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The objective of this study was to translate interpretation of wood color by human eye into mathematical values so that scientific measurement of wood color can be studied. Using 10 species of pine and 10 species of eucalypts, collected from Wood Collection of Creswick Forestry Department, wood colors were measured using Microflash-200® in CIE standard in dry condition. The results showed that pine and eucalypts family had different average of L*, a* and b* values; and pine group was more yellow than eucalypt group.

Keywords: Wood color, perception, measurement, Microflash-200®, CIE standard, pine, eucalypts
Keywords: In-situ and ex-situ conservation, extinction, Dipterocarpaceae

This short note provided information regarding potential and natural distribution of Mersawa (Anisoptera costata Korth.) in Java. The observation was conducted in Leuweung Sancang Nature Reserve (LSNR), Java, Indonesia. Considering there was only one Mersawa tree found in an area of 1.157 ha in LSNR, we believed this species faces a serious threat of extinction. This study suggested a serious action for in-situ and ex-situ conservation of A. costata.

Keywords: Acacia nilotica, wood anatomy, fiber, utilization

The objective of this study was to observe the anatomical properties and fiber dimensions of Acacia nilotica (prickly acacia or nilotica); and discuss the possible utilization of nilotica timber. The results showed that nilotica timber had a dark brown heartwood and a reddish brown sapwood. The denser cell wall showed streaked-in tangential surfaces. The length of wood fiber decreased from pith toward periphery. Longitudinally, higher stem has shorter fiber. Nilotica has second class quality of fiber, it is not recommended for construction material, but it is suitable for carved and turnery products; charcoal and fuel wood.

Keywords: Glomus clusius, Entrophospho uninoculated (control), survival rate, mycorrhizal N, P, K, Ca and Mg content, 88.9-91 and 85-90.1, 91%. Colonization weight and total length of root length of A. scholaris is higher than A. s. A. scholaris is a medium accelerating the establishment of establishing effort.

Keywords: Glomus promoting biomass growth of A. scholaris.
The objective of this study was to determine the effect of five arbuscular mycorrhizal (AM) fungi on the early growth of *Alstonia scholaris* (milkwood) seedlings. The seedlings were inoculated with *Glomus clarum* Nicholson & Schenk, *Gigaspora decipiens* Hall & Abbott, *Glomus* sp. ACA Tulasne & Tulasne, *Entrophospora* sp. Ames & Schenieder, and *Glomus* sp. ZEA Tulasne & Tulasne, and uninoculated (control) under greenhouse conditions. Percentage of AM colonization, plant growth, survival rate, mycorrhizal dependency (MD), shoot nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) concentrations were measured after 150 days. Survival rates were higher in the AM-colonized seedlings at 150 days after transplantation than those in the control seedlings. Mycorrhizal Dependency (MD) values were 80, 78, 79, 78 and 78% in *A. scholaris* inoculated with *G. clarum*, *G. decipiens*, *Glomus* sp. ACA, *Entrophospora* sp., and *Glomus* sp. ZEA, respectively. Shoot N, P, K, Ca and Mg content of the seedlings were increased by AM fungi as much as 82-86, 81-86, 81-86, 88-91 and 85-90%, respectively. The percentage of AM colonization of *A. scholaris* ranged from 64 to 91%. Colonization by five AM fungi increased plant height, diameter, total fresh weight, total dry weight and total length root.

*Glomus clarum* was more effective in improving nutrient content and plant growth of *A. scholaris* than *G. decipiens*, *Entrophospora* sp., *Glomus* sp. ACA, *Glomus* sp. ZEA and *Glomus* sp. ACA. Total root length of *A. scholaris* ranged from 1,180 to 1,310 cm. The results suggest that AM fungi can accelerate the establishment of the seedling stocks of *A. scholaris*. This finding would contribute to the effort of establishing *A. scholaris* plantation.

Keywords: *Glomus* sp., *Gigaspora decipiens*, *Entrophospora* sp., native mycorrhizal fungi, growth promotion, seedlings, greenhouse.

I. INTRODUCTION

The Apocynaceae family is important as they provide valuable timber (Turner, 2001). It consists of 164 genera, and some of these genera, i.e. *Tabernaemontana*, *Secamone*, *Ochrosia*, *Dyera*, and *Alstonia* produce timber and nontimber forest products (NTFPs). The genera of *Alstonia* consists of 40 species, with *A. angustiloba*, *A. angustifolia*, *A. macrophylla*, *A. pneumatophora* and *A. scholaris* producing milkwood (Soerianegara and Lemmens, 1994). *A. scholaris* is a medium-sized to large tree, which can grow up to 35 m in height. Species of *A. scholaris* is common in both primary and secondary lowland evergreen to deciduous rain forest
of South Asia, Southeast Asia, Southern China and Northern Australia. Natural regeneration of *A. scholaris* occurs preferentially in open areas at forest edges and in secondary forest, and is considered to be a light-demanding species. Milkwood is suitable for boxes, pencils, crates, coffins, matches, drawing boards, and furniture components. Moreover, valuable latex is also harvested from the stem of *A. scholaris*. The latex can be used for cleaning wounds, traditional medicine and a good-quality chewing gum. In Southeast Asia *A. scholaris* is a popular medicinal plant. Its root bark is known for its antimalarial properties (Macabeo et al., 2005) and anticancer (Jagetia and Baliga, 2004). However, natural regeneration of *A. scholaris* is scarce, and seedlings found scattered or in groups, making it difficult to produce milkwood.

Deforestation rates on the Indonesian islands of Sumatra and Kalimantan are categorized the highest in the world (Linkie et al., 2004). It is necessary to accelerate reforestation and afforestation in degraded tropical forests and to enhance the commercial value of timber, pulp and NTFPs. *A. scholaris* is among species that, for its value, should be used in both rehabilitating logged over forest and development of plantation forests. The fast production of high quality seedling stocks in nurseries is valuable for replenishing degraded tropical forests. Furthermore, a lot of soils of tropical forests are infertile and the majority of Indonesian soils are ultisols, which are acid soils. Acid soils are severe environments for plants; high concentrations of Al, Mn and H, and low availability of N, P, K, Ca, and Mg will decrease the chance for many tree species to establish and survive (Postma et al., 2007).

Some studies on the effects of arbuscular mycorrhizal (AM) colonization on plant growth of some tropical trees have been well documented. Arbuscular mycorrhizal fungi increased plant growth of tropical fruit tree species of *Parkia biglobosa, Tamarindus indica,* and *Zizyphus mauritiana* at after inoculation (Guisso et al., 1998), *Tectona grandis* (Rajan et al., 2000), *Azadirachta indica* (Muthukumar et al., 2001), and *Araucaria angustifolia* (Zandavalli et al., 2004). However, little is known about AM inoculation on growth of Apocynaceae species in tropical forests. Turjaman et al. (2006) reported that AM fungi increased growth of *Dyera polyphylla* seedlings, Guadarrama et al. (2004) reported that AM fungi increased growth of *Stemmadenia donnell-smithii*, Weber et al. (1995) reported that AM fungi increased growth of *Adenium obesum, Pachypodium lamerei* and *Plumeria obtuse*. Nevertheless, to the best of our knowledge, there are no reports on the effect of the growth of *Alstonia* tree species following AM fungal inoculation. The objective of this study was to determine whether five AM fungi, *Glomus clarum* Nicholson & Schenk, *Gigaspora decipiens* Hall & Abbott, *Glomus* sp. ACA Tulasne & Tulasne, *Entrophospora* sp. Ames & Schenck, and *Glomus* sp. ZEA Tulasne & Tulasne increase early growth of *A. scholaris* under greenhouse conditions. Isolates of the five AM fungi are native to the peat swamp forests of Central Kalimantan.

### II. MATERIALS AND METHODS

#### A. Seed preparation

Seeds of *A. scholaris* were collected from the arboretum of the Forest and Nature Conservation Research and Development Center (FNCRDC), Bogor, West Java. The seeds were soaked in water for two hours and then surface-sterilized by shaking in 5% NaClO solution for 5 min. They were then thoroughly rinsed twice in sterile distilled water. The seeds
were sown in a plastic flat containing autoclave-sterilized zeolite and grown under a 55% shading intensity net to control solar radiation. The seeds were allowed to germinate for 21 days after sowing.

B. Soil medium preparation

Soil used in the experiment was an ultisol collected from the Haurbentes Experimental Forest, Jasinga, West Java (6° 32'-33' S, 108° 26' E) and stored in a greenhouse. It was passed through a five mm sieve and then mixed with river sand (3:1, v/v) to improve drainage. The pH (H₂O) of the soil mixture was 4.8, available P (Bray-1) was 0.17 mg kg⁻¹, and total N (Kjeldahl) was 1.7 mg kg⁻¹. The soil mixture was sterilized at 121°C for 30 minutes. Polyethylene pots (15 x 10 cm) were filled with 500 g of sterilized soil mixture.

C. Arbuscular mycorrhizal fungal inoculum preparation

Five AM fungi *G. clarum*, *G. decipiens*, *Glomus* sp. ACA, *Entrophospora* sp. and *Glomus* sp. ZEA were isolated from peat soil of Kalampangan, Palangkaraya, Central Kalimantan by trap culture. The pot cultures began as single spore cultures. They were propagated in pot cultures of *Pueraria javanica*. Plastic pots were filled with 175 g of sterilized zeolite and five g of AM fungal inoculum in the planting hole. Plastic pots were hung in iron racks (1.5x1x1.5m) under greenhouse floor and they were made a distance 15 cm between pot cultures to avoid contamination. The AM fungi in culture pots were checked as determined by morphological features every two weeks (for three months). A microbial filtrate was not applied to the controls to account for differences from other fungi or bacteria. A preliminary experiment showed that AM fungal inoculum was pure culture and effective without a microbial filtrate application. Two 6-day-old *P. javanica* seedlings were transplanted into the pots and grown under natural light greenhouse conditions with no temperature and humidity control. After 90 days, spores, external hyphae, and colonized roots of *G. clarum*, *G. decipiens*, *Glomus* sp. ACA, *Entrophospora* sp. and *Glomus* sp. ZEA were observed in the zeolite.

D. Plants inoculation

One 21-day-old *A. scholaris* seedling was transplanted into the pots containing sterilized soil mixture medium. The AM inoculation was achieved by placing five gram of inoculum of each species 1-3 cm below seedlings. Control seedlings were not mock-inoculated because a preliminary experiment showed that the sterilized inoculum did not affect growth of the seedlings. Seedlings were watered daily with tap water to field capacity. No fertilizer was applied during the course of the experiment. Weeds and pests were removed manually. The seedlings were grown for five months in a greenhouse at the Forest and Nature Conservation Research and Development Center, Bogor, West Java (6° 36' S, 106° 45' E). Temperature varied from 26 to 35°C, relative humidity was 80-90% and the photoperiod was about 12 h.

E. Experimental design

The experiment consisted of six treatments of *A. scholaris* seedlings (a) control (no inoculation), (b) inoculation with *G. clarum*, (c) inoculation with *G. decipiens*, (c) inoculation with *G. decipiens*; (d) inoculation with *Glomus* sp. ACA; (e) inoculation with *Entrophospora* sp.;
(f) inoculation with *Glomus* sp. ZEA. There were ten replications per treatment. Shoot height and stem diameter at one cm from the soil surface were measured five months after transplantation. After harvest, shoots and roots were separated. They were oven-dried at 70°C for 72 h before weighing. Ground shoots were digested with H$_2$SO$_4$ and H$_2$O$_2$ solution (3:1, v/v). N and P concentration in the digested solution were determined by the semi-micro Kjeldahl method and vanadomolybdate-yellow assay (Olsen and Sommers, 1982), respectively. K, Ca and Mg were determined by means of an atomic absorption spectrophotometer (Heffernan, 1985). An additional 30 seedlings each of *A. scholaris* uninoculated or inoculated with *G. clarum* or *G. decipiens* or *Glomus* sp. ACA or *Entrophospora* sp. or *Glomus* sp. ZEA were grown under the same conditions as those of the seedlings in the above experiment. Numbers of viable seedlings were counted 5 months after transplanting. Survival rate was calculated as follows:

\[
\text{Survival rate (\%) = \left(\frac{\text{number of viable seedlings}}{\text{number of initial seedlings}}\right) \times 100}
\]

Roots of *A. scholaris* were washed gently over a two mm sieve under running tap water to separate them from soil particles. The roots were cleared in 100 g l$^{-1}$ KOH for 1 h, acidified with diluted HCl and stained with 500 mg l$^{-1}$ trypan blue in lactoglycerol (Brundrett et al., 1996). Roots were destained with 50% glycerol and 30 1-cm segments were viewed under a compound microscope at x200 magnification. Percentage of AM colonization was estimated using the gridline intersect method (Giovannetti and Mosse, 1980). Mycorrhizal dependency (MD) was calculated according to Plenchette et al. (1983): MD (%) = (dry weight of mycorrhizal plant-dry weight of non mycorrhizal plant) / dry weight of mycorrhizal plant x 100. Root length were measured by gridline millimeter block.

Data were statistically analyzed using analysis of variance with the statistical software StatView 5.0 (Abacus Concepts). Comparison of means was done using the least significant difference (LSD) method at the 5% probability level where the F-value was significant.

### III. RESULTS AND DISCUSSION

The roots of *A. scholaris* were colonized by *G. clarum*, *G. decipiens*, *Glomus* sp. ACA, *Entrophospora* sp. and *Glomus* sp. ZEA 150 months after transplantation under greenhouse conditions (Table 1.). There was no difference in percentage of colonization among *G. clarum*, *G. decipiens*, *Glomus* sp. ACA, *Entrophospora* sp. and *Glomus* sp. ZEA. The control seedlings of *A. scholaris* were colonized by indigenous AM fungi. AM colonization by *G. clarum*, *G. decipiens*, *Glomus* sp. ACA, *Entrophospora* sp. and *Glomus* sp. ZEA increased plant height, stem diameter, total fresh and dry weight of *A. scholaris* 5 months after transplantation (Table 1.) and ready for planting in the field.
Table 1. Arbuscular mycorrhizal (AM) colonization, shoot and root growth of *A. scholaris* inoculated with or without AM fungi

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Plant growth</th>
<th>AM Colonization (%)*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Height (cm)*</td>
<td>Stem diameter (mm)*</td>
</tr>
<tr>
<td>No inoculation</td>
<td>16.1a</td>
<td>3.9a</td>
</tr>
<tr>
<td><em>G. clarum</em></td>
<td>33.1b</td>
<td>6.5b</td>
</tr>
<tr>
<td><em>G. decipiens</em></td>
<td>34.1b</td>
<td>6.9b</td>
</tr>
<tr>
<td><em>Glomus</em> sp. ACA</td>
<td>32.8b</td>
<td>6.8b</td>
</tr>
<tr>
<td><em>Entrophospora</em> sp.</td>
<td>36.1b</td>
<td>6.6b</td>
</tr>
<tr>
<td><em>Glomus</em> sp. ZEA</td>
<td>32.5b</td>
<td>6.5b</td>
</tr>
</tbody>
</table>

*Values with the same letter are not significantly different (P<0.05)*

This study clearly demonstrates that inoculation of five AM fungi increased the early growth and nutrient content of *A. scholaris* five months under greenhouse conditions. This species is an important tree species in tropical forest of Asia because it produces milkwood. Within the same family of Aponynaceae, the growth of AM seedlings of *A. scholaris* is better than AM seedlings of *Dyera polyphylla* (Turjaman *et al.*, 2006). The AM seedlings of *A. scholaris* can be planted in the field after five months in greenhouse or nursery. Shoot height, stem diameter, and total dry weight were also increased by inoculation of AM fungi. These parameters can determine the value of *A. scholaris* as the milkwood. The improvement of early growth of these species would increase production of the milkwood. Moreover, inoculation of AM fungi would be useful for production of *A. scholaris* because this species is often scarce and found scattered or in groups in natural tropical forests.

Nutrient concentrations were higher in shoots of *A. scholaris* inoculated with *G. clarum*, *G. decipiens*, *Glomus* sp. ACA, *Entrophospora* sp., and *Glomus* sp. ZEA than those of control seedlings (Table 2.). The inoculation of *A. scholaris* by five AM fungi also increased their shoot N, P, K, Ca and Mg content. Arbuscular mycorrhizal colonization by five AM fungi increased shoot N, P, K, Ca and Mg content of *A. scholaris*. There was no difference in shoot N, P, K, Ca and Mg content of *A. scholaris* among *G. clarum*, *G. decipiens*, *Glomus* sp. ACA, *Entrophospora* sp., and *Glomus* sp. ZEA. Shoot nutrient concentrations and content of *A. scholaris* were higher in the seedlings inoculated with *G. clarum* than *G. decipiens*, *Glomus* sp. ACA, *Entrophospora* sp., and *Glomus* sp. ZEA treatments. Shoot nutrient concentrations of *A. scholaris* were higher in the AM seedlings than in the control seedlings, indicating that in the absence of AM associations, *A. scholaris* was not capable to absorb enough N, P, K, Ca and Mg from the soil and keep adequate levels in their tissues. Arbuscular mycorhizal seedling inoculated by *G. clarum* increased their shoot N, P, K, Ca and Mg concentrations by 27, 33, 30, 55, and 47%, respectively. Similar results, was reported by Zandavalli *et al.* (2004) that *Araucaria angustifolia*...
inoculated by *G. clarum* increased their shoot N, P, K concentrations, except for shoot Ca and Mg concentrations of inoculated plants were not different with control seedlings. Soil bases such as Mg and Ca have a role in root colonization and sporulation of AM fungi (Jarstfer et al., 1998). Moreover, high Mg/low Ca shoot concentrations induced premature root senescence, which may have disturbed the AM association process, indicating the importance of Ca for the maintenance of a functioning AM symbiosis. In addition, Cuenca and Azcón (1994) reported that AM fungi *G. etunicatum* was not only increasing the N, P, Ca, Mg and Zn uptake of tropical tree *Erythrina poeppigiana* in the presence of NO₃ fertilizer, but also P and Mg in the presence of NH₄ applications. The AM colonization by *G. clarum*, *G. decipiens*, *Glomus* sp. ACA, *Entrophospora* sp. and *Glomus* sp. ZEA increased also the nutrient content. Shoot height, stem diameter, fresh and dry weight were also increased by inoculating those five AM fungi. Increases of these parameters may lead to increase benefit from the milkwood and medicinal plant of *A. scholaris*. Furthermore, AM fungal inoculation induces healthy and vigorous growth of seedlings, which would be helpful to reforestation and afforestation activities. AM colonization also increased nutrient content of N, P, K, Ca, and Mg of *A. scholaris*. Shoot N, P, K, Ca, and Mg content of the AM inoculated seedlings were increased by 82-86, 81-86, 81-86, 88-91, and 85-90%, respectively. Fertilizers are generally of benefit to the tree, not the site, and measurable permanent site improvement is only likely if the amount of nutrient applied is large in relation to the soil fertility (Miller, 1981). Fertilization has been generally applied to *A. scholaris* in nursery on the commercial scale. Fertilization had the most dramatic effect and caused a decrease of AM colonization and thereafter reduces growth improvement by AM fungi (Titus and Lepš, 2000). Effective AM fungal inoculum could be produced on the commercial scale and at low cost production, therefore application of AM fungi can minimize fertilization without diminish AM growth enhancement of *A. scholaris*.

Table 2. Shoot nutrient concentration and content of *A. scholaris* inoculated with or without AM fungi

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Shoot Nutrient Concentration (mg/g)</th>
<th>Shoot Nutrient Content (mg/plant)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>P</td>
</tr>
<tr>
<td>Control</td>
<td>6.7a</td>
<td>1.4a</td>
</tr>
<tr>
<td><em>G. clarum</em></td>
<td>9.2c</td>
<td>2.1c</td>
</tr>
<tr>
<td><em>G. decipiens</em></td>
<td>8.8c</td>
<td>1.9b</td>
</tr>
<tr>
<td><em>Glomus</em> sp. ACA</td>
<td>7.8b</td>
<td>1.8b</td>
</tr>
<tr>
<td><em>Entrophospora</em> sp.</td>
<td>7.9b</td>
<td>1.7b</td>
</tr>
<tr>
<td><em>Glomus</em> sp. ZEA</td>
<td>8.6c</td>
<td>1.8b</td>
</tr>
</tbody>
</table>

*Values with the same letter are not significantly different (P<0.05)*
Arbuscular Mycorrhizal Fungi ..... M. Turjaman, E. Santoso, and K. Tawaraya

*Entrophospora* sp. and *Glomus* sp. ZEA increased the survival rates of *A. scholaris* 5 months after transplantation under greenhouse conditions. The survival rates of *A. scholaris* inoculated with *G. clarum* (93%), *G. decipiens* (100%), *Glomus* sp. ACA (100%), *Entrophospora* sp. (100%) and *Glomus* sp. ZEA (100%) were higher than control seedlings (80%). The *A. scholaris* seedlings inoculated with *G. clarum, G. decipiens, Glomus* sp. ACA, *Entrophospora* sp. and *Glomus* sp. ZEA were not different in survival rates. The survival rate of *A. scholaris* seedlings is an evaluation decisive factor of success in reforestation and afforestation programs. These results also have a number implication for forest plantation management of *A. scholaris*. This species can be planted as monoculture or agroforestry systems because *A. scholaris* is a fast growing species and almost similar growth performance with plantation forest industry species like *Acacia, Eucalyptus* and *Gmelina*. In South Sumatra (Indonesia), a forest plantation company has a sharing with local farmers to establish forest plantation industry for supplying raw materials of pencil. They provide *A. scholaris* to farmers who are planting and maintaining the seedlings in their forest gardens. The forest plantation company or farmers may get yield and increase production of *A. scholaris* inoculated by AM fungi.

Arbuscular mycorrhizal colonization by five AM fungi increased total root length, total first roots, total second roots and total third roots of *A. scholaris* (Table 3). There was no difference in total root length, total first roots, total second roots and total third roots of *A. scholaris* among *G. clarum, G. decipiens, Glomus* sp. ACA, *Entrophospora* sp. and *Glomus* sp. ZEA. There was no difference in total main root of *A. scholaris* between five AM fungi and control seedlings. The AM increased total root length of *A. scholaris*. Even though colonization by AM fungi characteristic results in more numerous lateral roots in the hosts, these are much shorter than in non-colonized root systems (Berta et al., 1993). The AM seedlings can increase the length and fineness of their roots or the length and density of their root hairs in the response to P deficiency (Trolove et al., 2003). AM seedlings are able to obtain more nutrients from nutrient-deficient soils than are control seedlings because hyphae exploit a greater volume of soil than roots alone (Entry et al., 2002). AM enhances plant acquisition of nutrients by increasing the absorptive surface area of the uptake system. P uptake is most likely the best described process in the AM associations, with the fungi supplying host plants with P in exchange for carbon (Smith and Read, 1997). In a greenhouse study, Inoculation of AM fungi increased soil compaction reduced root length, AM formation, root dry weight, P content and shoot growth on *Cajanus cajan* L. (Yano et al., 1998), *Trifolium subterraneum* L. (Nadian et al., 1997), *Trifolium pratense* L. (Li et al., 1997). The proportion of root length colonized by the fungus increases with decreasing nutrient availability (Graham et al., 1997).

Table 3. Total length roots of *A. scholaris* inoculated with or without AM fungi

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Root length (cm)</th>
<th>Total root length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>main root</td>
<td>1st root</td>
</tr>
<tr>
<td>Control</td>
<td>15.4 a</td>
<td>88.6 a</td>
</tr>
<tr>
<td><em>G. clarum</em></td>
<td>16.9 a</td>
<td>410.8 b</td>
</tr>
<tr>
<td><em>G. decipiens</em></td>
<td>17.5 a</td>
<td>440.6 b</td>
</tr>
<tr>
<td><em>Glomus</em> sp. ACA</td>
<td>18.6 a</td>
<td>384.6 b</td>
</tr>
<tr>
<td><em>Entrophospora</em> sp.</td>
<td>16.6 a</td>
<td>363.6 b</td>
</tr>
<tr>
<td><em>Glomus</em> sp. ZEA</td>
<td>15.1 a</td>
<td>378.7 b</td>
</tr>
</tbody>
</table>

*Values with the same letter are not significantly different (P<0.05).*

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For a given fungus, Mycorrhizal Dependency (MD) values were 80, 78, 79, 78 and 78% in *A. scholaris* inoculated with *G. clarum*, *G. decipiens*, *Glomus* sp. ACA, *Entrophospora* sp. and *Glomus* sp. ZEA, respectively. The MD in acid soil was higher (>75%) in *A. scholaris* inoculated with AM fungi. *A. scholaris* was very highly dependent according to the MD categories defined by Habte and Manajunath (1991). *A. scholaris* responded to the AM colonization more largely. The MD proposed that AM inoculation would be valuable in production of vigorous seedlings in the nursery which might establish in the field conditions and might be more resistant to drought stress, nutrient deficiency and pathogenic infection (Wilson *et al.*, 1991; Ghosh and Verma, 2006). Moreover, Cáceres and Cuenca (2006) reported that MD has other functions in two tropical species from Venezuela *Clusia minor* and *Clusia multiflora* in two soils with different pH. Both tree species were found to be highly dependent on AM fungi for their growth in acidic soil, and there was an inverse relationship between dependency of the species and the soil phosphorus content.

IV. CONCLUSIONS

This study is the first report of which we are aware concerning the inoculation of AM fungi on the growth of milkwood tropical tree species *A. scholaris*. Colonization by five AM fungi increased shoot nutrient content, plant growth, and survival rates of *A. scholaris* seedlings 5 months after transplantation under greenhouse conditions. *Glomus clarum* was more effective in improving nutrient content and plant growth of *A. scholaris* than *G. decipiens*, *Entrophospora* sp., *Glomus* sp. ZEA, and *Glomus* sp. ACA. Field trials with AM fungal inoculation are required to monitor the growth and survival rates of *A. scholaris*. Inoculation techniques may be adopted by a large scale nursery jointly with reforestation and afforestation programs, thereby aiding in the increase of the milkwood production of such tropical tree species as *A. scholaris*. These results suggested that AM fungi increased the establishment of the planting stocks of *A. scholaris*, thereby sustaining the production of milkwood *A. scholaris*.

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GROWTH OF RAMIN (Gonystylus bancanus (Miq) Kurz.) PLANTATION ON VARIOUS PEAT SWAMP FORESTS IN INDONESIA

Tati Rostiwati1, 2, Murniati3 and Hendromono3

ABSTRACT

Ramin (Gonystylus bancanus (Miq) Kurz.) is a trade name of timber produced from a group of Gonystylus species. It is a well-known species because of its high timber quality and value. Ramin natural population has been decreasing sharply since the last two decades due to over exploitation, and nowadays leads to extinction. The objective of this research was to analyze the growth of ramin plantation on various sites. Data were collected from February to April 2005 through field survey on five sites of peat-swamp forest areas in four provinces, Riau, Jambi, West and Central Kalimantan. The result showed that ramin annual early growth varied across sites. It grew better on deep peat soil (3 - 4 m in depth) and under moderate shading (55 - 60%) during early growth. The highest early height growth (52.27 cm/year) occurred at Sei Bakau, West Kalimantan. Whereas, it highest early diameter growth (0.73 cm/year) was found at Rokan Hilir, Riau. The characteristics of site are very important for a successful growth of ramin plantation, including peat depth and level of shading. Annual early growth of ramin as along in line with increasing of the plant age, namely a four-times increase of plant age (from 1.6 - 2 years to 6.5 - 7.3 years), the annual early height and diameter growth decreased until they reached a half and one third of the starting values. Since the growth of ramin is very slow, it is necessary to find and develop technologies to accelerate growth rate of the ramin plants. Application of mycorrhizal fungal inoculum is a promising technology, but their role in promoting ramin growth and the needed cost must be tested and analyzed under various conditions of the peat-swamp soils in Indonesia.

Keywords: Early growth, site characteristics, peat-swamp forest, peat depth, shading

I. INTRODUCTION

Gonystylus bancanus (Miq.) Kurz (ramin) is species with a medium-large trunk, measuring 40 to 45 m tall, up to 120 cm in diameter. The species natural distribution includes south-western Peninsular Malaysia, south-eastern Sumatra, Bangka and Borneo (Soerianegara and Lemmens, 1994). Ramin grows in small groups of an association at lowland freshwater swamp or peat-swamp forests not affected by tidal waters but often found in broad belts along the coast. Most ramin forests are subject to periodic inundation, but the species is also found in non-inundated areas up to 100 m above sea level. Ramin forest is occasionally found in pure stands e.g. in Sarawak.

In the early 1980s, Indonesia is the largest exporter of ramin timber, especially sawn-wood, accounting for 38% in volume and 46% in value of the total export, followed by

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Sarawak and Peninsular Malaysia. The average annual export was 598,000 m$^3$ with a value of US$119 million. In 1987, the export of sawn ramin was 299,000 m$^3$ (with a value of US$86 million) and in 1988 it was 224,000 m$^3$ (with a value of US$74 million) (Soerianegara and Lemmens, 1994).

Ramin natural population has been decreasing sharply since the last two decades due to over exploitation, and nowadays is leading to extinction. In order to protect the population of ramin in natural forests, a ban on ramin logging and trade was issued through the decree of Minister of Forestry No. 127/Kpts-IV/2001. It is meant to be a temporary stop of logging and trade of ramin, or called ramin moratorium. Only eco-label certified company is allowed to cut ramin trees and it should be recommended by Indonesian Institute of Science (Lembaga Ilmu Pengetahuan Indonesia/LIPI). In addition, ramin wood was included in Appendix II of the CITES (Anonymous, 2004).

Although ramin in natural peat-swamp forests nearly extincts, there has not been enough initiatives to develop ramin plantation yet. The lack of technical information is perhaps among the reasons. Research on silviculture of ramin was started by Alrasyid and Soerianegara in 1978. However, those researches were discontinued for about a decade, until it was initiated again around 1994. Istomo (1994) reported there was a significant correlation between existing of ramin in natural peat-swamp forest and thickness of the peat: the deeper the peat, furthermore ramin trees were found. Ramin trees were dominant at peat depth of 350 to 600 cm. He indicated that the growth behaviour of ramin species was semi-tolerant, at seedling and sapling stages, they did not need much sunlight. However, at pole stage they need more sunlight and at tree stage they can receive full sunlight as the ramin canopy occupied stratum A of the forest canopy. This ramin behaviour implies that a silviculture treatment is needed at the pole stage to help ramins obtain canopy opening in the forest. This finding confirmed a previous study by Soediarto et al. (1963), who reported that ramin trees needed sunlight, even though they need shading at seedling stage.

This study may be perceived by a continuation of previous researches. The objective of this research was to analyze the growth of ramin plantation on various sites. The information obtained would be necessary for supporting development of ramin plantation across different sites in Indonesia.

II. MATERIALS AND METHODS

A. Time and Location

The research was carried out from February to April 2005. Direct observation was carried out in five sites (four provinces) of ramin plantations. Table 1 presents the five sites including it's characteristics.

B. Research Method

Height and diameter of young ramin trees were measured at the five sample plots of ramin plantations. The sampling intensity ranged from 3 to 33 % of the ramin populations.
The size of ramin population and the sampling intensity used at each site are presented in Table 1.

C. Data Analysis

Data analysis is mainly calculation of early growth. The formulas used are, as follows:

\[
\text{Early height growth} = \frac{\text{Average height at measurement time} - \text{Average height of seedlings}}{\text{Plant age (years)}}
\]

\[
\text{Early diameter growth} = \frac{\text{Average diameter at measurement time} - \text{Average diameter of seedlings}}{\text{Plant age (years)}}
\]

Tabel 1. The size of ramin population and the sampling intensity at five sites

<table>
<thead>
<tr>
<th>No.</th>
<th>Site and Company/Institution</th>
<th>Site Characteristic</th>
<th>Size of Population (plants or ha) and Sampling Intensity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rokan Hilir, Riau PT Diamond Raya Timber (PT. DRT)</td>
<td>Thickness of peat: 3.5 to 5 m; Level of periodic inundating: 0 to 15 cm; Vegetation: secondary forest; Light intensity: ± 60%; Rainfall: 2637 mm/year; Altitude: 2 to 25 m asl</td>
<td>120 plants; 33%</td>
</tr>
<tr>
<td>2</td>
<td>Muara Jambi, Jambi PT Putraduta Indah Wood (PT. PIW)</td>
<td>Thickness of peat: 2 to 6 m; Level of periodic inundating: 20 cm; Vegetation: fern and alang-alang grass; Light intensity: ± 70%; Rainfall: 2000 - 2500 mm/year; Altitude: 10 - 30 m asl</td>
<td>6 ha; 3%</td>
</tr>
<tr>
<td>3</td>
<td>Sei Bakau, West Kalimantan Tanjungpura University</td>
<td>Thickness of peat: 0.6 - 4 m; Level of periodic inundating: 5 to 50 cm; Vegetation: secondary forest; Light intensity: 55%; Rainfall: 1100 - 3300 mm/year; Altitude: 10 m asl</td>
<td>1.5 ha; 20%</td>
</tr>
<tr>
<td>4</td>
<td>Mandor, West Kalimantan PT. Inhutani II</td>
<td>Thickness of peat: 0.6 - 1 m; Level of periodic inundating: 5 – 50 cm; Vegetation: shrubs; Light intensity: ± 50%; Rainfall: 3154 mm/year; Altitude: 0.5 m asl</td>
<td>36 plants; 22%</td>
</tr>
<tr>
<td>5</td>
<td>Teluk Umpan, Central Kalimantan BP2HT-IBB</td>
<td>Thickness of peat: &gt;5 m; Level of periodic inundating: 10 - 40 cm; Vegetation: secondary forest; Light intensity: ± 40%; Rainfall: 780 - 2660 mm/year; Altitude: 0 - 10 m asl</td>
<td>150 plants; 20%</td>
</tr>
</tbody>
</table>
III. RESULTS AND DISCUSSION

A. Results

Growth behavior of ramin species is semi-tolerant and the trees tend to be dominant at deep peat soils. It indicates that the important site characteristics for ramin growth are light intensity and thickness of the peat. Hence, measured height and stem diameter of ramin plants as well as their increment per year at five sites are listed according to light intensities and thicknesses of the peat (Table 2).

Table 2. Average of actual height and stem diameter of ramin plants as well as their early growth per year at five sites

<table>
<thead>
<tr>
<th>Site</th>
<th>Plant Age (years)</th>
<th>Site Characteristics</th>
<th>Strip</th>
<th>Average Height (cm)</th>
<th>Average Diameter (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rokan Hilir, Riau</td>
<td>1.6</td>
<td>3.5 - 5</td>
<td>± 60</td>
<td>1</td>
<td>81.50 1.83</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>82.63 1.68</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>60.63 1.45</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
<td>70.75 1.22</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5</td>
<td>60.57 1.29</td>
</tr>
<tr>
<td>Annual Early Growth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>34.24 0.73</td>
</tr>
<tr>
<td>Muara Jambi, Jambi</td>
<td>3.5</td>
<td>2 - 6</td>
<td>± 70</td>
<td>1</td>
<td>49.34 0.98</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>38.71 0.91</td>
</tr>
<tr>
<td>Annual Early Growth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.58 0.13</td>
</tr>
<tr>
<td>Sei Bakau, West Kalimantan</td>
<td>2</td>
<td>0.6 - 4</td>
<td>± 55%</td>
<td></td>
<td>141.13 1.536</td>
</tr>
<tr>
<td>Annual Early Growth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>50.27 0.49</td>
</tr>
<tr>
<td>Mandor, West Kalimantan</td>
<td>7.3</td>
<td>0.6 - 1</td>
<td>± 50</td>
<td></td>
<td>160.19 2.125</td>
</tr>
<tr>
<td>Annual Early Growth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>19.20 0.24</td>
</tr>
<tr>
<td>Teluk Umpan, Central Kalimantan</td>
<td>6.5</td>
<td>&gt; 6</td>
<td>±40</td>
<td>1</td>
<td>149.00 0.910</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>157.00 0.910</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>228.00 1.640</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
<td>71.00 0.580</td>
</tr>
<tr>
<td>Annual Early Growth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>23.27 0.16</td>
</tr>
</tbody>
</table>
Differences of height and diameter growth rate (annual early growth) of ramin plants among five sites are presented in Figure 1 and 2.

Figure 1. Annual early height growth of ramin plants on five sites (different thickness of peat and light intensity). Rokan Hilir (3.5 - 5 m; 60%), Muara Jambi (2 - 6 m; 70%), Sei Bakau (0.6 - 4 m; 55%), Mandor (0.6 - 1 m; 50%) and T. Umpan (> 6 m; 40%)

Figure 2. Annual early diameter growth of ramin plants on five sites (different thickness of peat and light intensity). Rokan Hilir (3.5 - 5 m; 60%), Muara Jambi (2 - 6 m; 70%), Sei Bakau (0.6 - 4 m; 55%), Mandor (0.6 - 1 m; 50%) and T. Umpan (> 6 m; 40%)
The highest annual early height growth of ramin plants was found at Sei Bakau, West Kalimantan with 0.6 to 4 m of peat depth and 55% of light intensity, while the highest annual early diameter growth was showed by ramin plants growing on 3.5 to 5 m depth of peat and under 60% of light intensity at Rokan Hilir, Riau. It means that the height growth was faster under 55% light intensity than that under 60% of light intensity, and diameter growth was faster under 60% of light intensity compared to that under 55% of light intensity. The lowest annual increment, both height and diameter, of ramin plants was found at Muara Jambi with 2 to 6 m of peat depth and 70% of light intensity. The very young ramin planted at Rokan Hilir and Sei Bakau (1.6 to 2 years old) indicated that the growth was much faster (more or less two times) compared to ramin planted at Mandor and Teluk Umpan that were much older (6.5 to 7.3 years old). Ramin grew at Mandor and Teluk Umpan with very different peat depth (Mandor: 0.6 to 1 m and Teluk Umpan: > 6 m) showed the most similar increment of height and diameter. Annual early height growth of ramin plants at Teluk Umpan with light intensity 40% was slightly higher than those found at Mandor with 50% of light intensity.

B. Discussion

The annual early height growth of ramin planted at four of these five study sites, ranging from 19.20 to 50.27 cm, was higher than the annual height early growth of ramin reported in some previous studies. Soerianegara and Lemmens (1994) reported that the height growth of ramin planted from nursery seedlings were 12.4 cm per year, while Soerianegara et al. (1996) informed the early height growth of ramin planted on peat soil with depth 50 to 200 cm was 14.42 cm per year. The highest increments in natural condition may be because a sufficient light intensity received by the young plants. Other more recently studies on ramin growth are by Muin and Purwita (2002) and Muin (2004) that informed the annual height increment of ramin planted under moderate shading were 20.88 cm and 48.4 cm, respectively. Compared to these reports, our findings showed a higher annual early growth values than those found by Muin and Purwita (2002), but only Sei Bakau ramin plantation had higher annual increment than those found by Muin (2004). The highest annual height increment of ramin planted at Sei Bakau compared to the other four study of this study and the other previous findings indicated an appropriate site characteristics, and intensive plantation maintenance. Bastoni (1999) and Bastoni and Sianturi (2000) suggested that horizontal liberation cutting should be done three times during the first year of ramin plantation. Further, Riyanto (1999) explained that the horizontal liberation cutting treatment showed a positive response to annual increment of ramin plants.

The annual early diameter growth of ramin planted at Rokan Hilir showed the highest value among all ramin plantation sites observed, followed by ramin plants at Sei Bakau. These annual diameter increments of ramin planted at the two different sites (Rokan Hilir and Sei Bakau) were higher than the other information available previously (Daryono, 1996; Muin and Purwita, 2002) except for report by Soerianegara et al. (1996). The annual diameter increment of ramin plants during their early growth reported by Soerianegara et al. (1996) was 1.81 cm at deeper peat (100 - 200 cm) and 0.94 cm at shallower peat (50 - 100 cm). However, they did not explain the light intensity of the experiment site.

Annual early growth, either height or diameter, of ramin planted along left and right side of the railway track of PT. PIW in Muara Jambi was very low (early height growth: 2.58 cm
and early diameter growth: 0.13 cm per year). This annual growth was the lowest one compared to the other previous findings (Soerianegara and Lemmens, 1994; Daryono, 1996; Soerianegara et al., 1996; Muin and Purwita, 2002) and to this current study. This is assumed because the site was nearly full open area with undergrowth vegetation of fern and alang-alang. The ramin plants were exposed to a high competition from these weed is due to no plantation maintenance at all. Previous research showed that ramin at early growth in the field needed moderate shade, because ramin is semi-tolerant species. When the height of ramin seedlings was less than 50 cm, they needed moderate shading (between 35 and 65 %), however after the seedlings reached height of more than 50 cm, vertical liberation by cutting of non-commercial trees and shrubs around seedlings may increase the growth of seedlings in the field (Muin and Purwita, 2002).

When the growth of ramin at Sei Bakau is compared to the growth of ramin at Mandor with nearly similar light intensity, it was clearly that the growth of ramin at Mandor was much lower than that of ramin at Sei Bakau. This perhaps is related mainly to the thickness of the peat, where at Sei Bakau site, the depth of the peat was 60 to 400 cm, while at Mandor plantation it was less than 100 cm.

In Teluk Umpan, Central Kalimantan, annual early height growth for 6.5 year old ramin plants was 23.27 cm and yearly diameter early growth was 0.16 cm. Measurement at the same area when the ramin plants were 5 years old showed that the annual height increment was 20.01 cm and stem diameter increment was 0.27 cm (Daryono, 1996). Those two time series of data indicated that during period of fifth to sixth year of the ramin age, height growth was more dominant than diameter growth. This is caused by the need of the ramin plants to catch more sunlight at that stage and this in line with Soediarto et al. (1963) study that ramin trees needed sunlight although at seedling stage they needed shading.

Analysis of a data series on the annual early growth of ramin plants at four sites (Rokan Hilir, Sei Bakau, Mandor and Teluk Umpan) with different age ranging from 1.6 to 7.3 years indicated that the stage of growth has a tight correlation to the early growth of the ramin plants. Annual early growth of ramin is decreasing in line with the increasing of the plant age. The correlations are as follows.

- By increasing of plant age four times (from 1.6 - 2 years to 6.5 - 7.3 years), the annual early height growth decreased until it reaches a half of the starting value (from average 42.25 cm to 21.24 cm)
- By increasing of plant age four times (from 1.6 - 2 years to 6.5 - 7.3 years), the annual early diameter growth decreased to one third of the starting value (from average 0.61 cm to 0.22 cm).

Based on the literature reviews and direct measurements of ramin growth in the fields, it can be stated that growth of ramin plants is very slow with the highest annual height and diameter growth were 50.27 cm and 0.73 cm, respectively. Therefore, it is necessary to find and to develop a technology to accelerate growth rate of the ramin plants. Application of mycorrhizal fungal inoculum is a promising technology, but their role in promoting the ramin growth and the needed cost must be tested and analyzed under various conditions of the peat-swamp soils in Indonesia.
IV. CONCLUSIONS

1. Moderate shading with light intensity from 55 to 60% and deep peat soil ranging from 3 to 4 m is an appropriate site characteristics to obtain a maximum annual increment of ramin. The highest annual height early growth was 50.27 cm found at Sei Bakau, West Kalimantan and the highest annual diameter early growth was 0.73 cm obtained at Rokan Hilir, Riau.

2. The growth of ramin plants is very slow. Therefore, it is necessary to find and to develop a technology to accelerate growth rate of the ramin plants. Application of mycorrhizal fungal inoculum is a promising technology, but their role in promoting the ramin growth and the needed cost must be tested and analyzed under various conditions of the peat-swamp soils in Indonesia.

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Growth of Ramin ..... T. Rostiwati, Murniati, and Hendromono

Tanjungpura, Pontianak. 34 pp.


COLOR DIFFERENCES OF PINE AND EUCALYPT WOODS MEASURED BY MICROFLASH-200®

Krisdianto1

ABSTRACT

It is not easy to define color because it refers to psychological response of human. As a result, perception of color achieved by people is relatively different. Wood color plays an important role in timber processing and it is an important consideration in wood identification. Each wood species has specific color and it becomes the species characteristic. Colors in wood are highly variable and unique features. Characteristics of wood color are influenced by extractive materials and moisture contents present on it. A standard of color measurement has been developed and it is called CIE model. The standard was developed to be completely independent of any devices and was based as closely as possible on human observation in color. CIELAB system is one of the simplest and most practical color measurement methods. The system has been used in one of the color measurement devices developed by Data Color International that is Microflash-200®. This research was aimed at translating interpretation of wood color by human eye into mathematical values so that scientific measurement of wood color can be studied. The measured wood color were 10 species of pines and 10 species of eucalypts woods in dry condition. The results showed that the two groups had different average of L*, a* and b* values. The average of L* for pine was 70.77, while eucalypt group made up to 52.40. It means that eucalypt group is darker than pine group. For a* value, pine group mean value is 20.23, whereas eucalypt group touches 19.11. In other words, pine and eucalypt group have an approximately similar redness. The b* value average for pine and eucalypt groups are 43.40 and 29.07, respectively. This value means that pine group is more yellow than eucalypt group.

Keywords: Wood color, perception, measurement, Microflash-200®, pine, eucalypts

I. INTRODUCTION

Defining color is not easy because it is not physically real. It refers to the psychological response of eye-brain combination to light waves falling upon the light-sensitive retina, which composes the inner surface of the eye. Sensitivity of the eye to color depends not only upon the light intensity, but also upon which area of the retina is being stimulated (Tilley, 1999). This condition causes different interpretation of color achieved by people.

Principally, there are three elements that build interpretation of color to the human eyes. These elements, which are known as triplet values, include the light source, the object and the observer. In order to measure the color scientifically, all of the elements must be measured in a standard condition (Boardman et al., 1992). Despite the complexity of the concept of color, all colors can be precisely specified by three parameters. These are hue, saturation and lightness. Hue corresponds to the wavelength or frequency of the radiation. The hue is given

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a color name such as red or yellow. Saturation or chroma represents the amount of white light into the hue. Lightness, brightness or value describes the intensity of the color, the number of photons reaching the eye (Chrisment, 1998).

Color in a wood is a highly variable and unique feature. Characteristic of wood color is influenced by the presence of extractive materials (Jane, 1970). The more the extractive materials, the darker the timber. This fact can be seen from color difference between sapwood and heartwood. Accumulation of extractive in heartwood, make it darker than sapwood. Timber color is also induced by its moisture content. The higher the moisture content in a timber, the stronger the color will be. Another factor that determine wood color is the length of time on which wood surfaces have been exposed to air or sunlight. The longer wood exposed to the sunlight the lighter the wood color (Ilic, 1990).

Wood color plays an important role in timber processing. In a pulp industry, for example, wood color associates with extractive content. The darker the color of wood, the greater the extractives content. In a pulp processing, darker timber, which means high in extractives content gives low yields of pulp. Pulpwood from lightly colored tree will be superior to that of darker colored species of similar density and fibre dimensions (Schimleck and Michell, 1997).

Natural timber color is also one of the important considerations in wood identification (Boardman et al., 1992). Each wood species has specific color that becomes species characteristics. There are groups of wooden species that have dark color, such as ebony (Diospyros celebica), ulin (Eusideroxylon zwageri), johar (Anthocephalus cadamba) and sonokeling (Pterocarpus indicus), while those of light colored include pine (Pinus spp.), sungkai (Peronema canescens), pulai (Alstonia scholaris) and gmelina (Gmelina arborea). Mahogany that has specific red color was popularly known as red wood.

Color is one of the important parameters for wood identification. Wood colors might be brown, white, yellow, brown or reddish-brown, or a tint in between. Due to its variability, wood color is not easy to define, especially if it is in intermediate colors. In 1990, Ilic has classified wood color into ten color standards to assist with color assessment. The color standards consist of straw, yellow-brown, brown, orange-brown, pinkish-brown, reddish-brown, chocolate-brown, greenish-brown, mauve-tint and bright-yellow. Figure 1. shows the ten of wood color standards.
Figure 1. Color chart for the assessment and matching of colors in wood (Source: Ilic, 1990).

Based on wood color standards, the specimen is matched into the closest standard. However, this color matching is not accurate enough. As mentioned before, the interpretation of color highly depends on humans eye observation and lighting condition. This fact shows that an accurate standard is needed to measure wood color (Nishino et al, 1998).

The developed general standard for color measurement is called Commission Internationale de l’Eclairage (CIE) model. The derived model response to various concerns, such as textile and automotive industry. The standards were developed to be completely independent of any devices and were based as closely as possible on human observation in color. Unlike the RGB and CYMK color models, Lab color or known as CIELAB is designed to approximate human vision. It aspires to perceptual uniformity. The three basics coordinates represent the lightness of the color ($L^*$, $L^* = 0$ yields black and $L^* = 100$ indicates white), its positions between red/magenta and green ($a^*$, negative value indicate green, while positive values indicate magenta) and its position between yellow and blue ($b^*$, negative values indicate blue and positive values indicate yellow). CIELAB system is one of the simplest and most practical color measurement method as long as colorimeter instrument is available. In the last ten years, Data Color International has developed colorimetric measuring instrument. One of them is Microflash-200®, which was designed based on CIE standard sources (1931) and the CIE observer standard 2 field of vision (1931) and 10 field of vision (XYZ, 2001).

Microflash-200® is believed to be a stable measurement which has capability of repeatable measurements with high level of accuracy. This tool is also faster, lighter and smaller than other tools. It offers capability of analyzing diverse samples, more flexibility in the processing of information and easy use, as well as less cost.

This research was aimed at translating interpretation of wood color by human eye into mathematical values, so that wood color measurement can be scientifically defined. The tool used in this research was the one developed by the CIE system called Microflash-200®.
II. MATERIALS AND METHODS

Measured wood samples in this study were 10 species of pine woods (*Pinus* sp.) and 10 species of eucalypt woods (*Eucalyptus* sp.), which were collected from wood collection of Creswick School of Forestry, Australia. In order to have similar condition of finished product, samples were measured in air dry condition.

Specimens were measured using Microflash-200® in CIE standard, which were mostly implemented by color observer for solid material. The standard of illuminant A and the standard observer 10 were used. Illuminant A represented the light source from a tungsten lamp at 2856K, whereas the standard observer 10 meant that an observer viewed the sample at the angle of 10 degree. The diameter of sensor head was 6 mm (SAV = small area view). Every specimen was measured 10 times in tangential surfaces of the plank (Figure 2). The final colourimeter value every species was the average of measurement.

![Figure 2. Ten measurements of the wood plank](image)

III. RESULTS AND DISCUSSION

The results of 20 species wood color measurement, values are averaged from 10 times measurements (Table 1).
The values indicated that, L*, a* and b* have a different pattern. The differences can be seen in Figure 3a and b.
Figure 3. Color value L* a* b* of pine species (a) and eucalypts species (b)

As seen in Figure 3, the measurement of wood color of the two groups of the wood resulted in different average L*, a* and b* values. Generally, pine timber species have higher L* and b* value than eucalypts species, while a* values are approximately similar on both groups. Among pine wood species, P. palustris has the lowest L* value, while P. canariensis has the highest value of L* value. In human perception P. palustris is darker than P. canariensis. In the eucalypts groups, E. gummifera has the lowest L* value, while E. viminalis has the lowest value. In other words, E. viminalis is darker than E. gummifera. The measurement result in comparison between two groups is shown in Figure 4.
Figure 4. Wood color of pine and eucalypt
Remarks: (L*) Lightness values, (a*). Position between red and green, (b*) Position between yellow and blue

The three basic coordinates represent the lightness of the color (L*), its position between red or magenta and green (a*) and its position between yellow and blue (b*). The value of L* = 0 yields black and L* = 100 indicates white, while negative value of a* indicates green and positive indicates magenta. The negative value of b* indicates blue and positive
values indicates yellow. The measurement shows that the two groups had different average of L*, a* and b* values. The average of L* for the pine sample group is 70.77, while eucalypt group makes up to 52.40. It means that eucalypt group is darker than pine group. For a* value, pine group mean value is 20.23, whereas eucalypt group touches 19.11. In other words, pine and eucalypt group have an approximately similar redness. The b* value average for pine and eucalypt groups are 43.40 and 29.07, respectively. This value means that pine group is more yellow than eucalypt group.

As mentioned before, Lab system is designed to approximate human vision. In comparison with human eye, the perception is easily put on L* value, while the a* and b* value are hard to identify. In other word, human perception point out euclaypts group is darker than pine, while the redness and yellowness is different to any people.

The result of paired sample t-test of L*, a* and b* value is shown in Table 2.

Table 2. Paired samples t-test result

<table>
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<tr>
<th></th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
<th>t</th>
<th>Sig. (2-tailed)</th>
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<td>1.331767</td>
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<td>0.000**</td>
</tr>
</tbody>
</table>

Remarks : ** significantly differences

The paired sample t-test shows the L* and b* value is significantly different between pine and eucalypt groups, while a* value is not significantly different between those two groups. In other words, the lightness and yellowish value of pine and eucalypt wood are significantly different, while redness value is approximately identical.

IV. CONCLUSIONS

1. Wood color is not easy to be defined because it is not a physical reality. It refers to the psychological response of the eye-brain combination to light waves falling upon the light-sensitive retina, which makes up the inner surface of the eye. As a result, color measurement has been developed in order to standardized color. One of the equipment developed was Microflash-200®.

2. Mathematical values of wood color obtained using CIE system are also substantive to justify a particular species of wood during wood identification process.

3. The average of L* value for pine group is 70.77, while eucalypt makes up to 52.40. It means that eucalypt group is darker than pine group. For a* value, pine group mean value is 20.23, whereas eucalypt group touches 19.11. In other words, pine and eucalypt group have an approximately similar redness. The b* value average for pine and eucalypt groups are 43.40 and 29.07, respectively. This value means that pine group is more yellow than eucalypt group.
ACKNOWLEDGEMENT

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REFERENCES


ANATOMICAL PROPERTIES AND FIBER DIMENSION OF PRICKLY ACACIA (*Acacia nilotica* L.) FROM BALURAN NATIONAL PARK

Krisdianto¹ and Ratih Damayanti²

ABSTRACT

*Acacia nilotica* (L.) Willd. ex. Delile growing in Baluran National Park has dramatically altered the ecological balance of grasslands and thereby threatens the existence of local biodiversity. Prickly acacia is able to spread rapidly and remains uncontrollable. Baluran National Park authorization has been struggling to control this prickly acacia trees. One possible action that can be taken to encounter this problem is allowing wood based industries, and local people take advantages of this nilotica timber utilization. This paper studies the anatomical properties and fiber dimensions of nilotica timber and discusses the possible utilization of nilotica timber. This timber is characterized by dark brown heartwood which is clearly distinct from reddish brown color of sapwood. The denser cell wall shows attractively streaked in tangential surfaces. The length of wood fiber decreases from pith toward periphery portion. Longitudinally, higher stem has shorter fiber. Nilotica wood has second class quality of fiber, which means its fiber is moderately thick with narrow lumen diameter. Due to small log diameter and branches, the nilotica timber is not recommended for construction material. The timber is suitable for carved and turnery products. Nilotica timber is suitable for charcoal manufacture and fuel wood due to its high calorific value.

Keywords: *Acacia nilotica*, wood anatomy, fiber, utilization

I. INTRODUCTION

*Acacia nilotica* (L.) Willd. ex. Delile is an exotic acacia species native to India, Pakistan and much of Africa. Nine subspecies are currently recognized and widely distributed in tropical and subtropical Africa extending from Egypt and Mauritania to South Africa (Brenan, 1983). Due to its ecological, economic, and social impacts of this thorny shrub, prickly acacia has been recognized as Weed of National Significance (WONS) in Australia and it becomes one of Australia’s worst weeds (Spies and March, 2004).

In Baluran National Park, *A. nilotica* from Africa has been developed in order to isolate savanna from fire that frequently happens in savanna Bekol. Nilotica mature trees are classified as highly fire resistant trees (Carter, 1994). However, after several years, this prickly acacia has dramatically altered the ecological balance of grasslands and thereby threatens the existence of local biodiversity. Trees compete with grasses for limited soil moisture, thereby reducing food supply and increasing animal pressure on the remaining pasture, particularly the palatable perennial grasses. The infestation of nilotica trees leads to reduction in ground

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cover at the beginning of the growing season, putting maximum pressure on new grass tillers and seedlings. As a result, land degradation is one significant impact from prickly acacia plantation.

Carter (1994) reported that prickly acacia was able to spread rapidly due to some characteristics of its own, such as seedlings and young trees, which were unprotected from grazing by thorns; large seed production up to 175,000 seeds/tree; long lived seeds; the young plants able to grow rapidly; being tolerant of grazing, drought, fire and salinity; long lived trees (30-60 years); and tree growth possible over extensive climatic change.

Baluran National Park authorization has been struggling to control this prickly acacia trees. However, there long-lived seeds make the acacia growing more uncontrollable. Prickly acacia fruit seedling has been eaten by animal and its manure has been a seedling vector for this acacia spread. This thorny plant has spreaded in Bekol savanna and formed homogeny forest like nilotica trees (Sumayku, 2003).

The easiest way to control nilotica tree is to burn them. However, it is not easy as the tree is fire resistant and the fire must be controlled so that it will not spread along the grasslands. Another option to control this tree is allowing wood based industries and local people take advantages of this nilotica timber utilization. However, the study on properties of this timber is needed to provide information on its utilization as currently there is no such information available. If information on its utilization is available for the industry and community, then economical values can be obtained from this timber. This paper studies the anatomical properties and fiber dimensions of nilotica timber and discusses the possible utilization of nilotica timber.

II. MATERIALS AND METHODS

Nilotica timber sample was taken from two trees growing in Bekol savannah, Baluran National Park, Eastern Java. Wood samples in the form of 7 cm length discs were taken from three heights: bottom, medium and top of the log. In each height, samples for fiber maceration were taken from five parts horizontally between the pith and the bark as shown in Figure 1.

Sample blocks were also prepared from the tree log using sample preparation method as reported by Fujii (1989). As many of tree block sections taken from heartwood were each assigned for examination of anatomical features properties on consecutively cross-sectional (transverse), radial and tangential surfaces of the block. The block section of sample for such anatomical feature examination were at first air-dried and then soaked in distilled water for about one week. After being saturated, the samples were then transferred into a container containing solution of etronol-glycerin 1:1 and further kept for about one week before sectioning.

The observed characters with respect to the anatomical features were based on IAWA Committee list (Wheeler et al., 1989). Some of the features were quantitative data. The quantitative data in this study were a representation of first performing 30 measurements on certain features of each investigated sample, and then taking average of them. The quantitative features include vessels (diameter, length, frequency per sq. cm), rays (height, frequency per mm) and fibers (length, diameter, wall thickness).
The quantitative data of fibers dimension and vessels length were measured from the macerated samples, and their preparation before maceration is as described in Figure 1. In this regard, the associated wood samples were macerated based on modified Schulze methods (Tesoro, 1989). The sample materials were heated slowly at 40 - 60°C in the mix fuse of concentrated nitric acid and hydrogen peroxide in ratio of 1:1. The heating took about 12 hours to produce adequately macerated material or a satisfactory separation of wood fibers for further dimensional examinations. The qualification of fiber dimensions was based on Rachman and Siagian (1976) criteria.

Figure 1. Cutting sample pattern for macerated samples
III. RESULTS AND DISCUSSION

A. Anatomical Properties

1. General characteristics

   Color: heartwood is dark brown turning to black, which is clearly distinct from reddish brown of sapwood. Figure: flat sawn board fine and lustrous, the denser and lighter part of the wood cell wall shows attractively streaked in tangential surfaces. Texture: rather fine. Grain: shallowly interlock. Hardness: wood is very hard.

2. Anatomical properties

   Growth ring: distinct marked by defined growth zones and thin banded parenchyma. Vessel: diffuse, solitary and radial multiples of 2 – 4, moderate in size of 270.98 ± 51.46 μm in tangential diameter; length 507.3 ± 6.6 μm, vessel frequency 4 ± 0.4 per mm², perforations simple; inter vessel pits vestured, alternate to elongated diameter 8.9 ± 0.9 μm in diameter; vessel-ray and vessel parenchyma pits are similar in type and size to intervessel pits; tyloses and substances were rarely found in the vessels. Parenchyma: sparse to moderately abundant paratracheal, vascicentric, usually in prominent sheaths, 2 – 4 cells wide around the pores, tending to aliform particularly around the smaller pores in 2 – 4 celled strands. Rays: 4.3 ± 0.2 rows/mm, 1 – 4 seriate, an average of 1.015,9 ± 86,8 μm high, up to 40 cells high. Silica bodies absent. Fibers: without septate, 1,554.03 ± 86.15 μm in length; fiber diameter 36.6 ± 0.4 μm; lumen diameter 2.2 ± 0.05 μm and fiber pits is about 3.8 ± 0.2 μm in diameter. Material inclusion: prismatic crystals are found in chambered parenchyma strands. The anatomical structure of nilotica is shown in Figure 2, while thick cell walls and intervessels pit are shown in Figure 3 and 4, respectively.
Figure 2. Surface of *A. nilotica* (L.) Willd. ex Delile

a. Transverse surface, scale bar = 1 mm;
b. Transverse surface, scale bar = 200 μm;
c. Radial surface, scale bar = 200 μm;
d. Tangential surface, scale bar = 200 μm.
B. Fiber Dimensions

The average fiber lengths of *A. nilotica* from three different heights and five horizontal depth in every disc are shown in Figure 5. The t-test result showed significant differences between mean in every disc. Generally, the disc from bottom part of the tree has longer fibers than those of middle and top discs. The average fiber length from the bottom disc is 1,561.99 μm, while the length from middle and top is about 1,551.22 μm and 1,531.6 μm respectively.

In every disc, the fiber length pattern horizontally is almost similar to the vertical pattern on above. The length of wood fiber decreases from pith toward periphery. The shortest fiber is found in the samples that was taken near the pith, while the longest fiber is the one taken from periphery. Mean comparison between samples taken from pith toward periphery shows significant differences. In the overall discs, the longest fiber up to 1,706.74 μm is found in the samples that was taken from bottom near periphery. The phenomena of shorter fiber length from bottom to top and from pith toward periphery was also mentioned by Jane (1970).
The fiber quality of nilotica timber based on criteria stated by Rachman and Siagian (1976) is shown in Table 1. The fiber quality is assigned from fiber length, Runkel ratio, flexibility ratio, felting power, coefficient of rigidity and Muhlsteph ratio. Fibers of middle and top of the disc are in second class quality, while fibers in three samples from five of that taken from bottom disc fall into third class quality. Overall, fiber quality of nilotica is in the second class quality, which means wood fiber is moderately thick with narrow lumen diameter. During pulp and paper processing, the fiber is easily flattened and interfiber bonding is relatively high. In terms of tear strength the paper from this timber is relatively moderate (Rachman and Siagian, 1976).

Figure 5. Fiber length of *A. nilotica*
Table 1. Fiber dimensions and qualities of nilotica wood

<table>
<thead>
<tr>
<th>Samples</th>
<th>Fiber length</th>
<th>Fiber diameter</th>
<th>Lumen diameter</th>
<th>Wall thickness</th>
<th>Runkel ratio (^1)</th>
<th>Flexibility ratio (^2)</th>
<th>Felting power (^3)</th>
<th>Rigidity (^4)</th>
<th>Muhlsteph ratio (^5)</th>
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<tr>
<td></td>
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<td>(\mu m)</td>
<td>(\frac{w}{l})</td>
<td>(\frac{l}{d})</td>
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<td>(\frac{w}{d})</td>
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</table>

Remarks:  1) Runkel ratio = \(\frac{2w}{l}\); 2) Flexibility ratio = \(\frac{l}{d}\); 3) Felting power = \(\frac{L}{d}\); 4) Coefficient of rigidity = \(\frac{w}{d}\); 5) Muhlsteph ratio = \((d^2 - l^2)/d^2\) \times 100\%; \(L\) = fiber length; \(d\) = fiber diameter; \(l\) = lumen diameter; \(w\) = fiber thickness
C. Utilization Possibility

Prickly acacia is a thorny shrub or small tree that usually grows to 5 m high but occasionally to 10 m (Carter and Cowan, 1988). It is usually single-stemmed but may be multi-stemmed at the base (Figure 6). Stem diameter is about 16.5 cm in 25 years old and the log is classified as small diameter log. Even though, this timber is stiff and hard enough for construction requirements (density about 650 - 830 kg/m³), however, it is hard to find smooth straight plank from the trees. As a result, this timber is not recommended for construction material.

The streaky figures of nilotica timber make a good timber product for carving, turnery and boatbuilding. Variation of light and denser fiber cell density gives streaky appearances particularly in tangential surface. Carving of streaky timber gives interesting carved and sculpture products that have high artistically value of art. The streaky appearances gave multilayered looks and bring higher value of turnery products. However, this timber is relatively stiff and hard to work with. As a result, working on wet conditions is recommended.

The calorific value of this timber is relatively high. Carter (1994) reported that calorific value of this timber is around 4,800 - 4,950 kcal/kg. Goel and Behl (1996) reported that high density, high heat of combustion, low ash, and initial moisture content lead nilotica timber to be a good quality for fuel wood.

Patil et al. (2000) reported that nilotica timber showed high quality charcoal. Nilotica charcoal contents (dry basis) in fixed carbon are 82% (db), volatile material 15%, and ash content 5% (db). Nilotica timber produces charcoal with relatively high fixed carbon and low volatile material. This timber should satisfy for firewood and charcoal manufacture. The excellent firewood and charcoal quality derives the use of nilotica wood for fuel locomotives, river steamers, and boilers in some small industries.

Figure 6 a and b. *Acacia nilotica* (L.) Willd. stem
Fresh bark of nilotica is also a good resource of tannin. Tannins are water soluble high molecular weight polyphenolic compounds and rich in phenolic group. Industrially, tannins are used in the production of leather, adhesive material, dye stuff, and ink. Also, owing to their astringent properties, tannins are used as medicinal materials which promote rapid healing and formation of new tissues on wound and inflamed mucosa (Ayoub, 1982). Mahdi et al. (2006) reported that fresh bark of nilotica contains more than 10% tannins and was thus suitable for commercial exploitation. The tannin type of nilotica bark is hydrolysable-condensed.

IV. CONCLUSIONS

1. General characteristic of nilotica timber heartwood is dark brown turning to black which is clearly distinct from reddish brown color of sapwood. The denser cell wall shows attractively streaked in tangential surfaces.
2. The length of wood fiber decreases from pith toward periphery. Longitudinally (axially), higher stem has shorter fiber.
3. Fiber quality of nilotica is in the second class quality, which means wood fiber is moderately thick with narrow lumen diameter.
4. Due to small diameter log with branches, nilotica timber is not recommended for construction material. The timber is suitable for carved and turnery products.

REFERENCES


Short Note

AN OVERVIEW ON THE CONSERVATION STATUS OF MERSAWA 
({\textit{Anisoptera costata}} Korth.) IN JAVA

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{\textit{Anisoptera costata}} Korth., which has a commercial name of mersawa grows and proliferates naturally, often gregarious, in semi-evergreen dipterocarp forest and evergreen forest in areas with seasonal climate and rare but widespread in lowland everwet forest from sea level up to 700 m in continental S.E. Asia, Malay Peninsula, Borneo, Sumatra, and Java (Ashton, 1982). In Java, it has been recorded to occur only in Banten (Backer & Bakhuizen van den Brink,1963) and in Leuweung Sancang Nature Reserve (LSNR) (Kalima, 2006).

{\textit{A. costata}} belongs to Dipterocarpaceae. It is a large to very large tree reaching up to 50 - 65 m tall, with cylindrical branchless bole of up to 45 m in height 150 cm in diameter (Figure 1). Other characters commonly used to identify this species are the presence of few buttresses of up to 4 m high, spreading out up to 2.5 m, with greyish-brown fissured bark. The leaves are obovate to oblong, (6 - 18 cm x 5 - 10 cm), dull yellowish or greenish lepidote beneath, secondary veins 8 - 27 pairs, hardly or not depressed above. The venation is scalariform-reticulate and usually distinctly hairy on the undersurface. The petiole is about 2.5 - 4 cm long, with coarse stellate hairs (Figure 2) (Kalima, 2005). This species is highly variable and the variation on the whole is continuous, with geographically localized forms occurring in the less seasonal areas and the Javan species is one of the forms similar to that occurring in Sumatra (Ashton, 1982).

This hard timber is commonly used as light construction, handicraft, veneer, plywood and timber board for ships construction (Hoffman and Wong, 1994). The main concern of studying this particular species is mainly due to the limited information regarding its potentials and natural distribution in the wild. Without this information, it is difficult to argue that this species is under a serious threat. Therefore, there is a need to carry out a field survey to determine the population size in its natural habitat.

The forest area of LSNR is considered as the largest remaining lowland rain forest on Java. Currently, this area has been seriously threatened by the massive land utilization and uncontrolled human activities, such as illegal logging, shifting cultivation, forest conversion for settlements and plantation, forest encroachment and forest opening for agriculture (Balai Konservasi Sumber Daya Alam, 2007). Degraded forest in LSNR area covers about 1000 ha out of the total forest area of 2.157 ha (Hidayat, 2003).

LSNR, gazetted as protected area in Sancang districts, Cibalong, by the Decree of the Minister of Agriculture in 1978 (SK Menteri Pertanian Nomor 370/Kpts/Um/6/1978 tanggal 9 Juni 1978), has been so far experiencing severe environmental destruction, that further causes habitat degradation, especially the mersawa habitat. This could eventually lead to the extinction of this particular plant species. This condition might become worse and

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seriously threaten the future of LSNR natural resources unless there are some actions to halt these ongoing degradation processes.

A field survey carried out in LSNR in 2005 revealed that, *mersawa* was recorded only from the eastern part of Sagara country side. It is growing in association with *Caesalpinia sappan*, *Macaranga subfalcata*, *Artocarpus rigidus*, *Alseodaphne umbelliflora*, *Eugenia* sp., and *Knema cinerea*. During the previous survey in the LSNR forest, Sidiyasa *et al.* (1986) recorded that *A. costata* was found in the western part of LSNR, near the Cikalomberan and Cipalawah villages at 30 - 40 m above sea level, where *Dipterocarpus basseltii* was the most prevalent species in the study plot. The most recent study carried out by Kalima (2006) in Cipalawah village showed that *A. costata* was no longer present (Kalima, 2006). During the 2006 field survey, forest condition in the study area has changed greatly and the habitat of *A. costata* has been damaged significantly. Numerous felled trees and stumps in some places were noticed nearby the habitat of this species. There were also some evidences of the felling of *D. gracilis* and *D. hasselti* with stem diameter of 58 cm and 76 cm, respectively, but *mersawa* remained undisturbed. In the future, however, there is no guarantee that *mersawa* will be able to survive under current serious threats.

Beside human disturbances, *mersawa* has a biological limitation for its regeneration due to its unique biological characters. For example, *mersawa* requires special attention to allow it to regenerate naturally as seedlings are difficult to survive in the wild. *Mersawa* seeds are recalcitrant, easy to rot and are often attacked by pest. This condition may influence the seedling population in its natural habitat and thus natural regeneration process may not work properly. During our observation we found only one tree within an area of 1.157 ha (six sample plots of 0.13 ha each) in LSNR and no seedling at all was encountered underneath. To date there is no information so far on the seed predation by animals.

Considering that we recorded only one individual of *mersawa* during our field observation, we, therefore, predict that this species is becoming endangered. We suggest that
counting the entire population in the field is deemed to be the proper way to determine the level of species rarity in the wild. Unless serious attempt to protect this species is carried out, within a short period of time $A. \text{costata}$ will face a high risk of extinction. Actually, the conservation status of this species is subject to change based on the recent data and information that have been submitted to IUCN. However, the tentative status of $mersawa$ in the wild could be used as a reference for the conservation status of the taxa.

Ashton (1998) has claimed that the distribution of $A. \text{costata}$ in the Philippine was very limited and there was only one individual collected during survey in some forest areas in the Philippines. During the Conservation Expert Meeting in 2006, scientists have agreed to put the status of $A. \text{costata}$ under EN A1cd+2cd criteria in IUCN Red List of Threatened Species. This mean that $A. \text{costata}$ has been seriously threatened and at high risk to be extinct in the wild. Similar to the Philippine situation, LSNR has now been facing great pressures from human activities, including tree cutting as well as forest conversion into agriculture and plantation areas. It is very obvious that this forest fragmentation will reduce the habitat of $mersawa$ and most importantly is the loss of germplasm diversity. This genetic loss may increase the risk of species extinction. So far, attempt to develop $mersawa$ conservation program has not been done yet because seeds or fruits are difficult to collect from their natural habitat. Thus, there is an urgent need to conserve this species, or otherwise, $mersawa$ may soon be extinct from its natural habitat in Java island.

Nowadays, there is a strong indication that this species has become difficult to find in its habitat. Based on Government Regulation No. 5 Year 1990 concerning Conservation on Natural Resources and its Ecosystem, there is an immediate need to put $A. \text{costata}$ under special protection action to prevent extinction attributed to illegal logging and other disturbances. The implementation of this regulation should be carried out in line with the environmental education program focusing on protecting $mersawa$ as rare and endangered species and promoting regional development program for rare and endangered species conservation, such as the development of Baturaden Botanical Garden in Central Java.

A subsequent conservation effort should be implemented, such as planting $mersawa$ within its natural habitat (in-situ conservation) and outside its natural habitat (ex-situ conservation) to ensure that this particular species is managed and utilized properly for its long-term existence. The development of in-situ conservation program can be carried out in LSNR while ex-situ conservation program can be developed in Baturaden Botanical Garden (Central Java), Bogor Botanical Garden (West Java), arboreta in climatically seasonal areas and some Research Forests Areas across Java islands (Departemen Kehutanan, 1984). Finally, we also suggest to carry out tree improvement program by means of species cross-breeding as this would be necessary in order to increase the diversity of $mersawa$ in the wild. By developing these activities, we would expect that a detailed and comprehensive information could give a significant contribution to the development, utilization and conservation program of $mersawa$. 

REFERENCES


