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Effect of seed quality and management system on the growth and plant health of teak (*Tectona grandis* L.F) in the humid tropic

Yusanto Nugroho[1*], Luthfi Rayes[1], Didik Suprayogo[1], Ahmad Kurnain[2]

[1]*Faculty of Agriculture, University of Brawijaya, Malang, Indonesia*

[2]*Faculty of Agriculture, University of Lambung Mangkurat, Banjarmasin, Indonesia*

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Abstract

Teak in humid tropical of South Kalimantan is a type of introduction plants from Java, built in the form of community forests which is known as Teak. Development of community forests of teak plant is not preceded by planting concepts based on knowledge resulting in variations on the growth and health of plants, seeds and usage factors management system as important role for the existing variations. The aim of this study was to evaluate the diversity of plant growth and health of teak in humid tropical from variation factors of seed and management system. This research was conducted in community forest teak plantation at the age of 11 years using a factorial design with variations in the use of seeds and variations of management system. Data collected with deep interviews and the direct measurement of the field. The results shows that the use of certified seed and intensive management system was effect the high productivity to growth (height, diameter and volume) of teak plant on community forest of humid tropic. Unavailable of one of the factors (certified seeds and intensive management system) led to the slow or not optimal growth of teak plants. The use of certified seed and intensive management produce a higher number of healthy plants up to 87.09% compared with the use of uncertified seed and unintensive management system only reached 44.51% - 64.29%. Therefore certified seed and intensive management are recommended for Teak plant in humid tropic community forest. However, intensive management system needs to be overviewed for longterm forest management.

* **Corresponding Author:** Yusanto Nugroho ✉ yusant_1977@yahoo.co.id

Introduction

Teak (*Tectona grandis* Linn. F) is a type of plant in Indonesia from 400 to 600 years ago (Ombina, 2008; Verhaegen *et al.*, 2010; Widjajani *et al.*, 2011), but on an industrial scale began in earnest of 19th century concentrated in Java (Na'iem, 2005). It lives in climatic conditions with rainfall between 750-2500 mm.year^{-1} and the temperature between 20-39°C with dry months 4-6 months and the site on Java with a high pH which causes the teak plants thrive in Java (Purwowidodo, 1991; Sumarna, 2001). Indonesia is the second largest country in the world which has an area of teak plantations after India (Rugmini *et al.*, 2007; Sofyan *et al.*, 2007; Zhou *et al.*, 2011). Teak plantation development in Indonesia is not only concentrated on the island of Java, the public interest for selling teak (Na'iem, 2005) led to the development of teak plants began to enter the humid tropic area such as in South Kalimantan. Climatic conditions in the humid tropics has different habitat conditions in Java, e.g. high rainfall (>2,000 mm.th^{-1}), the period of dry season and the rainy season is not distinct; challenge the teak plant introductions. The development of teak plants began rapidly developed in 2002 in the form of community forests.

The development pattern of community forest in the humid tropic is not yet have a system of targeted organizations such as Perhutani in Java (Na'iem, 2005) and Sustainable Forest management in India (Thulasidas and Bhat, 2012). Thus the management system varies according to the knowledge, skills and individual skills of community forest farmers both in terms of management on seed source and plant management systems. According to Nai'em (2002), development of plant identity is not complemented with good silvicultural management practices which led to unoptimal growth.

Quality of seeds determines the success of cultivation. It serves as a carrier for the seeds of superior genetic material inherited from the parent thus it required quality selections before planting the seed (Sutopo, 2004). Good seed comes from a good source of seed production area of seed/orchards or seed stands (Hadiyan, 2009). The use of quality seeds can increase production up to 25% (Reano, 2001), while the use of poor seed quality is characterized by vigor and suboptimal germination cause yield reduction up to 20% (Shenoy *et al.*, 1988). Farmers often have both costs and time loss due to the use of low-quality seeds that have an impact on the growth and health of plants and plant production (Sutopo, 2004).

In addition to the quality of seedlings, timber production is influenced by management system of plants and site quality (Sutopo, 2004). Teak plant intensive management resulting better plant's growth and diameter (Supriatna and Wijayanto, 2011). Variations in the use of seeds and management system performed by community forest farmers of teak plant can lead to variations in plant growth. According Hadiyan (2009), growth variation on teak plants can be strongly influenced by different sources of seed used. The maintenance activities of teak plant in the form of weeding and fertilizing give positive impact on the speed of teak plant growth in Forest Park of Cikabayan, West Java (Nugroho, 2003). Therefore, the aim of this study is to evaluate the diversity of plant growth and health of teak in humid tropical from variation factors of seed and management system.

Materials and methods

Materials and Study Site

The study was conducted on community forest of Teak (*Tectona grandis* Linn. F) at the age of 11 years (age class II) in the District of Tapin and Banjar, South Kalimantan with caracteristic site of humid tropics. Location studies have type B climate 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, has temperatures between 25-32°C. The types of soil research sites include the type of soil Inceptisol covers (Oxic Dystrudepts, lithic Eutrodepts, Typic Eutrudepts and Typic Epiaquepts) and Oxixols covers (Typic Kandiudox and Typic Hapludox). This type of land system of the area study covered of *Tanjung* (TNJ), *Lawang-uwang* (LWW), *Okki* (OKI), *Pendreh*

(PDH), *Teweh* (TWH) and *Maput* (MPT).

Data collection

Data collection procedure in the field was conducted by interviews with 49 farmers in community forest of teak plants and measuring the growth and health of teak plants in the research site.

Research design

The research design using a factorial design with 2 factors: seed quality factor and management system factor. Seed quality factors are divided into two levels, namely certified seed (A_1) and non-certified seed (A_0). Uncertified seeds come from the stand and have not done any testing of seed sources, while certified seed certification has been performed test of seed sources from related agencies. These seeds originating from the area of seed production, seed stands and seed orchards. Management system factors are divided into two levels, namely intensive management (B_1) and unintensive management (B_0).

Intensive management includes land preparation and planting patterns which are irregular; routine maintenance includes cleaning weeds once every 4-6 months, fertilization, stitching, pruning, the thinning plan periodically. Non-intensive management is if the management activities are not performed regularly or are not done at all. So there are 4 treatment combinations of Community forests: uncertified seed-unintensive management (A_0B_0), uncertified seed-intensive management (A_0B_1), certified seed-unintensive management (A_1B_0), certified seed-intensive management (A_1B_1). Each treatment was carried out as many as six replications so there are 24 blocks of observation. Benchmark observations are: a) the growth of the plant include height, diameter, volume; b) plant health.

Interview farmers

Based on interviews community forest farmers from 49 farmer teak obtained showed that farmers using certified seed as many as 31 farmers (63.27%) and farmers who do not use certified seed as many as 18 farmers (36.73%). Based on land management systems used were obtained that farmers who applied intensive land management is 29 farmers (59.18%) and farmers who do not do intensive management is 20 farmers (40.82%). Based on a combination treatment of farmers, 20 farmers use A_1B_1 (40.82%), 11 farmers use A_1B_0 (22.45%), nine farmers use A_0B_1 (18.37%), and nine farmers use A_0B_0 (18.37%). Each combination treatment of farmers randomly selected 6 farmers as repetition thus the number of observations is 24 farmers.

Measuring growth (high, diameter and volume) and plant health

Method of measurement is done by creating a plot by systematic sampling with a distance of 50 meters, on every block there are 4 plots of observations. Plot that used a circular to the size of the radius of 7.94 m (standard plot measuring conditions for trees age class I and class II age), thus the observation of planting as many as 24 blocks of combination treatment, then there are total of 96 plots.

Clearbole height or height of the beginning of the crown measured from tree base at the ground surface and the first brance which shape the crown. While the total height determined by measuring the plants from the tree base at ground surface up to the top of the tress. Plant stem diameter measurement performed on the main stem with a height from ground level at dbh (diameter of bossom height) or ± 130 cm from ground level.

Plant health measurements performed at the level of individual plants according to Alexander (1996), tree health assessment criteria with three important values, namely the location of damage, type of damage and the severity of the damage. Damage to the location identified by signs and symptoms of damage are given priority and are recorded based on the location of the order: root, root and stem bottom, stem bottom and the top of the stem, crown stem, branches, buds and shoots and leaves. Damage was recorded maximum of 3 types of damage for each tree, if the tree has more than 3 damages, the three main damage is noted, starting from the root. The

type of damage identified based on the type of damage that appears on parts of the plant, which showed abnormalities that appear on parts of the plant. The severity of damage is a measure of the affected areas number above threshold value at a certain location and type of damage.

The severity of the damage assessment showed the percentage of plants based on the weight or value against attack or damage arising in parts of the plant.

Data analysis

Stem volume calculated by reference to the formula used by Simon (1993) as the multiplication of basal area, plant height and plant form factor. Calculation of plant health used an index of crop damage in accordance with the formula of Alexander (1996). Index damage area (Area index level) is calculated from the average damage to trees in the area.

Tree Damage Index = (1 × type of damage 1 × severity of the damage location 1) + (2 × type of damage 2 × severity of the damage location 2) + (3 × type of damage 3 × severity of the damage of location 3).

Diversity test used analysis of variance in factorial experiments according Yitnosumarto (1993) on the results of plant height and diameter growth by estimating model parameters to two factors. Factor A (Quality seeds) with 2 levels (certified and uncertified) and factor B (systems management) with 2 level (intensive management system and unintensive) by the number of 6 replications.

Results and discussion

Plant growth (Height, Diameter and Volume)

The observation on the treatment of A_1B_1, A_1B_0, A_0B_1 and A_0B_0 in the field shows the variation of growth, both in high growth, stem diameter and volume of produced crop.

Growth measurement results of each treatment are presented in Table 1a and 1b.

Table 1a. Results of measurement of height, diameter and volume.

Treatment	Clearbole (m)	Height Total Height (m)	Diameter (cm)	Volume ($m^3.ha^{-1}$)
Uncertified seed-unintensive management (A_0B_0)	4.99 a	11.47 a	14.84 a	49.67 ab
Uncertified seed-intensive management (A_0B_1)	5.68 b	12.53 b	17.00 b	72.96 bc
Certified seed-unintensive management (A_1B_0)	5.16 ab	11.84 ab	15.67 ab	56.75 abc
Certified seed-intensive management (A_1B_1)	8.10 c	15.59 c	20.37 c	148.93 d

Table 1b. Growth Parameter in P (0.005); SD (Standard Deviation); LSD (Least Significant Different).

Parameter	Mean	SD	LSD
Clearbole height	5.98	0.288	0.614
Total Height	12.86	0.288	0.613
Diameter at breast height	16.97	0.876	1.866
Volume	83.70	12.01	25.59

The results of measurements of plant height, diameter and volume of plants in Table 1a indicate that the use of quality seeds certified with intensive management (A_1B_1) showed significant effect ($P < 0.05$) against the clearbole height, total height, diameter and volume of crop plants.

Effect of treatment provides effects that are additive (best effect). It can be seen in the interaction that influence each other thus the mean clearbole height on the interaction of A_1B_1 provide results 62.33% higher than the treatment of A_0B_0. A_1B_1 interaction results 56.98% higher than the treatment A_1B_0, and A_1B_1 interaction results 42.61% higher than A_0B_1 treatment. Likewise with a total height of the plant treatment gives additive effect on total plant height so that the mean value of the interaction A_1B_1 provide results 35.92% higher than the treatment of A_0B_0. A1B1 interaction results 31.67% higher than the treatment of A_1B_0, and A_1B_1 interactions provide 24.42% higher results than treatment A_0B_1. Plant management activities such as pruning branches, weeding and fertilizing plants can spur the growth of the plant height and diameter of teak in age classes I and II (Nugroho, 2003; Zhou *et al.*, 2011; Viquez and Perez, 2005). Based on Table 1a, A_1B_1 treatment can stimulate the increment of plant height reached 1.42 $m.th^{-1}$, higher than treatment A_0B_0, A_1B_0, A_0B_1 with increment 1.04 to 1.14 $m.th^{-1}$.

Table 2a. Results of Measurement of Plant Health.

Treatment	Healthy plants (%)	Plants with mild damage (%)	Plants with moderate - very heavy damage (%)
Uncertified seed-unintensive management (A_0B_0)	44.51 a	33.52 c	21.97 c
Uncertified seed-intensive management (A_0B_1)	66.86 b	24.57 b	8.60 c
Certified seed-unintensive management (A_1B_0)	48.88 a	31.28 b	19.84 b
Certified seed-intensive management (A_1B_1)	87.09 c	12.36 a	0.55 a

Table 2b. Plant Health Parameter in P (0.005); SD (Standard Deviation); LSD (Least Significant Different).

Parameter	Mean	SD	LSD
Healthy plants	61.83	3.32	7.08
Plants with Mild Damage	25.43	3.30	7.04
Plants with Moderate - Heavy Damage	25.43	3.30	7.23

Treatment of A_1B_1 delivers greater diameter growth 37.26% of the average diameter A_0B_0 treatment. A_1B_1 treatment results greater diameter growth of 29.99% from the average height of the treatment A_1B_0, and A_1B_1 treatment results greater diameter growth 19.82% of the average diameter A_0B_1 treatment.

Results average diameter of these plants showed that the plants A_1B_1 produce diameter increment of 1.85 $cm.th^{-1}$ greater than the treatment A_1B_0, A_0B_1 and A_0B_0 with diameter increment between 1.35 to 1.55 $cm.th^{-1}$. In the opinion of Nugroho (2003), land management activities such as maintenance and fertilization can increase crop diameter of 1.27 cm super teak for 6 months. Crop management through pruning branches (pruning) at 3 m increase in height pruning teak trunk diameter 2.1 cm greater than the control without pruning or pruning over 3 m in the measurement of plant age at 6.1 years (Viquez and Perez, 2005).

Height and diameter growth is the basis for the calculation of the volume of the plant. A_1B_1 treatment resulted in an average production volume is 148.93 $m^3.ha^{-1}$ or 61.90% higher than the A_1B_0 (72.96 $m^3.ha^{-1}$), 51.01% of A_0B_1 (56.75 m3 .ha-1) and 66.65% of the A_0B_0 (49.67 m^3ha^{-1}). The use of certified seed and intensive management is able to increase the volume of production plants up to 2-3 times the volume of wood from other treatments. The volume increase

will be proportional to the increment of growing plants, A_1B_1 treatment will have the highest increment of 13.54 $m^3.ha^{-1}$ and the three other treatments (A_1B_0, A_0B_1 and A_0B_0) had increment from 4.52 to 6.63 $^{m3}.ha^{-1}$.

Volume productivity of plants could be increased by adding high bole and thinning plants (Jumani, 2009). Selection of superior seeds from the best family able to increase timber production by 37%, even seed selection with a simple selection method such as mass selection, genetic gain can increase 20-30% of timber volume (Na'iem, 2003). The use of teak seeds from the best seed production area can improve the productivity of 5-12% compared to the volume of seed from unselected seed stands (Mahfudz, 2007). Intensive management by Perum Perhutani KPH sumedang delivers growth in height, diameter and basal area better than the people of the community forest management in the District Congeang (Supriyatna and Vitello, 2011).

Plant Health

Plant health measurement results (Table 2a and 2b) showed that treatment with the use of certified seed and intensive crop management showed significant effect ($P<0.005$) to the large number of plants grown teak healthy at 87.09% as compared to the other treatment between 44.51-66.86%. In addition to the very significant effect ($P<0.005$) to the amount of crop damage is mild damage, heavy to very heavy with a small percentage of the most damage. This indicates that the use of certified seed and intensive management is able to prevent the space for the development of pests and diseases that can damage community teak forests.

The location of the damage mostly occurs on the lower bole of 39.29% and the upper bole of 24.24%. The second part is the shaft that is productive for wood production is mainly used for contruction wood, so that damage to the timber production can affect the quality of the wood produced. If the percentage of damage locations are divided into two categories, namely wood production through clearbole height and category for the growth of plants in the canopy. Then 70.02% location of the damage occurs at the base of the lower and upper bole, while 29.98% occurred in part plant canopy (leaves, buds and branches).

The type of damage to the plant teak in community forest is largely a low branching or excessive (38.64%) and the disturbance parasite (19.81%). Genetic factors and a lack of maintenance of the plant can cause excessive branch in teak (Soeseno, 1985). According Hasanbahri *et al.* (2014), attack effective plant parasite on the plant teak age class II and class V-VI age. While other attacks occupies 6-10% are cancer, fungal attack, resinosis and discoloration of the leaves. Cancer stem (black cancer) can be caused by fungi *Phytopthora palmivoria* and *Hypoxylon mammatum* (Sumardi and Widyastuti, 2004). While the open wounds can occur as a result of the order Coleopteran pests that can damage the skin until cambium (Kuswanto, 2003). Based on the type of damage related to the activities of the plant management, especially the maintenance of the plants (e.g. pruning, land clearing and thinning the spacing) except the leaf color change – is assumed to originate from soil fertility. Development of fungi and some other pests teak plants can occur due to climatic factors (temperature and humidity), soil, altitude and biological factors such weeds as host (Sumardi and Widyastuti, 2004; Kuswanto, 2003).

The severity of the greatest damage to the intensity of the severity of 30-29% and 40-49%, with the percentage of 29.98% and 26.73%. Hasanbahri *et al.* (2014) explained the severity of the damage caused by the parasite attack on the teak on the younger age classes (KU I and the KU II) and in older age class (KU V and KU VI) is quite high and attacked the severity of the damage teak plants can reach 20-70% in each type of damage.

Conclusion

The use of certified seed and intensive management of significant effect on plant growth teak on the community forest in humid tropic by providing the

results of the highest of the high growth of clearbole height and total height, diameter and volume of plants. Non-fulfillment of one of the factors, especially the use of uncertified seeds or unintensive crop management led to the growth of teak plants will slow or not optimal. The use of certified seed and intensive crop management showed significant effect (P<0.005) to the large number of plants grown teak healthy at 87,09% as compared to the other treatment between 44,51% -66,86%, in addition to The use of certified seed and intensive crop management was highly significant (P<0.005) to the number of plants that suffered damage mild damage, as well as heavy to very heavy damage with the smallest percentage of damage.

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