling performance potential in some way. Weight is commonly measured on whole seedlings or root, shoot, and foliage separately. Because water content in the tissue can vary greatly, dry weight tends to provide a more consistent measurement than fresh weight. Not amazing, shoot and root volumes are strongly correlated with shoot and root dry weights (Haase 2007).

In this study, using a variety of media combination on two dipterocarp seedlings showed a positive influence on seedling quality. The results of Dickson Quality Index (DQI) calculation on *D. aromatica* and *S. balangeran* seedling for 3 months observation in the nursery is showed in Table 3.

Seedling quality specifications have been based on certain morphological characters such as robustness (height/ diameter ratio) and root/shoot ratio. Higher root/shoot ratio helps in survival and growth after planting. Seedlings with larger root systems have better survival, growth, and drought resistance. Shoot root ratio is a good indicator of internal water stress and potential survival of an out planted seedling because shoot and root sizes directly affects water loss and uptake. Low shoot root ratio increase survival and height growth. The seedlings with lower shoot root ratio able to survive better because (i) desiccation and moisture stress immediately after planting were minimized, and (ii) later internal water stress was low enough to permit some root growth, which improved the absorptive ability of the root system. Seedlings with a high shoot root ratio will have a greater transpiring surface in relation to the root's surface area, which could be detrimental during a drought (Binotto et al. 2010).

Table 3. Robustness of seedlings, root shoot ratio, and Dickson Quality Index of *D. aromatica* and *S. balangeran*

Variation of growing media	Dry weight (g)		Robustness of seedling	Shoot root ratio	Dickson Quality Index
	Shoot	Root			
D. aromatica					
100% top soil (control)	1.20	0.50	9.176	2.40	0.147
80% top soil + 20% saw dust compost	1.10	0.70	11.325	1.57	0.140
80% top soil + 20% *biochar*	0.80	0.30	8.136	2.67	0.102
80% top soil + 20% *coco peat*	0.80	0.30	8.527	2.67	0.098
S. balangeran					
100% top soil (control)	0.70	0.5	12.609	1.40	0.09
80% top soil + 20% saw dust compost	2.0	2.5	11.197	0.80	0.375
80% top soil + 20% *biochar*	0.6	0.2	13.957	3.00	0.05
80% top soil + 20% *coco peat*	0.9	0.4	17.329	2.25	0.07

Although production of containerized seedlings is more expensive and the transport of seedlings is more cumbersome, increased survival and growth can compensate for the disadvantages. This is especially relevant on dry, harsh sites which difficult to regenerate. Several features in newer containers minimize root spiraling. Some containers contain vertical internal ribs to reduce root spiraling and possible root strangulation. The ribs help direct the roots to the bottom of the container, which has a hole in the bottom. The low humidity of the air beneath the hole stops the roots from growing further, but the roots retain the ability to grow when the seedling is planted (Luis et al. 2004; Shepperd and Battaglia 2002). Although this technique prevents root spiraling, the distribution of the root system in the container does not correspond to the naturally grown seedlings. Seedlings grown in containers have lateral roots that are forced to grow downward, producing a dense, fibrous root mass bunched around the taproot in the upper soil layers. When the seedling is planted, new lateral roots are produced by the growth of new root tips from the cut ends of the existing laterals initiated higher up the stem.

The biomass of seedling is mainly depends on diameter, height and root growth. Determination of seedling quality besides using height and diameter growth are also used other indicators, the value of the robustness of seedlings shoots and roots ratio (top root ratio). This indicator is very important to the quality of the seedlings before planting in the field. According Adman (2011), ratio of height and diameter (value robustness), ratio of shoots and roots (root top ratio) before the seedlings are planted is supporting character that is often used to assess the morphological characteristics of seedlings in the nursery.

The robustness of seedlings represents the balance between height and diameter growth of seedlings in the field. Seedling with high robustness values showed low viability because of the imbalance between stem height and diameter. Value of robustness seedlings included good category is approaching 4- 5. Meanwhile, the seedlings are planted in containers with seedlings quality are greater than 0.09 will be easier to grow in the field (Adinugraha 2012). Calculation of Dickson Quality Index of *D. aromatica* seedlings get the value > 0.09, so that each combination of growing media used can produce the seedlings easier to grow when planted in the field. Thus, it can be argued that the *D. aromatica* seedlings planted on media combination as used in this study and maintained in the nursery for 3 months can be directly planted in the field.

Calculation of Dickson Quality Index of *S. balangeran* seedling which indicates the values > 0.09 only on the combination of 80% + 20% top soil compost that is 0.375. However, this does not mean that other combination of growing media is not good for seedling *S. balangeran*. This study was only carried out for 3 months, if the observation time was extended will likely be seen the response demonstrated by *S. balangeran* seedlings similar to the response of the *D. aromatica* seedlings.

High seedlings viability indicates that environmental factors have provided a variety of facilities sufficient for the plants, such as water, nutrients and air and free of pests and diseases that attacking the crop potential. Seedlings can be compared better on the basis of certain quality parameters. In this context, growth may compete for survival in common growing media.

In conclusion, the survival rates in all combination of growing media used in this study showed > 85% and can be categorized as a good combination media. Seedling of *D. aromatica* indicates the best height and diameter increment on the combination media of 80% top soil + 20% charcoal rice husk media, while the seedlings of *S. balangeran* the best height increment on the combination media of 80% top soil + 20 % coco peat; the best increase of diameter on the 100% top soil media. Dickson Quality Index of *D. aromatica* seedlings indicates values > 0.09 so any growth on combination of growing media used can produce seedlings that are easier to grow when planted in the field. Dickson Quality Index (DQI) of *S. balangeran* seedlings that indicates the value of > 0.09 only on the combination media of 80% top soil + 20% saw dust compost, which is 0.375.

ACKNOWLEDGEMENTS

We would like to express our gratitude to Ferdie Kurniawan Wijaya and Mikail for their assistance in the field. Many thanks to the members of Silviculture Laboratory, Faculty of Forestry, Mulawarman University, Samarinda, Indonesia for supporting this project.

REFERENCES

Adinugraha HA. 2012. Effect of Seeding and NPK Fertilizer to the Growth of Mahogany Broad Leaves Seedlings in the Nursery. Research Institute of Forest Biotechnology and Plant Breeding, Bogor. [Indonesian]

Adman B. 2011. Growth of three grades of quality seedlings of red meranti on three IUPHHK in Kalimantan. Jurnal Dipterokarpa 5 (2) : 47-60. [Indonesian]

Apaolaza LH, Gasco AM, Gasco JM. 2005. Reuse of Materials as Growing Media for Ornamental Plants. Bioresource Technology. Elsevier, Amsterdam.

Basirat M. 2011. Use of palm waste cellulose as a substitute for common growing media in *Aglaonema* growing. J Ornament Hort Pl 1 (1): 1- 11.

Binotto AF, Lucio ADC, Lopes SJ. 2010. Correlations between growth variables and the Dickson quality index in forest seedling. Revista Cerne, Lavras, 16 (4): 457-464.

Brakels R, Nguyen V, Wijngarart MVD, Walters J, West N. 2010. Enriching Soil with Biochar. Flinders University. Adelaide. Australia.

Glaser B, Lehmann J, Zech W. 2002. Ameliorating physical and chemical properties of highly weathered soils in the tropics with charcoal- a review. Biol Fert Soils 35: 219-230.

Haase DL. 2007. Morphological and Physiological Evaluations of Seedling Quality. USDA Forest Service Proceedings RMRS- P- 50. 2007.

Hunt J, DuPonte M, Sato D, Kawabata A. 2010. The Basics of Biochar: A Natural Soil Amendment. College of Tropical Agriculture and Human Resources. Soil and Crop Management. SCM-30. University of Hawai'i at Manoa.

Laird D. 2008. Carbon-negative Biochar Strategy. United States Department of Agriculture (USDA), Washington DC.

Luis VC, Peters J, Gonzales- Rodriguez AM, Jimenez MS. 2004. Testing nursery plant quality of Canary Island pine seedlings grown under different cultivation methods. Phyton 44 (2): 231- 244.

Marjenah. 1998. Effect of Charcoal Rice Husk and NPK Fertilizer on the Growth of three Dipterocarps Seedling. [M.Sc.-Thesis]. Faculty of Forestry. University of Mulawarman, Samarinda. [Indonesian]

Moore R, Clark WD, Vodopich DS. 2003. Botany. 2nd ed. McGraw- Hill, Boston, Mass.

Mori S, Marjenah. 1993. Mycorrhiza inoculation with charcoal rice husk. Jurnal Pembangunan dan Penerapan Teknologi 1 (1): 10-12. [Indonesian]

Mori S, Marjenah. 1994. Effect of charcoaled rice husks on the growth of Dipterocarpaceae seedlings in East Kalimantan with special reference to ectomycorrhiza formation. J Japan For Soc 76: 462-464.

Nirawati B, Nurkin, Putranto B. 2013. Evaluation of success on Plant Growth Forests and Land Rehabilitation (GNRHL) Bantimurung Bulusaraung National Park (A case study of the year 2003- 2007). J Sains & Teknologi13 (2): 175-183. [Indonesian]

Prabhu SR, Thomas GV. 2002. Biological conversion of coir pith into a value-added organic resource and its application in agri- horticulture: Current status, prospect and perspective. J Plantation Crops 30 (1): 1-17.

Shepperd WD, Battaglia MA. 2002. Ecology, Silviculture, and Management of Black Hills Ponderosa Pine. United States Department of Agriculture (USDA), Forest Service, Fort Collin.

Warnock DD, Lehmann J, Kuyper TW, Rillig MC. 2007. Mycorrhizal responses to biochar in soil – Concepts and mechanism. Plant Soil 300: 9-20.

Wilson GB. 1989. Combining Raw Materials for Composting. Organic Waste Processing. Biocycle, Maryland.