

Quality Evaluation of Land and Growth Teak (*Tectona Grandis* LF) in the Humid Tropic

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Abstract Variations in plant growth teak forests in the humid tropics of the people is influenced by the diversity of land quality, this study aimed to evaluate soil quality and plant growth generated from each site quality in humid tropics regions compared with deciduous (deciduous), Research was conducted on private forest teak humid tropics areas which are in Tapin district and Banjar South Kalimantan as well as comparison deciduous teak forest area in Ngawi, East Java. Research methods to evaluate the quality of land use land for land quality index in land humid tropical and land deciduous and production growth. Quality of land in the humid tropics are divided into three classes, namely good quality land with an index > 0.7 on Okki land system and Tanjung (cape), quality of land with a moderate grade has 0.6-0.7 index contained on lawang uang land systems, Pendreh and Teweh 0.60 and quality of land with bad class has a land quality index < 0.55 are on maput land systems. Index of land quality in humid tropic land that has similarities with the class index of land quality in the area of deciduous in Ngawi, East Java on the system Okki land and Tanjung. Land quality index is proportional to the bonita index so that land quality index increase will be followed by an increase in soil bonita index used in determining soil fertility class for teak plants, soil quality index can be used at the planning stage while land bonita index can be determined after the plant was at least 5 years.

Keywords Index of land quality, Growth, Humid tropical, Deciduous

1. Introduction

Teak plants entered Indonesia since 400 to 600 years ago (Ombina, 2008; Verhaegen et al., 2010; Widjajani et al., 2011), however, on an industrial scale began in earnest in the 19th Century (Na'iem 2005). The economic value of teak because it is in a beautiful wood provide public appeal for teak plantation development (Bermejo et al., 2003). The high economic value of teak caused by teak wood has many advantages, among others, including a luxurious and durable timber (Sumarna, 2001; Bermejo et al., 2003; Ombina, 2008). Teak plantation development not only in Java (Deciduous), but since 2002 has begun to be developed in the humid tropic as in South Kalimantan in the form of community forests. Teak crop development in the area of introduction in the humid tropics are built by people without any prior knowledge of the site to match the type of teak on the introduction region. Differences in growing conditions in the humid tropics is different from the place of origin of plants grown teak in Java (deciduous) resulted in variations in plant growth. In the humid tropics with soil pH tends to acidic, has a high rainfall ($> 2,000 \text{ mm.Th}^{-1}$) with the dry months

between 2-3 months, has a period of drought that are not expressly will vary with site conditions in the area of origin of teak in Java with a clear distinction of the season (dry months 4-6 months) and rainfall below $< 2000 \text{ mm.Th}^{-1}$.

Plant growth is influenced by internal factors of genetic and environmental factors growth, differences in the quality of growing footprint can cause variations in height and diameter growth of teak (Sumarna, 2001). Teak plants require soil that is neutral or slightly alkaline and the pH of the soil is considered as one of the main factors limiting the distribution and development of teak (Zhou et al., 2011; Bermejo et al., 2003; White, 1998; Kaosa-ard 1998; Purwowidodo, 1991). Basic chemical elements that influence plant growth teak is calcium (Ca), to the growth and development of teak requires a relatively large amount of calcium in the soil (Zhou et al., 2011). Another important factor for the growth of teak is drainage and soil depth (Rugmini, 2007; CSR / FAO Staff, 1983). Teak plants also require high base saturation (60-80%) to very high ($< 80\%$) (Chongsuksatikum and Tantiraphan, 1991).

Suitability place to grow the humid tropics as a regional introduction teak plantation development is vital needs of the community developers, especially for teak. Site quality factor will be an important influence on the growth of teak plants to ensure the quality of plant growth until the prescribed cycle (Na'iem, 2002). During the development of

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community forest teak is still based on the economic value of teak interest in the market, it has not been constituted by the tread knowledge potential for the development of identity. This is because the development of teak are not organized in the form of the company, is still limited to people who wish to develop and encouragement from government programs. Site quality assessment teak plants still use the index bonita (Jumani, 2009), but the index bonita can be used after the teak planted at least 5 years of age because of the element of bonita index is age and high maker. Therefore, it is necessary to evaluate the quality of teak plantations in the humid tropics that can determine the quality of the land suitable for the development of teak plants before planting so as to reduce the risk of investment failure. The aim of this study was to evaluate soil quality and plant growth generated from each site quality in humid tropical regions compared with deciduous.

2. Materials and Methods

2.1. Research Sites

The study was conducted on community forest Teak (*Tectona grandis* Linn. F) planting year 2002 (Age Class II) in Tapin district and Banjar regency, South Kalimantan, with the characteristics of the humid tropics and as a comparison the area of origin of teak in Ngawi, East Java is an area with a climate deciduous (deciduous). Community forest teak plants in the study site was built with quality seedlings and certified management intensively. Location research has climate type B ($Q = 27.5$) with an average rainfall of 2,466 mm.th⁻¹, has two periods of the season that is dry and rainy

seasons with dry month period an average of 2-3 months, the difference of the season rainy and dry season is not firm, has temperatures between 25-32°C. Meanwhile, as a comparison area deciduous in Ngawi in East Java has an average rainfall of 1,815 mm.th⁻¹ with the climate type D ($Q = 71.43$) had two periods of dry and rainy seasons with the difference between the dry season and the rainy season is very firm, having a dry month period of 4-6 months. The type of soil in humid tropical research locations covering Inceptisol soil types include (Oxic Dystrudepts, Lithic Eutrodepts, Typic Eutrodepts and Typic Epiaquepts) and Oxixols include (Typic Kandiodox and Typic Hapludox). This type of system study sites include land on a Tanjung land systems (TNJ), lawang uwang (LWW), Okki (OKI), pendreh (PDH), Teweh (TWH) and maput (MPT).

2.2. Data Retrieval Procedure

Data retrieval procedure begins with a unit of observation with the observation unit approach based land systems. Land systems at the study site includes six (6) land system is a system of land-Lawang Uwang, Okki, Pendreh, Tanjung, Teweh and Maput, therefore the land is used as treatment system. Each treatment is done repetition three times so that there are 18 blocks of observations in the humid tropics and as a comparison is the origin of land plants in Java teak (deciduous climate regions) are in Ngawi, East Java. Land quality index is calculated using the criteria Mausbach & Seybold (1998) in Partoyo (2005) modification of the attributes of land and land indicators that are tailored to the needs of teak plant life to grow optimally. Calculation of land quality attributes and characteristics of land is done by weighting approach as presented in Table 1.

Table 1. Modifications of Land Quality Index for Production Teak on Humid Tropical Regions

| Land Quality Attributes | Weight | Land Characteristics | Weights | Weighted Index | Scores land test results | Land Quality Index |
|---------------------------|----------|----------------------|----------|----------------|--------------------------|--------------------|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| 1. Rooting Media | 0,2 | Solum | 0,4 | 0.08 | 1 | 0,4 |
| | | Permeability | 0,4 | 0.08 | 1 | 0,4 |
| | | Texture | 0,2 | 0.04 | 1 | 0,2 |
| | | Total | 1 | | | |
| 2. Water Availability | 0,3 | Dry Months | 0,3 | 0.09 | 1 | 0,3 |
| | | Annual Rainfall | 0,3 | 0.09 | 1 | 0,3 |
| | | Porosity | 0,4 | 0.12 | 1 | 0,4 |
| | | Total | 1 | | | |
| 3. Nutrients Availability | 0,5 | Soil pH | 0,2 | 0.1 | 1 | 0,2 |
| | | C-Organic | 0,2 | 0.1 | 1 | 0,2 |
| | | KTK | 0,2 | 0.1 | 1 | 0,2 |
| | | P-Available | 0,1 | 0.05 | 1 | 0,1 |
| | | Ca-dd | 0,2 | 0.1 | 1 | 0,2 |
| | | K.B | 0,1 | 0.05 | 1 | 0,1 |
| Total | 1 | Total | 1 | | | 1 |

Table 2. Land Suitability Criteria

| Quality / Land karakteristiek | Land Suitability Level | | | | |
|-------------------------------|--|--------------------------|--------------------------|----------------|----------------|
| | S1 (1) | S2 (0,75) | S3 (0,5) | N1 (0,25) | N2 (0) |
| 1. Effective Depth | >150 | 100 - <150 | 75 - <100 | 50 - <75 | <50 |
| 2. Soil Permeability | 2,0-6,3 | 2-0,5 | 0,125-0,5 | >6,3 <0,125 | >6,3 <0,125 |
| 3. Dry Month | 4-5 | 3-4 | 2-3 | 5-6 | >6 <2 |
| 4. Rainfall | 1500-2000 | >2000-2250 1250-<1500 | >2250-2500 1000-<1250 | - | >2500 <1000 |
| 5. Soil pH | 5,5-7,0 | >7,0 – 7 5,0-<5,5 | >7,5 – 8,0 4,5 - <5,5 | td | >8,0 <4,5 |
| 6. Soil Porosity | 50-60 | 50-40 | 30-40 80-60 | <30 >100 | <30 >100 |
| 7. C-Oragnik | >3 | 2-3 | 1-2 | - | <1 |
| 8. KTK | >24 | 17-23 | 5-16 | <5 | <5 |
| 9. P-Available | ≥ 5 | 3 -<5 | 1-<3 | - | <1 |
| 10. Ca-dd | >11 | 8-<11 | 5-<8 | 2-<4 | <1 |
| 11. Base saturation | >36 | 27-<36 | 18-<27 | 10-<18 | <10 |
| 12. Soil Texture | L, SCL, Sil, Si, CL, SC, SiCL, SiC | SL, Str C | LS, massive lit | Td | Gravel Sand |

Measuring growth (height, diameter and volume plants) by systematic sampling using a measuring plot a circle with a radius (r) of 7.94 meters and the distance between plots measuring 50 m. Each block of observations taken by 4 plots measuring, so that the observation block 18 which includes six land systems and three replications takes 72 plots measuring. Plant height is measured at ground level to a high branch-free trunk and calculated from ground level to the top of the stem. Plant diameter measured at breast height diameter or ± 130 cm from the soil surface. Analyze the nature of physics, mechanics and levels of extractive substances on the basis of laboratory test data based on the production of timber each land system. Physical properties observed were wood moisture content of wood, wood density and shrinkage of wood, while the mechanical properties of teak covering tensile testing constancy, constancy press parallel fibers, firmness press perpendicular to the fiber, shear firmness, determination sides, determination of bending fracture (MOR) , firmness elastic bending (MOE), end violence and violent side.

Specification:

Index Calculation is as follows:

1. The index weights (5) is calculated by multiplying the weight attributes land (2) with a weight of land characteristics (4)
2. Scores in column 6 is the value of the field measurement and analysis laboatorium on the character of land (column 3) were then carried matching scores in Table 2.
3. Index of land quality (7) is calculated by

multiplying the index weights (5) and score (6).

2.3. Data Analysis

Stem volume calculation by reference to the formula used by Simon (1993) as the multiplication of basal area, plant height and plant form factor. Analysis of variance by using analysis of variance (ANOVA) and Linear Regression (Yitnosumarto, 1993; Gomez and Gomez, 1995; Simon, 1993).

3. Results and Discussion

3.1. Evaluation of Land Quality and Plant Growth

Land quality evaluation using the index of land quality done by measuring the character of land which is then weighted to determine the index land quality. Results of the evaluation of land with the land quality index approach every system of land as a land unit approach can be seen in Table 3. Based on the results of the evaluation of the six systems of land on land in humid tropic and as a comparison of land in East Java (deciduous) it was found that there is a difference significant index of land quality on each system in humid tropical land ($P < 0.005$) as well as in the area of climate deciduous in Ngawi, East Java as a comparison. Land in humid tropical system has a range of values from 0:55 to 0.75 of land quality index value with the highest index of land quality on land Tanjung System (TNJ) of 0.75 is closer to the land of origin of teak in Ngawi, East Java (Diciduous) of 0.80 and the Lowest land quality index system Maput land of 0:55.

Table 3. Results of Measurement of Land Quality Index and the Growth in Humid Tropical and Deciduous Area (Ngawi in East Java)

| No. | Land System | Land Quality Index | Clear Bole height (m) | High Total Plant (m) | Diameter (cm) | Wood volume (m ³ .ha ⁻¹) |
|---------------------|---------------------------|--------------------|--|---|---|---|
| Humid Tropical Area | | | | | | |
| 1 | Maput | 0,55 ^a | 5,23 ^a | 10,91 ^a | 16,40 ^a | 63,83 ^a |
| 2 | Teweh | 0,60 ^b | 7,07 ^b | 13,91 ^b | 18,18 ^a | 108,56 ^b |
| 3 | Pendreh | 0,64 ^b | 7,64 ^b | 14,25 ^b | 18,55 ^{ab} | 114,42 ^b |
| 4 | Lawang Uwang | 0,66 ^b | 7,81 ^b | 14,24 ^b | 19,26 ^{bc} | 135,19 ^{bc} |
| 5 | Okki | 0,72 ^c | 8,34 ^b | 15,39 ^{bc} | 20,61 ^{cd} | 162,37 ^c |
| 6 | Tanjung | 0,75 ^c | 8,38 ^b | 15,85 ^c | 22,27 ^d | 169,94 ^c |
| Deciduous Area | | | | | | |
| 7 | Ngawi East Java (control) | 0,80 ^c | 8,19 ^b | 15,39 ^{bc} | 21,34 ^d | 168,25 ^c |
| | | | Lsd : 1,38 Mean : 7,52 SD : 0,67 | Lsd : 1,71 Mean : 14,28 SD : 0,84 | Lsd : 2,19 Mean : 19,51 SD : 1,11 | Lsd : 46,64 Mean : 131,79 SD : 25,04 |

Description: LSD = least significant difference, HSD = Standard Deviation; Notation marks a distinguishing mark, at the same notation does not have the land quality index difference.

Based on the results of different test to the humid tropics zones with 6 zone based on the land system and a comparison of the land of deciduous area in Ngawi East Java, the results of different test based on high growth, stem diameter and volume, then the index of land quality classified into three zones index of land quality. The first zone with the lowest index value of 0.55 or humid tropical (0.6) has an index of land quality with bad classification. The second zone having an index range of 0.60 to 0.66 or approach index between 0.6-0.7 have an index of land quality with moderate classifications and the third zone with the index range from 0.72 to 0.75 and a comparison on the land deciduous area of 0.80 or index approaches above 0.7 (>0.7) has an index of land quality with good classification. If value index of land quality is smaller, the more limiting factor on the land character to support the growth of teak plant and conversely the greater index of land quality, the smaller the limiting factor on the land character to support the growth of teak.

Land quality index value indicates that the increase in the index of land quality real positive linear relationship ($P < 0.005$) on plant growth (height, diameter and volume). The greater index of land quality it will be followed by an increase in plant height both clear bole height and total height, diameter and volume of wood. This can be seen in the linear regression equation between index of land quality to the clear bole height of the $\hat{Y} = 0.24 + 10.80X$ with r value of 0.85 and an index of land quality to total height of the plant that is $\hat{Y} = 3.17 + 16.47X$ with r value of 0.87, the index of land quality to the diameter of the plant that is $\hat{Y} = 4.68 + 21.99X$ with r value of 0.95 and an index of land quality on the plant stem volume that is $\hat{Y} = -155.53 + 426.11X$ with r value of 0.95. Correlations between soil quality index with excellent growth for quality shows where the plants grow (Jumani, 2009; Widodo, 1989).

Based on growth data in Table 3, the highest-growth teak humid tropics regions show high increment of 1.44 m.th⁻¹, diameter increment of 2.03 cm.th⁻¹ and volume increment of 15.45 m³.ha⁻¹.th⁻¹, while on location in the deciduous area in Ngawi, East Java has a high increment of 1.39 m.th⁻¹, diameter increment of 1.94 cm.th⁻¹ and volume increment 15.29 m³.ha⁻¹.th⁻¹. Growth teak plants in several locations in West Java, high rainfall in the Sub-district Congeang at the age of 12 years have a high increment of 1.02 m.th⁻¹ and volume increment of 14.08 m³.ha⁻¹.th⁻¹ (Supriatna and Widjayanto 2011) and in the area of Ciamis, West Java can reach 2.25 m.th⁻¹ at the age of 5 years (Hadiyan, 2009). Teak growth in East Borneo in Community Forests in humid tropics climate at the age of 8 years reached increment of the high total 1.13 m.th⁻¹ (Jumani, 2009). Based on a comparison with other regions, the growth of teak in humid tropics in South Borneo is able to compete with the region of origin Teak in East Java and other areas in West Java.

3.2. The Relationship between Land Quality Index and Soil Bonita Index

Soil Bonita Index is the classes of index a place to grow for a type of plant in result (Siswanto, 2008). The main element in the determination of soil bonita index is age and improvement, this is because the improvement is the size sensitive to differences of the footprint (Widodo, 1989). Bonita consists of bonita I-VI with interval of bonita index is 0.5, the higher bonita value, the increasing soil fertility. Bonita index commonly used to measure soil fertility in teak plants in Perhutani, use of bonita table has been used since 1932. The soil bonita index used to test the suitability of the index against the land quality index test results are used in the humid tropics. Results of measurement of land quality index and soil bonita index presented in Table 4.

Table 4. Test results of the Land Quality Index compared with Soil Bonita Index

| No. | Land System | Land Quality Index | Soil Bonita Index |
|--------------------|----------------------------|--------------------|-------------------|
| Humid Tropics Area | | | |
| 1 | Maput | 0,55 | II |
| 2 | Teweh | 0,60 | III½ |
| 3 | Pendreh | 0,64 | III½ |
| 4 | Lawang Uwang | 0,66 | III½ |
| 5 | Okki | 0,72 | IV |
| 6 | Tanjung | 0,75 | IV |
| Deciduous Area | | | |
| 7 | Ngawi Jawa Timur (Control) | 0,80 | IV |

Results of measurement of land quality index showing value equation with the soil bonita index, on the tanjung land system and okki produce soil bonita value equal to the land area of deciduous in Ngawi, East Java. The regression analysis between land quality index to soil bonita index resulted in the regression equation $\hat{Y} = -1.05 + 6.74 X$ with r value of 0.83. From the results of regression analysis for land quality index to soil bonita index showed that the index of land quality real positive linear relationship to the soil bonita index, the greater land quality index, it will be followed by an increase in the value of the soil bonita index. The results of the use of land quality index to determine the teak soil fertility class in humid tropics has linear results for soil bonita index. The second difference of this index is the soil bonita index the value of the suitability of a new land can only be known after planting is at least 5 years, with the improvement overlay (100 the tallest trees) is generated on the age of the plant. However, the usage index of land quality, class of soil fertility can be known at the planning step. Use of the soil bonita index give the speculation of possible failure of investment, because the cost of making the plant that is not cheap. Approach to the planning stages of planting should use the index of land quality and yield growth after aged > 5 years can be corrected with an index value of the soil bonita.

4. Conclusions

Quality of land in the humid tropics is based on the value of land quality index and linear relationship to the land quality index to growth both height, diameter and volume, as well as different values to the soil of deciduous region in Ngawi East Java, the humid tropics soil is divided into three classes, namely good land quality with an index >0.7 on Okki land system and Tanjung, quality of land with a moderate grade having an index 0.6-0.7 contained on lawang uwang land system, Pendreh and Teweh 0.60 and quality of land with bad class having a land quality index <0.55 contained on maput land system. The land quality index in

humid tropics soil that has similarities with the class index of land quality in the area of deciduous in Ngawi, East Java on the okki land system and tanjung system. The land quality index is proportional to the soil bonita index so increase of the land quality index will be followed by an increase of soil bonita index used in determining soil fertility class for teak plants, land quality index can be used at the planning stage while soil bonita index can be determined after the plant was at least 5 years.

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