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Wood Specific Gravity and Water Content of Several Pioneer Trees on Biological Education and Research Forest Andalas University, West Sumatra

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Abstract – Specific gravity is an important variable in determining forest biomass and trees adaptation against environmental factors. The purpose of this study is to estimate the specific gravity value of wood of five pioneer trees species in Biological Education and Research Forest Andalas University (HPPB) and its relationship to growth rate and water content. Observation was conducted for five important species in HPPB; *Macaranga gigantea, Pternandra echinata, Macaranga triloba, Eurya acuminata, Dillenia* sp. The relationship between specific gravity to growth rate and water content were analyzed by using the Spearman correlation test. From this study, we found the specific gravity of the five species ranged from 0.55-0.74 and wood water content ranged from 0.45-0.65 g/cm^3. The highest specific gravity value was found in *Dillenia* sp, while the highest water content was found in *Macaranga gigantea*. Relative Diameter Growth Rate of five tree species observed ranged from 0.017 cm/cm/year to 0.047 cm/cm/year. We found a negative correlation between specific gravity and RDGR (r-value = -0.106) and specific gravity and water content (r-value = -0.453) but not significant.

Keywords – Wood Specific Gravity, Water Content, Pioneer Trees, Forest Andalas.

I. INTRODUCTION

Tropical forests have various types of woody trees that have very high economic value (Kobayashi, 1994). Wood is a product of the metabolic processes of living organisms, namely trees. During its growing period, trees are affected by a variety of very complex factors, so that the characteristics of the wood vary widely. Many factors influence wood variability and specific gravity is one of them. Some of the properties of wood that are influenced by specific gravity are the strength of the wood, and changes in wood moisture content (Miles and Smith, 2009).

The specific gravity of wood representing the quality and strength of wood. The specific value of wood gravity affects the strength and changes in wood water content (Boyrer and Smith, 1998). Specific gravity is also an important variable in determining forest biomass (Vavrcik, Gyc and Konas, 2010). The specific value of high wood gravity will make the tree stronger against physical damage, predators and pathogens (Rowe and Speck, 2005). Specific values of wood gravity that have a wide range in tropical forests indicate that forests have high diversity not only in taxonomy but also in ecological functions (Suzuki, 1999). High specific gravity wood is often found in low-light, high-stress environments such as windy areas, pathogens and infertile soils (Parolin and Ferreira, 1998).

Andalas University has a forest area that is protected and designated as a forest area for education and research. Biological Education and Research Forest (HPPB) of Andalas University is also one of the regions that have important biodiversity in Sumatra. Some information about HPPB forests has been identified through the following research: Tree Composition and Structure in the Limau Manis

Secondary Forest Area, Padang (Hendra and Mukhtar, 2004), Growth Rate of Pioneer Tree Plant Diameter (Fitria, 2008) and Basic Vegetation Analysis (Mustika, 2008). This study aims to estimate the specific gravity value and its relationship to the relative growth and water content of wood in several species of pioneer trees in HPPB. This research is expected to contribute to the management and protection of forests as carbon stocks in the West Sumatra region as well as information on the use of tree species.

II. Research Methodology

This study was conducted in a permanent plot of Biology Education and Research Forest (Hutan Pendidikan dan Penelitian Biologi/HPPB) located in the Andalas University Limau Manis, Padang City, West Sumatra (Figure 1). The HPPB is located ± 12 km northeast of Padang City, with an altitude of 250-350 masl and has an area of ± 150 hectares (Rizaldi et al., 2018).

Data was collected from August to December 2018. Field and laboratory procedures in this research refer to Suzuki (1999). The samples used were five tree species that had a high importance value in HPPB based on data from the results of Hendra and Mukhtar's research in 2004. The five plants were *Macaranga gigantea, Pternandra echinata, Macaranga triloba, Eurya acuminata,* and *Dillenia* sp. Tree diameter measurements were also carried out in this study to analyze the relative growth of trees. The Relative Diameter Growth Rate (RDGR) value is calculated using the formula from Hunt (1982).

$$RDGR = \log Dt - \log D_0 \ /\Delta t$$

Where: D_0 and Dt are diameter counts at the beginning and end of the measurement time interval (Δt).

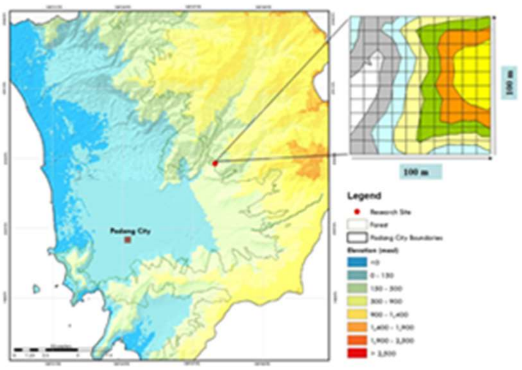

Figure 1. Map of Permanent Plot of Biology Education and Research Forest Andalas University

The wood sample used for specific gravity is the base of the tree. The wood specific gravity and water content were analyzed using formulations by Suzuki (1999).

$$SG \ = 0.67807\,\rho\alpha + 0.042901$$

$$WC \ = (Fresh\ weight - ovendried\ weight) \\ /fresh\ volume$$

Information: SG (Specific Gravity), WC (Water Content), ρ_α (dried weight).

Regression analysis is used to determine the relationship between the value of wood specific gravity and RDGR, as well as the relationship between the wood specific gravity and water content.

III. Results And Discussion

3.1. Relative Diameter Growth Rate

The results show that RDGR of the five tree species observed ranged from 0.017 cm/cm/year to 0.047 cm/cm/year. The highest value was found at *Macaranga triloba* and the lowest at *Eurya acuminata*. Detailed information of each tree species can be seen in the Table 1.

Table 1. RDGR of the Five Tree Species in the HPPB

No	Species	Family	RDGR (cm/cm/year)
1	*Macaranga triloba*	Euphorbiaceae	0.047 ± 0.0047
2	*Macaranga gigantea*	Euphorbiaceae	0.033 ± 0.0023
3	*Pternandra echinata*	Melastomataceae	0.028 ± 0.0020
4	*Dillenia* sp	Dilleniaceae	0.027 ±0.0040
5	*Eurya acuminata*	Theaceae	0.017 ± 0.0013

Trees from Euphorbiaceae such as *Macaranga* spp are the pioneer's species that commonly exist in secondary forests. In general, these species have rapid growth in open habitats. The results of Fatima's research in 2010 at HPPB also found *that Macaranga* triloba had the highest rate of (0.041 cm/cm/year), the same results were also obtained on *Macaranga triloba* species (0.21 cm/cm/year) in Bukit Pinang-pinang (Nelhadi, 2003) and the Bukit Ulu Gadut permanent plot of 1.15 cm/cm/year (Adriadi, 2015).

Relative growth rate of plants varies depending on the species of plant and the environment (Spur and Barness, 1992). Differences in environmental factors received by each individual affect its growth. The difference in the growth response of each species in the permanent plots of HPPB was due to differences in the distribution of individuals, canopy shade, and microclimate (Fitri, 2008). Light directly affects the assimilation and growth hormone which sequentially increases the growth of cambium (Kozlowzki and Pallardy 1997). Environmental conditions especially groundwater supplies also related to tree growth (Kramer and Kozlowski, 1960). Rainfall will affect soil water content and soil aeration and humidity which directly affect the diameter growth. High growth rates in secondary forest tree species are possible because of conditions without shade at an early stage of development.

Whitmore (1990) states that pioneers grow rapidly with different diameter growths of each species. Pioneer species produce large volumes with low density. Tree growth is closely related to photosynthesis. Each type of tree has a different photosynthesis rate due to differences in the character, anatomy, physiology and morphology of each species. Similarly, the rate of photosynthesis in each individual in a tree species will also be different, this is caused by external factors (microclimate) such as air temperature, air humidity, light intensity, soil pH and groundwater. Altitude also affects the rate of photosynthesis of a tree species, this is closely related to the CO2 content in the air.

3.2 Wood Specific Gravity

Based on the results of research in HPPB, the specific gravity of five tree species observed between 0.55-0.74. The highest specific gravity was found in the *Dillenia* sp. and the lowest in *Macaranga gigantea*. Detailed information of each tree species can be seen in Table 2.

Based on the criteria of the International Association of Wood Anatomists (IAWA), the values of wood specific gravity are divided into three groups: low (<0.40), moderate (0.40-0.75) and high (> 0.75) (Wheeler et al., 2008). From the specific gravity grouping, the five wood species of wood in this study were classified into the medium group and the wood strength class II (Martawijaya et al., 1989).

Table 2. Specific gravity values of the five plant species at the study site

No	Species	Specific gravity
1	*Dilenia* sp.	0.74 ± 0.006
2	*Macaranga triloba*	0.72 ± 0.086
3	*Ptenandra echinata*	0.67 ± 0.0046
4	*Eurya acuminate*	0.64 ± 0.0053
5	*Macaranga gigantea*	0.55 ± 0.086

Timber in Indonesia is divided into five classes which are determined according to their specific gravity by classification methods which show the relationship of specific gravity with flexural strength and compressive strength (Martawijaya et al., 1989). The strength of each species of wood is always different and is expressed in the strength class of the wood. The strength of wood depends on several factors, including environmental temperature, the anatomical structure of wood, specific gravity, water content, age of the tree and the speed of its growth (Kasmudjo, 2010). *Macaranga gigantea* wood has specific gravity and is classified as strong class III wood, while for *Macaranga triloba, Dillenia* sp., *Eurya acuminata*, and *Pternandra echinata* are classified as wood strength class II.

In the same species but different locations (Kalimantan), specific gravity for *Macaranga triloba* is 0.31 and *Macaranga gigantea* is 0.29 (Suzuki, 1990). While the wood specific gravity value at this location for *Macaranga triloba* is 0.72 and Macaranga *gigantea* is 0.55. The results of this study indicate that specific gravity at this location is higher than forests in Kalimantan. This specific gravity difference is thought to be due to gradient in altitude. The location of this study is located approximately 250-350 masl. While Suzuki's research location in 1990 was lower, namely in the Seribu (100-250 masl) and Senujuh (160-300 masl). In Sheikh's study (2011) there was an increase in specific gravity from 0.521 (altitude 1050 masl) to 0.606 (1800 masl) (Culmsee *et al*., 2010) and the average specific gravity for lower altitude areas (580-900 masl) was 0.631 and for higher altitude areas (1900-2300 masl) is 0.727.

The higher the specific gravity, the better the strength and the value of wood for construction materials. However, this does not apply to the pulp industry because the specific gravity of wood for pulp raw materials must be mild to moderate in the range of 0.35-0.65 (Miranda, Gominho and Pereira, 2012). From the results of Haroen's research (2017), it can be concluded that wood intended as raw material for pulp is cultivated for wood with a specific gravity of less than 0.70. If the type of wood in this study is used as material for pulp, then *Eurya acuminata, Ptenandra echinata* and *Macaranga gigantea* wood are good choices for pulp.

3.3 Wood Water Content

Based on the research results, it is known the value of wood water content of five tree species ranging from 0.45-0.65 g/cm^3. The highest water content was found in *Macaranga gigantea* at 0.65 g/cm^3 and the lowest was in

Dillenia sp. Detailed information of each tree type can be seen in Table 3.

Table 3. The wood water content of five tree species at the study site

No	Species	Water Content (g/cm^3)
1	*Macaranga gigantea*	0.65 ± 0.0060
2	*Eurya acuminata*	0.59 ± 0.0020
3	*Pternandra echinata*	0.56 ± 0.0040
4	*Macaranga triloba*	0.49 ± 0.0053
5	*Dillenia* sp.	0.45 ± 0.0081

The water content of wood species is very dependent on the volume of the cell cavity and the specific gravity of the wood. When the cell wall loses water below the fiber saturation point, the strength of the wood will quickly increase with decreasing water content. This increase in strength is caused by the stiffness of the cell wall when it dries and the joining of wood substances when it shrinks (Lempang, 2016).

The water content in this study is higher than the results of the Suzuki (1990) study where the water content in *Macaranga gigantea* was 0.36 g/cm^3 and *Macaranga triloba* was 0.35 g/cm^3. This is presumably due to the influence of different growing sites and seasons at the time of logging. Shmulsky and Jones (2011) explain that the value of water content of freshly cut wood ranges from 33-249% (from absolute dry wood weight value) depending on the wood part, a place to grow, age, harvest season, and tree size.

The highest water content is found in *Macaranga gigantea* but this species has the lowest specific gravity value. Similarly, *Dillenia* sp. has the lowest water content (0.45) but has the highest specific gravity (0.74). From these results, it can be seen that the water content has a negative relationship with specific gravity. This is in line with the statement of Prawirohatmodjo (2001) stated that between specific gravity and fresh-water content there is a strong negative relationship, where an increase in wood density will cause a decrease in the fresh-water content of woods. Wood water content affects wood quality. Wood water content affects wood quality. Wood with large water content generally has a lower specific weight, so the strength/quality of the wood is also not good (Kasmudjo, 2010).

3.4 Relationship Between Specific Gravity with RDGR

Based on the results of the Spearman correlation test it was found that RDGR with specific gravity is negatively correlated (-0.106). When the initial phase, the tree has a rapid growth period and causes a low specific gravity value. In line with the statement of Skolmen (1972) which states that specific gravity increases when wood RDGR decreases. RDGR with specific gravity in this study has a weak relationship, it can be seen from the r-value obtained which is equal to 0.106. It can be interpreted that RDGR does not significantly affect the specific gravity of wood (Pvalue> 0.05). The negative correlation was also found by Zhang (1995) between specific gravity and RDGR. RDGR also does not significantly affect specific gravity. The results of Perera, Amarasekera and Weerawardena (2012) also found a weak correlation between RDGR and specific gravity in *Swietenia macrophylla* (-0.186) and *Powlonia fortunei* (-0.185) types. The graph of the relationship between RDGR and specific gravity can be seen in Figure 2.

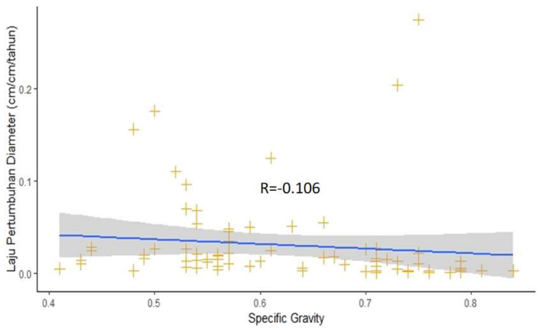

Figure 2. Relationship between RDGR and specific gravity.

3.5 Relationship of Specific Gravity with Water Content

In Figure 3 it can be seen that the specific value of gravity has a negative relationship with water content (R = -0.453). Haygeen and Bowyer (1996) stated that the specific gravity of wood tends to decrease with increasing wood water content. Explanation of this is related to the increasingly small proportion of cell cavities that hold free water (Marsoem et al., 2014). According to Prawirohatmodjo (2001), between specific gravity and fresh-water content, there is a strong negative relationship. Kasmudjo (2010) said that specific gravity is related to water content, whereas wood with large water content generally has lower specific gravity.

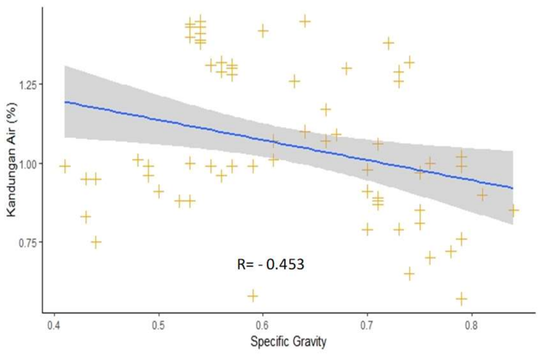

Figure 3. Relationship between water content and specific gravity.

IV. CONCLUSION

RDGR of five tree species ranged from 0.017 cm/cm/year to 0.047 cm/cm/year, where the highest value was found at *Macaranga triloba* and the lowest at *Eurya acuminata*. The specific gravity of five tree species observed ranged from 0.55-0.74, where the highest specific gravity was found in the *Dillenia* sp and the lowest in *Macaranga gigantea.* The wood water content ranged from 0.45-0.65 g/cm^3, where the highest water content was found in *Macaranga gigantea* at 0.65 g/cm^3 and the lowest was in *Dillenia* sp. There is a negative correlation between specific gravity and RDGR but not significant (r-value = -0.106). A negative correlation was also found between specific gravity and water content (r-value = -0.453).

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