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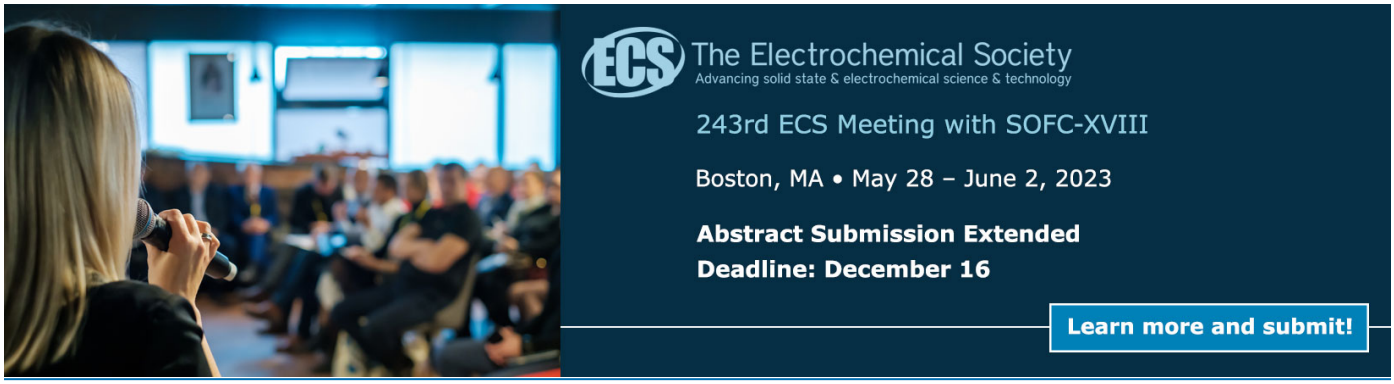

Anatomy adaptation of *Ketak* (*Lygodium circinatum* (Burm.) Sw) to relative light intensity in agroforestry systems, on Senaru Education Forest, West Nusa Tenggara

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Abstract. *Ketak* requires other plant as a climbing host for tendrils in order to get light. Research on the types of stands that affect tendril production in agroforestry systems is needed. This study aimed to determine anatomical adaptation of *ketak* at various types of stands and relative light intensity in agroforestry systems. The research method used a randomized block design. There were 2 treatments i.e. the stand type (natural stands, coffee stands, gliricidia stands, and mahogany stands) and Relative Light Intensity (RLI). Each stand consists of 3 blocks with 30 replication plants, making it a total of 90 plants per stand type. We used natural seedling as understory and combined with forestry plants. Number of leaves, plant height, plant number, plant length, tendrils diameter and growth percentage of *ketak*, and RLI were measured or calculated in each stand type. Variance analysis was used to determine the effect of stand type. Multiple linear regression was used to determine the relationship between stand types or RLI and number of leaves, plant height, plant number, plant length, and tendrils diameter. This study showed that (1). The growth percentage of *ketak* in natural stand, coffee stand, gliricidia stand, and mahogany stand respectively 62.22%, 97.77%, 75.56%, and 74.44% (2). The stand type with significant differences were found in the total number of leaves ($F = 17.441$; $p = 0.000$); plant height ($F = 24.065$; $p = 0.000$) and tendril diameter ($F = 7.747$; $p = 0.000$), but not in the total number and lengthof tendrils. (3). There were significant differences in stand type and RLI on total number of leaf, plant height, and tendril diameter of ketak plants with value of total number of leaf ($F= 15{,}92$, $p = 0{,}00$, and R square = 0,08); value of plant height ($F = 34{,}63$, $p = 0{,}00$, dan R square = 0,0005); and value of tendril diameter ($F = 5{,}62$, $p = 0{,}00$, dan R square = 0,0034). While in the total number of tendrils and tendrils length of ketak plants were not significant. The conclusion were (1) The highest growth percentage of *ketak* in Coffee stand is 97.77%. (2) Coffee stand had the highest influence on the total number of leaves, plant height and tendrils diameter. 3. The stand type and RLI only had a relationship with total number of leaf, plant height, and tendril diameter of ketak plants but not with total number of tendrils and tendrils length.

Keywords: *Ketak*, NTFP, agroforestry, stand type, RLI

1. Introduction

Ketak (*Lygodium circinatum* (Burm.) Sw) is classified in ferns and has tendrils that climb in other plants in order to get light. Ferns generally grow in humid conditions, while *ketak*, in particular, grow in places where there is a lot of light [1]. *Ketak* is naturally distributed in tropical forest and highly light demanding

[2]. Mountain tropical forests provide plenty of light and springs [3]. In Indonesia, *ketak* distribution is in Java, South Kalimantan, Bali, NTB, NTT, and Flores [4]. It grows in dry land, open space and secondary forest. *Ketak* is a fern that shows extensive adaptation and can survive in a very dry place. According to Steenis and Holttum (1967) in [5], plants have adaptive resistance if they can grow in dry habitats (xerophytes) which is related to the morphological structure and anatomy. Natural regeneration of *ketak* are with fertile leaves as a vegetative organ and spores as a natural dispersion medium [6]. Tendrils of *ketak* is considered as one of NTFP products which are used as raw materials for woven crafts and handicraft products, particularly in NTB. Therefore, it is an important raw materials for handy crafts. Craftsmen fulfill the needs of this raw materials from the nature and outside of Lombok island, including Kalimantan, Sumbawa and NTT [7]. The increasing demand for raw materials for handicrafts can support the sustainability of *ketak* in nature. Besides, it can also increase the cost of production of raw materials because they have to buy raw materials from outside of Lombok Island. Therefore, to ensure availability of this raw materials and reduce production costs, efforts are required to cultivate *ketak* so that the preservation of *ketak* in nature is maintained.

Ketak needs another plant as host in order to get sunlight. Agroforestry system could be adopted in the effort to cultivate *ketak* by combining forest plants as host plant of *ketak*. This system can hopefully increase the productivity of *ketak*. Therefore, research is needed to determine the best stand type for this system by observing anatomical adaptations of *ketak*.

2. Materials and Methods

The research method was a randomized block design. Research locations was in Senaru Education Forest, Senaru Village, and in the Pusuk Forest Area, Forest Management Unit of Rinjani Barat at 500 – 700 m above see level. Determination of this location was based on some considerations i.e. close to the habitat of *ketak* in nature and the presence of several types of agroforestry stands for *ketak* cultivation.

There were two treatments, namely the stand type (natural stand, coffee stand, gliricidia stand, and mahogany stand) and Relative Light Intensity (RLI). Each stand consists of three blocks with 30 replication plants, making it a total of 90 plants per stand type. Natural seedling was used as understory and combined with forestry plants. Growth percentage of *ketak*, total number of leaves, plant height, total number of tendrils, tendril length, tendril diameter, and RLI were measured or calculated in each stands.

Variance analysis and multiple linear regression were used to determine (1) the effect of stand type and (2) the relationship between stand types or RLI and total number of leaves, plant height, total number of tendrils, tendril length and diameter.

3. Results and Discussion

It was known that in each stand produced a different percentage of *ketak* growth. During the study, there were four different stands, namely natural stand, coffee stand, gliricidia stand, and mahogany stand. Determination of stand type was based on previous research, which observed coffee, mahogany and legumes, as host plant chosen by *ketak* [8]. Therefore, it is planted as a ground cover and forestry plants as host plant of *ketak* with agroforestry system in the Senaru education forest. Whereas the natural stand is observed in the Pusuk Forest Area, Forest Management Unit Rinjani Barat. Pictures of those four stands types are presented in Figure 1.

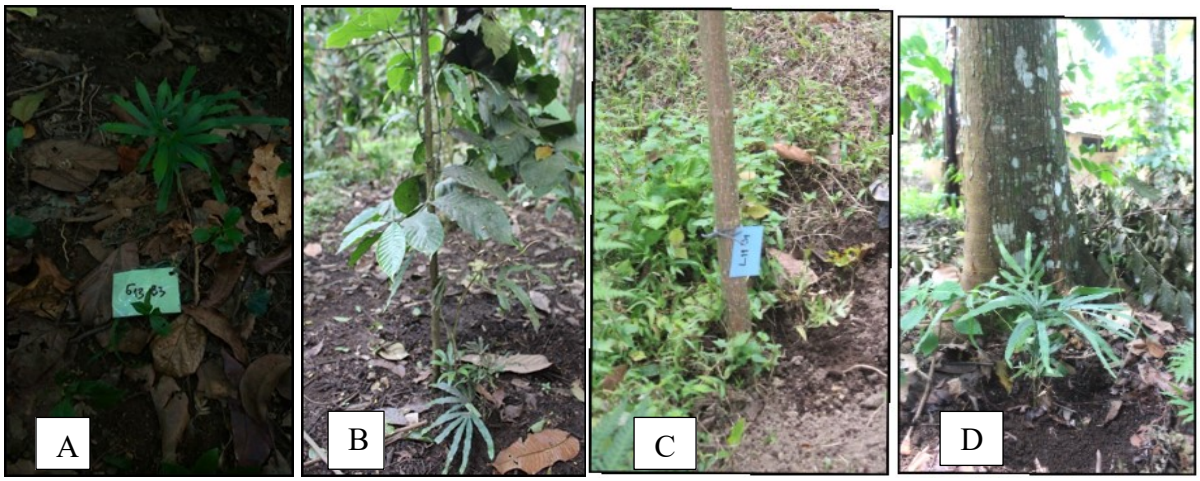

Figure 1. A. Natural stand; B. Coffee stand; C. Gliricidia stand; D. Mahogany stand

Based of the growth percentage in each stand, the natural stand showed the lowest growth percentage. The growth percentage in each stand are as follows: natural stand = 62.22%; coffee stand = 97.77%; gliricidia stand = 75.56% and mahogany stands = 74.44%. The growth percentage in each stand are shown in Figure 2.

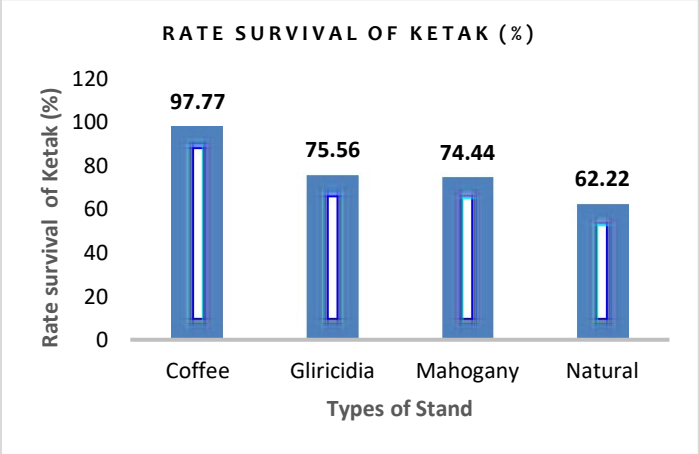

Figure 2. Rate Survival of *ketak* (%) on stand types

Figure 2 shows that the highest percentage of *ketak* growth is in coffee stand, namely 97.77%. This is also supported by the results of previous studies which observed that *ketak* grows better in conditions under relatively lightly shaded compared to those under heavy shading conditions [9]. The percentage of plant growth in natural stands was 62.22%,the lowest compared to other types of stands. This is probably because the host plant made heavy shading condition, which affected the percentage of *ketak* growth. Based on the literature, *ketak* require other plants as climbing host to get light [1]. Growing conditions with too heavy shading are not suitable for the growth of ferns, although they still need protection from direct sunlight. Some types of forest ferns grow well with full lighting (sun fern), by forming thickets and climbing [10]. The growth percentage at coffee stand was the highest because canopy of coffee was light, so the need for sunlight is sufficient.

Analysis of variance was used to determine the effect of stand types on *ketak* growth. One-way variant analysis was carried out to see the effect of stand types on total number of leaves, plant height, total

number of tendrils, tendrils length and diameter, in each observation plot. The results of the analysis are presented in Figure 3.

A summary of the results of variance analysis regarding the effect of stand types, and the results of multiple linear regression analysis on the relationship of relative light intensity in each stand type to total number of leaves, plant height, total number of tendrils, tendrils length and diameter are presented in Table 1.

Table 1. Summary of the results of variance analysis and multiple linear regression of total number of leaves, plant height, total number of tendrils, tendrils length and diameter of *ketak*.

Variable	df	Total number of leaf	Plant Height	Total number of tendril	Tendrils Length	Tendril Diameter
Stand types	3	*	*	NS	NS	*
RLI*	-	*	*	NS	NS	*

Note: * = significant, NS = not significant, RLI* analyzed using multiple linier regression

Based on Table 1, it shows that the stand type had a significant influence on the total number of leaves, plant height and tendril diameter, but not on total number of tendrils and tendril length. The results of the analysis (Duncan test) are presented in Figures 3, 4 and 5.

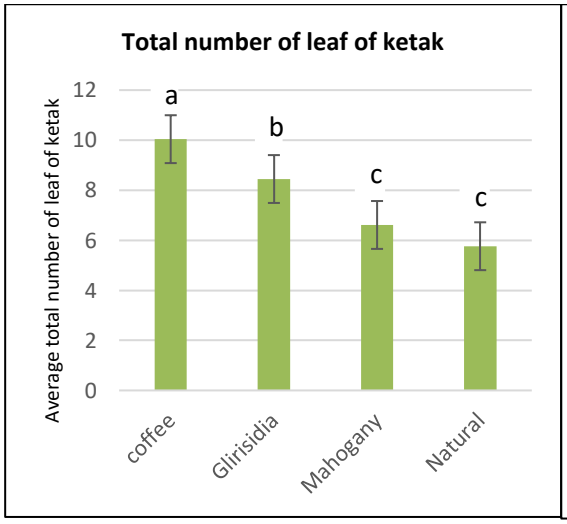

Figure 3. Average total number of leaf of *ketak*

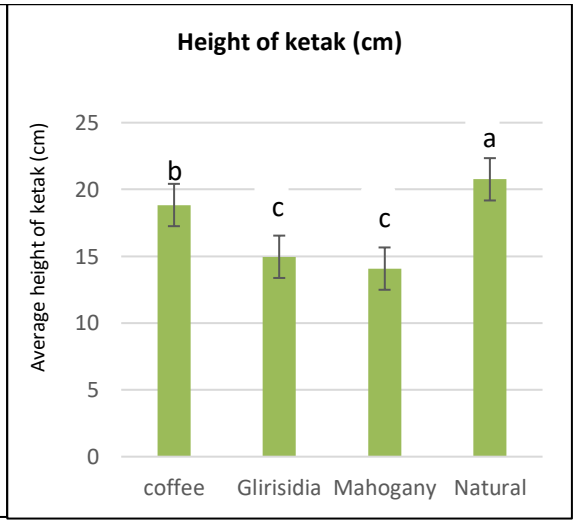

Figure 4. Average height of *ketak* (cm)

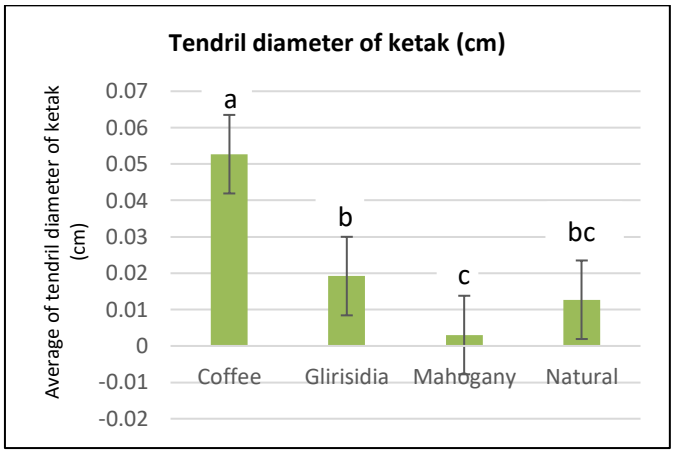

Figure 5. Average of tendril diameter of *ketak* (cm)

Figure 3 shows that coffee stands provided the highest significant difference in the total number of leaf variables. The leaves consisted of fertile leaves and sterile leaves. Fertile leaves produce spores that are found on the tips of leaves in adult *ketak* [11]. In coffee stand, the average total number of leaves was the highest because it was supported by environmental conditions under coffee stands with light canopy, so that the need for light for leaf growth is sufficient.

The results of the analysis on natural stand (Figure 4) showed that it had the highest influence on plant height. Forest ferns will grow well if under shaded conditions [12]. The coffee stand (Figure 5) had the highest significant difference in tendril diameter. The tendrils grow well in low light conditions but are sufficient to produce large diameter and fertile tendrils. Tight shading conditions will cause tendrils to grow long and thin, because the production cycle slows down [12].

Based on Table 1, it is known that there was real relationship between stand type and RLI and total number of leaf, plant height, and tendril diameter with a value of is as follows : Value of total number of leaf (F= 15,92, p = 0,00, and R square = 0,08); value of plant height (F = 34,63, p = 0,00, dan R square = 0,0005); and value of tendril diameter (F = 5,62, p = 0,00, dan R square = 0,0034), but not in the case total number of tendrils, and tendril length. The correlation between RLI (%) of all stands types and total number of leaf, plant height and tendril diameter can be seen in Figures 6,7, and 8. The equation of multiple linear regression between stand type and RLI on the total number of leaf of *ketak* plants and value of R^2 is as follows: Y1 = 0.0595x + 3.7828 (1), R^2 = 0.0401; Y2 = 0.101x + 4.7359 (2), R^2 = 0.0164; Y3 = 0.0324x + 6.7863(3); R^2 = 0.0068; Y4 = - 0.0109x + 7.006(4); R^2 = 0.0019.

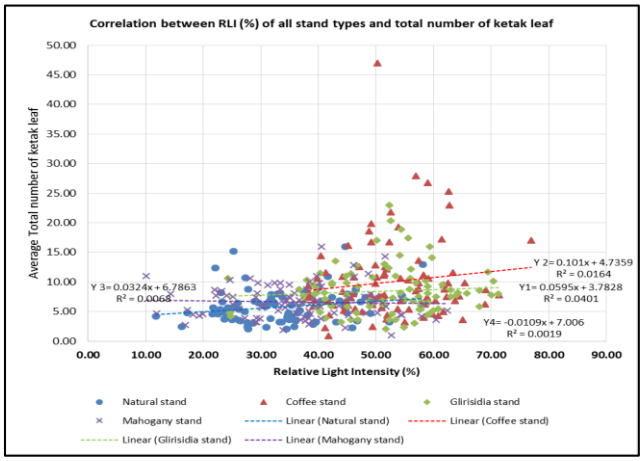

Figure 6. Correlation between RLI (%) of all stand types and total number of leaf of *ketak* plants
Note : Y1= Natural stand, Y2 = Coffee stand, Y3 = Glirisidia stand and Y4 = Mahogany stand

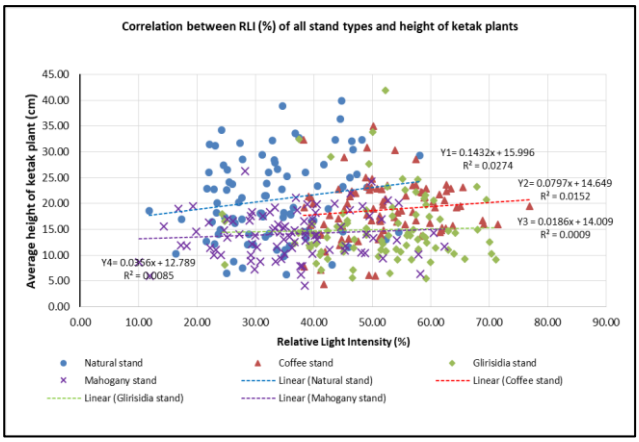

Figure 7. Correlation between RLI (%) of all stand types and height of *ketak* plants

Based on Figure 7, the equation of multiple linear regression between stand type and RLI on height of ketak plants and value of R2 is as follows: Y1= 0.1432x + 15.996 (1), R^2 = 0.0274; Y2= 0.0797x + 14.649 (2), R^2 = 0.0152; Y3 = 0.0186x + 14.009 (3), R^2 = 0.0009; Y4= 0.0356x + 12.789 (4), R^2 = 0.0085.

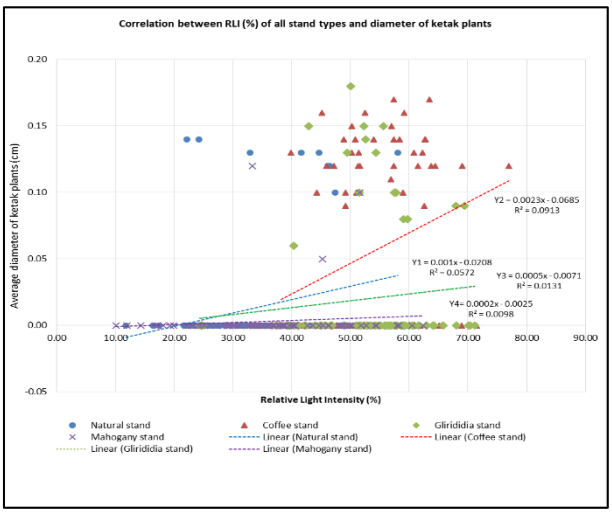

Figure 8. Correlation between RLI (%) of all stand types and tendril diameter of *ketak* plants

Based on Figure 8, the equation of multiple linear regression between stand type and RLI on tendril diameter of ketak plants and value of R2 is as follows: Y1 = 0.001x - 0.0208 (1), R^2 = 0.0572; Y2 = 0.0023x - 0.0685 (2), R^2 = 0.0913; Y3 = 0.0005x - 0.0071 (3), R^2 = 0.0131; Y4= 0.0002x - 0.0025 (4), R^2 = 0.0098.

Based on the results of the analysis above, it shows that there is a relationship between the intensity of light with total number of leaf, plant height and tendril diameter of ketak plants. As it is known that ferns will grow well in sufficient light conditions and shaded. According to [12], the best light intensity for ferns growth ranges from 200-600 f.c. (foot-candles). The abundance of climber ferns depends on light availability [13].

4. Conclusion

1. The growth percentage of *ketak* in each stand type is as follows natural stand = 62.22%, coffee stand = 97.77%; gliricidia stand = 75.56% and mahogany stand = 74.44%.
2. The stand type shows significant with total number of leaves (F = 17,441; p = 0,000); plant height (F = 24,065; p = 0,000) and tendril diameter (F = 7,747; p = 0,000).
3. There is a significant correlation between stand types and RLI with total number of leaf, plant height and tendril diameter of *ketak*

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