MORPHOLOGICAL VARIABILITY OF IRONWOOD (*Eusideroxylon zwageri* T.et B.) IN NATURAL FOREST

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Abstract

Ironwood (Bulian/ulin/belian/borneo ironwood) (*Eusideroxylon zwageri* T.et B.) belongs to family of Lauraceae, tribus of cryptocaryeae and subtribus of Eusideroxylineae. It is one of the most important construction wood in Indonesia because it is not vulnerable to termites and other ubiquitous tropical wood-destroying insects and fungi. Research on morphological structures of ironwood was conducted in order to obtain information on variability of ironwood, which can be used as basic information for ironwood cultivation and breeding. The variability of ironwood has been already discussed since the beginning of last century but until today there is no detail information on it. The research is one part of comprehensive research on variability of ironwood including ecology, anatomy, morphology and genetic variation point of view. The research has been carried out in Jambi province – Indonesia for three months from 10 October 2001 until 23 December 2001. It was conducted by direct observation to field using purposive random sampling. Practical experiences of local people were used to determine sample trees. The result shows that morphological structure of ironwood significantly varied on almost all of traits. Ironwood's seeds have various form and size, each variety has specific seed's characters. The leaf form of ironwood variety are also different, the forms of *sirap's* leaves are oblong to elliptic. *Tanduk's* and *daging's* leaves tend to obovate while *kapur*'s leaves tend to ovate. The most different form and color of ironwood bark surface is form and color of *kapur* variety. It is smooth and white color that can not be found on any other varieties.

Keywords: Ironwood, morphological structure, variability

I. INTRODUCTION

1.1. Background

Bulian/ulin/belian/borneo (ironwood) (*Eusideroxylon zwageri* T.et B.) belongs to the family of lauraceae, tribus of cryptocaryeae and subtribus of Eusideroxylineae (Kostermans, 1957). Ironwood is one of the most important construction wood in Indonesia. The wood is used for making furniture, window and door frames, harbors, heavy constructions, roofs, bridges, railway sleepers, marine pilling, boat constructions, fence posts, heavy duty industrial flooring, shingles and vehicle body work.

The ironwood most valuable characteristic is that it is not vulnerable to termites and other ubiquitous tropical wood-eating insects and fungi. For this reason, the wood is in great demand for construction throughout Indonesia (Peluso, 1992). Martawijaya *et al.* (1989) explained that physical characteristics of ironwood are excellent. Class of strength is one, durability class one and it is very hard with specific gravity of 0,88 – 1,19.

Several varieties can be possibly be distinguished within ironwood, based on the form and size of the fruits. In practice, `bulian *sirap*`, having wood suitable for manufacture of shingles, is sometimes distinguished from `bulian *tanduk*` or `bulian *daging*`, which suitable for the production of timber (Heyne 1927; Soerianegara and Lemmens, 1994). De Wit (1949) suggested that the purpose of the present study was to investigate whether actually no correspondence whatever between fruit character and other characters (flowers, leaves, timber) existed. The opinion of earlier observers was confirmed and, as no detailed investigation had been carried out till now, received a firmer basis. The size may vary somewhat but one individual produces one single kind of fruit. As in nature several kinds of fruit are found in one locality this points to the possible occurrence of varieties or taxa of lower rank of ironwood.

Each variety of ironwood is so far never thoroughly investigated. The different characteristics among them could be recognized only by the local people mostly from the wood and other morphological structures. Therefore, it is important to conduct a research on

morphological variability of ironwood as a part of a comprehensive research on variability of ironwood including ecology, anatomy, morphology and genetic variation. The term of variety with local names of *daging, kapur, sirap* and *tanduk* are used to describe the variability of ironwood.

1.2. Research hypothesis and objectives

The hypothesis of research is there is any variability on morphological structures of ironwood related to its varieties. While the objectives of research were (1) to identify morphological structures of ironwood related to ironwood varieties especially on morphological structure of seeds, stems and leaves, (2) to compare morphological structures of ironwood among its varieties (3) to provide information on variability of morphological structures of ironwood, which can be used as basic information for ironwood cultivation and breeding.

II. LITERATURE REVIEW

2.1. Leaf morphology

Leaf morphology of native vegetation has often been interpreted as a sensitive indicator of environmental conditions, presumably as a result of natural selection. If environmental pressures act as a selective force on community leaf morphology, then we would expect a high degree of similarity in similar environments, regardless of biogeographic origin of the flora. The results of the experiment suggest that plant community morphology is an emergent property, the magnitude of which is environmentally constrained (Halloy and Mark, 1996). The wide variation of leaf characters and their importance in systematic descriptions has resulted in the accretion of a large collection of descriptive terminology. The observation of leaf morphological traits is suitable to confirm the species status of population (Dickison, 2000; Finkeldey, 2001).

The leaf characters of Lauraceae family are as follow: the leaves are usually leathery and (on the upper surface) of a waxy, glossy dark green color; the lower surface is often glaucous (layer of wax). The dried leaves have a definite color in different species. The lower leaf-surface is often provided with domatia in the nerve-axils; they appear to represent a constant characters for certain species and not to be caused by insects. Pinnately veins leaves are a rule, but in several genera triplinerved leaves occur. The venation, which becomes visible after drying, is either lax or very dense. The leaves are spirally arranged (phyllotaxis 2/5 and 3 /8) sometimes subopposite to opposite. Stipules are absent (Kostermans, 1957).

2.2. Seed morphology

Corner (1976) characterized on dycotyledon seeds for each family including information on the seed of seven lauraceous genera. These are described as usually having the testa (seedcoat) at outer part closely adherent to a lignified, stelate-or undulate-faceted endocarp; the outer epidermis of the testa is unthickened, the mesophyl usually multiplicative, and the inner epidermis composed typically of short tracheids. The inner layer of the testa, the tegmen, is ephemeral. The pericarp of the fruit has oli cells and often stone cells. Kostermans (1957) explained that the seed of lauraceae is composed of two large, flat-convex cotyledons that are easily separable; as a rule the cotyledons are whit, rarely pink; they contain fatty oil, carbohydrates and proteins. The outside of cotyledons is either smooth or irregularly sulcate. The radicle is as rule a rather small, rarely swollen. The testa is thin and smooth.

2.3. Stem morphology

The bole form of a tree is that portion of the stem that has no live branches. Bole form refers to the number of dead branch stubs the evident and amount of paper from the ground to the base of the crown, or even higher; also the nearness to a circular cross-sectional shape that the bole attains needs to be considered in judging form, as well as the amount of sweep and the number of crooks (Hocker, 1979). The bole of lauraceae is usually smooth (although thick, deeply fissured barks occur too) and then often covered with numerous large, round, flat lenticels. The dead bark is as a rule very thin and is shed in small fragments. The living bark is either thin or may be very thick; its color varies between white, yellow, pink and dark red; it is usually brittle, but for an inner fibrous layer; often it has a more or less pronounced aromatic smell (Kostermans, 1957).

III. RESEARCH METHODS

3.1. Materials and methods

The material that used were film, and natural stand of ironwood while the instruments are camera, micrometer screw, GPS, Leaf area meter type CL-202, oven (Memmert), balances (Sartorius type 2842 and Oertling) and stationery. This research has been carried out for about 3 months from 10 October 2001 until 23 December 2001 at Senami natural forest stand Jambi - Indonesia. It was conducted using purposive random sampling. The practical experiences of local people were used to determine sample trees. The characters that were used to determine variety by local experts were split ability in radial direction of wood, the form of shavings (straight pieces, waving pieces or fractures), wood smell and color, the form, surface and color of trunk. Two local experts who have worked for this research were Rizal (38 years), who has experienced with ironwood for about 14 years and able to recognize ironwood variety and Umar (35 years) also a local person who has responsible as a local forest ranger at Senami forest stand. To increase the validity of sample trees, each of sample tree was observed thoroughly on the characters of leaves, flowers, fruits, seeds, stem, bark and young seedlings. Those data were used to verify the identification results that conducted by local experts.

The number of sample trees varies from 5 until 10 trees for each variety. The space between each sample trees varied from 500 meters to 1500 meters. The sample leaves were taken 10 to 20 leaves per sample tree. The leaves were taken as samples were mature leaves (green until dark green color) and located at the tip, middle and base part of twigs. The number of leaves for each variety were between 100 – 120. While the sample seeds were taken from selected sample tree with the number varies from 25 to 30 seeds per sample tree. The number of seeds that were collected were 150 – 200 seeds for each variety. They were taken from the ground around of sample trees. The qualitative data were compared qualitatively to each other among varieties and quantitative data were analyzed statistically using two-sided of t test.

3.2. The parameters are:

1. Morphological structure of leaf parameters including (a) lamina length (cm), (b) lamina width (cm) (c). lamina length : width ratio and (d). dry weight (gr).
2. Seed parameters that were observed are (a) seed length (cm) (b) seed diameter (cm) (c) seed length : diameter ratio (d) seed weight (gr) and (e) seed coat thickness (mm)
3. Stem morphological traits **(**form and color of bark surface)

IV. RESULTS AND DISCUSSION

4.1. Leaf morphological traits

Table 1. Mean values of leaf traits of four varieties of ironwood (*Eusideroxylon zwageri* T. et. B.) that analyzed using two-sided of t test.

No.	Varieties	length (cm)	width (cm)	Length : width ratio	dry weight (gr/cm²)
1	*Tanduk*	26.34699 b	10.1157 c	2.6104 a	0.00894 bc
2	*Daging*	27.2253 a	9.8048 c	2.8592 b	0.00987 a
3	*Sirap*	28.48072 a	12.8639 a	2.4319 c	0.00902 b
4	*Kapur*	27.48735 a	11.3229 b	2.2107 d	0.00827 c

Note: The mean values that follow by the same alphabets are not significantly difference based on 5 % of two-sided of t test.

Table 1 shows that mean leaf length of *sirap*, *kapur* and *daging* varieties are not significantly difference based on two-sided of t test but they are significantly difference to *tanduk* variety. The mean leaf width of *sirap* variety is the widest and significantly difference to other varieties. While *Tanduk* and *kapur* varieties are not significantly difference one to another but they are significantly difference to *kapur* variety. Mean length : width ratio of leaves of *daging* variety is the highest while *sirap* is the lowest. Both of them are significantly difference one to another as well as other varieties. The statistical analysis shows that the mean dry weight of 1 cm² of leaves of four varieties are vary from one variety to another. *Daging* is significantly

difference to other varieties. *Sirap* is significantly difference to *kapur* but not significantly difference to *tanduk* variety while *tanduk* and *kapur* are not significantly difference each other.

The color of mature leaf of ironwood is green until dark green while the young leaves are reddish brown until yellowish red. There seems no relationship between leaf color (mature and young) with the varieties. The leaf shapes of ironwood variety are different, *sirap* is widest and tappered to boths ends but with the sides more or less parallel therefore its shape is elliptic to oblong. *Tanduk* and *daging* tend to obovate while *kapur*'s leaf shape tends to ovate (see fig. 1). The leaf apexes are acuminate while the leaf bases are rotundate for *sirap* and *kapur* while taduk and *daging* tend to obtuse until rotundate. Upper surface smooth; having a surface without hairs or any unevenness (glabrous), lower surface covered by fine soft hair on the larger veins (pilous). Leaf venation of all varieties is penninervis.

The obovate leaf shape of ironwood also reported by De Wit (1949). He noted that in billiton (the venacular name "billiton" used for a kind of ironwood that common grows near Tanjung Pandan, Bangka Belitung Province) apparently only the long cylindric kind of fruit is found with clearly attenuated top and base. The leaves tend to obovate. Based on the fruits and the leaves characters, the billiton has the same characters as *tanduk* variety.

Figure 1. Showing the different characters of ironwood leaves. From left to right: *Daging*, *kapur*. *Sirap* and *tanduk* variety.

4.2. Seed morphological traits

Table 2. Mean values of seed traits of four varieties of ironwood (*Eusideroxylon zwageri* T. et. B.) that analyzed using two-sided of t test.

No	Varieties	length (cm)	diameter (cm)	Length : diameter ratio	weight (gr)	Seed coat thickness (mm)
1	*Tanduk*	12.5035 a	4.7539 a	2.6603 a	162.3808 a	3.8448 a
2	*Daging*	11.4593 b	3.9153 b	2.9519 b	95.2881 c	2.9853 b
3	*Sirap*	9.6076 c	4.7369 a	2.0408 c	123.4010 b	3.1295 c
4	*Kapur*	7.9484 d	4.6728 a	1.7146 d	96.3409 c	3.7035 a

Note: The mean values that follow by the same alphabets are not significantly difference based on 5 % of two-sided of t test.

Table 2. shows that mean seed length of ironwood varieties are significantly difference each other. The longest seeds belong to *tanduk* while the shortest seeds belong to *kapur*. The mean diameter of seeds of four ironwood varieties are only slightly difference (table 2). Three varieties (*tanduk*, *sirap* and *kapur*) are not significantly difference to each other but they significantly difference to *daging* which has smallest diameter. The statistical analysis results on seed weight of ironwood show that *tanduk* is significantly difference to other varieties. *Sirap* is also significantly difference to *kapur* and *tanduk* but they are not significantly difference one to another. Table 2. shows that seed coat thickness of *tanduk* and *kapur* are not significantly difference one to another but they are different significantly to other varieties while the last two varieties (*sirap* and *daging*) are significantly difference one to another. Table 2. Shows that highest value of mean length : diameter ratio of seeds belongs to *daging* variety and the lowest value belongs to *kapur*. However mean length : diameter of seeds of four ironwood varieties are significantly difference to each other.

Ironwood seeds have various shapes (see fig. 2). Relatively, *tanduk* has long cylindrical shaped with clearly attenuated top and base while *daging* variety has slender seed shaped. In general, *Kapur* has rounded seed shaped while *sirap*'s seed shape is in between long cylindrical and rounded. Those seed shapes are the common seed shape in the nature however, there are also could be found other seed shapes from the same variety, e.g. in the field could be found

daging variety with rounded seed shapes but they are asymmetric in one direction while rounded shape of *kapur* seeds is symmetric. Another characteristic of *daging*'s seeds is bent (crooked) and clearly sharp tips at both sides. *Tanduk* also has rounded seed shapes but they are commonly bigger than the other rounded seeds.

Figure 2. Showing the different characters of ironwood seeds. From left to right: *Daging*, *kapur*. *Sirap* and *tanduk* variety.

The result of study conducted by Sindhuveerendra *et al.* (1999) on seed characters of clones of teak (*Tectona grandis*) showed that three seed characters i.e., seed length, seed width and seed weight of clones of teak revealed good amount of genetic variability. The significant amount of variation of these clones may be attributed to several factors including reduced gene flow due to spacio-temporal variability phenological characters, variation in selection intensity over a small geographical scale and genetic drift due to low population density combined with limited gene dispersal. The study conducted by Gabriel (1978) on Sugar Maple (*Acer saccharum* Marsh.) also revealed that seed and fruit characters varied genetically among and within provenances.

The different seed shapes of ironwood has not directly reported by scientists before, most of them reported on various fruit shapes of ironwood (e.g. Koopman and Verhoef 1938; De Wit 1949; Soerianegara and Lemmens, 1994). The fruit and seed characters quietly clear could be used as the basic consideration in separating two genera or species e.g. Hayland (1989) who stated that the considerable number of differences in their infructescence, fruit and seed suggest that *Beilschmeida taraire* and *B. tawa* are probably not closely related to one another.

4.2. Stem morphological trait (form and color of bark surface)

Figure 3. Stem and bark performance of ironwood varieties (left to the right: *Daging*, *kapur*, *sirap* and *tanduk* variety.

The most different form and color of the ironwood bark surface is form and color of *kapur* variety. It is smooth and white that could not be found on any other varieties. This phenomena also already reported by Alphen De Veer (1954). He reported that in the ironwood plantations in Semandai (South Sumatra) some smooth-barked trees have been noted with a white color, wholly different from the normal trees. It supposed that these smooth-barked individuals may be presented as abnormal types, in the same manner as the smooth-*barked Tectona grandis* and *Pinus merkussi*. While the color of *daging*, *tanduk* and *sirap* mostly brown or gray brown with thin cracks and debarking in small subquadrangular pieces. Bark surface with some bruises also could be found on *tanduk* variety. Whitmore (1962) explained that the bark color, which is often a distinctive characters of taxonomic value, depends on the tissue forming the surface and so depends on the plane of sloughing and the degree of subsequent erosion by external weathering. Another scientist (e.g. Soerianegara and Lemmens, 1994), argued that the white color is likely to be induced by external factors (fungi). The results of field observation indicated that this color is not induced by fungi because at that bark could not be found any mycelia or other fungi organs and also it is distributed smoothly to whole stem.

V. CONCLUSIONS AND RECOMENDATIONS

5.1. Conclusions

1. In the natural forest, morphological structure of ironwood significantly varies on leaves, seeds and stems (bark surface).
2. Ironwood's seeds have various form and size, each variety has specific seed's characters. T*anduk* has cylindrical seed, *daging* variety has slender seeds, *Kapur* has rounded seeds while *sirap* has seed shapes in between cylindrical and rounded.
3. The leaf form of ironwood variety varies, the forms of *sirap's* leaves are elliptic to oblong. *Tanduk's* and *daging's* leaves tend to obovate while *kapur*'s leaves tend to ovate.
4. The most different form and color of ironwood bark surface is form and color of *kapur* variety. It is smooth and white that can not be found on any other varieties.

5.2. Recommendations

1. In order to obtain comprehensive information on ironwood variety, it is important to conduct research on ecology, anatomy, morphology, seedling characters and genetic variation of ironwood
2. To make sure whether the characters of ironwood varieties are inherited or not, long term research on seedling test is required.

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