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Morphological Characteristics of *Arenga pinnata* Merr. from Maros and Sinjai Provenances in South Sulawesi, Indonesia, and its relationship with Brix Content

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Abstract. Palmae is a tree family that has the third biggest potential after the Gramineae and Fabaceae families. *Arenga* belongs to the genus of the multipurpose palm family (Mogea, Seibert, and Smits 1991), famously known as the "tree of life" and it has high economic potential, especially its sap. The sap produced is the result of photosynthesis which has a high amount of sugar with various inorganic substances and nutrients and good for health. This research provided information regarding the association of sugar content with morphological characteristics and environmental factors, in this case, the intensity of light, humidity and elevation. Morphological parameters observed were stem height, the girth of the bunch, number of green leaves, length of petiole, leaf width (lad), leaf length (pad), number of the female and male inflorescence. Correlation analysis between morphological characters and Brix content showed a moderate correlation on length of the leaf, number of green leaves, and stem height. While the character of environmental factors to Brix content had a moderate correlation on light intensity below the tree stand with a negative correlation value, which was not in line with the value of confidence interval (UpperCI = 0.004) and significantly affected the Brix content.

1. Introduction

Arenga pinnata Merr is one of the most important commercial palms locally, nationally, and globally. Besides its sugar production, this type of palm is also a bioenergy plant [1]. Alcohol and bioethanol are produced from its sap [2]. It is classified as an annual plant that has an important role in the nation's economy. Thirty million of Indonesians depend on agriculture and forestry to collect and manage non-timber forest products [3].

Sugar palm products are the fruit that can be eaten and fiber that can be used as building materials and household appliances [4]. These potentials must be supported by superior characters to support sugar palm breeding and conservation programs in the future. Morphological characteristic is one parameter that is able to provide information regarding the superior nature of a species, like Teak [5], and mahogany [6]. The main parameter of sugar palm that determines the superior nature is the Brix content of the sap because it can contribute as the livelihoods in the rural area which made it into



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block sugar, brown sugar, and also as an alternative fuel called bioethanol. The quantity and content of palm sugar are largely determined by the morphological, physiological, genetic and environmental conditions.

Sugar palm in producing high Brix content is strongly influenced and supported by many factors. Besides agronomic and environmental factors, it is also influenced by the characteristic of plants. Research by Ibrahim et al (2018) on an analysis of the association of Brix content and sap production on the important morphological reproductive characterization of palm trees found that characters associated with Brix content and palm sugar production are the trunk circumference and average rachis length [7].

Study such as that conducted by Nurholis and Saleh Ismail (2019) have shown that result on the correlation analysis of leaf area with ovary diameter and fruit weight was positively correlated, while fruit weight was negatively correlated with cherry fruit sweetness. The leaf area is correlated with the origin of the leaf, not the leaf position on the tree in the provenance. Information regarding the correlation between plant anatomy characteristics is basic knowledge for an efficient selection program [8].

Although some sugar palm morphological characteristics have been found, the character only found on the tested population. Testing is needed in order to determine the morphological characteristics in different palm populations. Tenda and Maskromo (2012) stated that the current problems of sugar palm are it has not been cultivated and many of its planting areas have been changed into settlements and replaced with other commodities [9].

In order to cultivate sugar palm specifically in South Sulawesi, data and information about specific characters such as morphological characteristics and environmental factors are needed to be able to supply high-quality seeds from superior sugar palm which produce sap with high Brix content [10].

2. Research Materials and Method

The tools used for sampling were Global Positioning System (GPS), laser distance meter, humidity meter (digital thermohygrometer), light intensity meter, chlorophyll meter, refractometer, tape meter, roll meter, plastic clip, pencil, caulking, envelopes, rulers, cutter blades, and digital laser height meters. The materials were labels, tally sheets, and palm leaf samples. The number of sample trees was 25 trees per provenance which were Maros and Sinjai provenances, thus the total sample were 50 tree samples. The sample tree should be on the sap collection process, therefore Brix content from the sap can be measured.

2.1. Research Sampling

Samples were taken from two provenances. The first sample was Maros Provenance from Bonto Somba Village, Tompobulu District. While the second sample was Sinjai Provenance from Bonto Sinala Village, Sinjai Borong District. Morphological characters observed were on (1) Trunk: Stem height (m) was measured with a laser distance meter towards the lowest green leaf and the shooter position was 10 m from the target tree, the girth of bunch (m) was measured by using a measuring tape and measured at breast height; (2) Leaves: Number of green leaves (sheet), length of petiole (m), leaf width (cm), and leaf length (cm); (3) Flower: calculated the number of female inflorescence (stems), the number of male inflorescence (stems), and (4) the content of Brix (percent) [9].

The Brix content was obtained by taking sap in the morning and evening, then measured with a refractometer to get the Brix value. Then the morning and evening measurements were calculated to get the average Brix value of the sample. Brix is a parameter for estimating total Brix content (Tsuchihashi and Goto, 2005). Measurements of environmental factors related to palm sugar levels were the light intensity inside and outside of tree stands (Cd), humidity inside and outside of tree stand (°C), and elevation (masl).

2.2. Data Analysis

Data were analyzed by R statistics with correlation analysis methods, plot methods, significant tests, and correlation matrix. To determine the correlation between the character of Brix content ~ morphological characters and the correlation between Brix content ~ environmental factors were done by observing the correlation coefficient, p-value, and confident interval. The correlation of each variable showed the closeness level of the relationship between one variable with another. [11] found that there are three categories on the correlation level of interpretations between variables according to the Guilford empirical rules reference (modification) which is shown in table 1.

Table 1. Interpretation of Correlation Coefficients

| Scale of r_{yx} | Interpretation of The Correlation Result Between Variable |
|-------------------|---|
| 0,00 – 0,20 | Low relation/correlation |
| 0,20 – 0,70 | Moderate relation/correlation |
| 0,70 – 1,0 | Strong relation/correlation |

3. Result and Discussion

3.1. Morphological characteristics and the correlation with palm Brix content (*Arenga pinnata Merr.*)

Observation of sugar palm morphological characteristics was carried out in two provenances, which were Maros Provenance, Bontosomba Village, Tompobulu District, and Sinjai Provenance, Bonto Sinala Village, Sinjai Borong District. Correlations showed the correlation coefficient between the variables of Brix content, stem height, stem circumference, number of green leaves, length of petiole, leaf width, leaf length, numbers of male and female inflorescences table 2.

Table 2. Correlation, P-Value, Confidence Interval Between Brix Content Character with The Morphological Characteristics of Sugar Palm (*Arenga Pinnata Merr*) of Maros Provenance and Sinjai Provenances

| Kg~Morphological Characteristic | R | P-value | Confidence Interval | |
|-----------------------------------|-----------|---------|---------------------|---------|
| | | | LowCI | UpperCI |
| Kg~ Stem Height | 0,166 | 0,2476 | -0,1172 | 0,4252 |
| Kg~ Girth of Bunch | 0,07151 | 0,6217 | -0,211 | 0,343 |
| Kg~ Number of Green Leaf | 0,184 | 0,2008 | -0,0994 | 0,4399 |
| Kg~Length of Petiole | 0,02675 | 0,8537 | -0,2535 | 0,3028 |
| Kg~Leaf Width | 0,07641 | 0,5979 | -0,2063 | 0,3474 |
| Kg~Leaf Length | 0,2175 | 0,1292 | -0,06479 | 0,4675 |
| Kg~ Number of Male Inflorescence | -0,007195 | 0,9604 | -0,285 | 0,2717 |
| Kg~Number of Female Inflorescence | 0,03867 | 0,7898 | -0,2423 | 0,3136 |

The correlation coefficient of Brix content variable with leaf length, number of green leaves and stem height showed a positive correlation with value = 0.2 (enough). [10] identified that stem height and number of leaves were positively correlated with Brix content on sugar palm because the leaf is a generative organ with a big role in the photosynthesis process which produces carbohydrates that needed by palm trees to grow and producing sap. Leaves are needed to absorb and convert light energy through photosynthesis process, for growth and development process, especially on sink or plant parts that use assimilation [12]. Furthermore, [13] stated that the most common compound found in the assimilate transport process was sucrose.

The negative value of the correlation coefficient indicated that the direction of the correlation was unidirectional, the number of male inflorescences was negatively correlated with Brix content. An addition of male inflorescence would reduce Brix content. A negative correlation means that an

increase in one trait will increase another trait which being addressed (Samudin and Saleh 2009). Based on LowCI and UpperCI test results, the correlation between the value of Brix content with morphological character variables tested showed no significant effect, thus the H₀ Hypothesis was accepted. It means there was no significant correlation between the Brix content variable and the morphological characters.

3.2. Characteristics of Environmental Factors and the correlation with palm Brix content (*Arenga pinnata*, Merr.)

The results of the Brix content correlation with provenance environmental factors showed that Brix content with humidity outside of tree stand and Brix content with elevation showed positive or unidirectional results. Additional in one unit of the environmental factors, such as elevation, provenance and outside humidity of the stand, was causing an increase in palm Brix content table 3.

Table 3. Correlation, P-value, and Confidence Interval Between The Character of Palm Brix Content (*Arenga Pinnata*, Merr) and The Environmental Factors of Maros and Sinjai Provenances

| Kg~ Morphological Characteristic | R | P-value | Confidence Interval | |
|---|-----------|---------|---------------------|----------|
| | | | LowCI | UpperCI |
| Kg~ Provenance | 0,1631 | 0,2577 | -0,4233 | 0,4223 |
| Kg~ Light Intensity Below of Tree Stand | -0,2373 | 0,09706 | -0,4837 | 0,04395* |
| Kg~ Light Intensity Outside of Tree Stand | -0,04603 | 0,7509 | -0,3203 | 0,2353 |
| Kg~ Humidity Below of Tree Stand | -0,007972 | 0,9562 | -0,2857 | 0,271 |
| Kg~ Humidity Outside of Tree Stand | 0,1041 | 0,4717 | -0,1794 | 0,3717 |
| Kg~Elevation | 0,2031 | 0,1572 | -0,07977 | 0,4557 |

A correlation value of light intensity below of tree stand presented a negative correlation with Brix content ($r = -0.2373$), and a significant effect with UpperCI value = 0.0439, meant that the light intensity below of tree stands significantly affected the addition or reduction of the Brix content. The results of the hypothesis H₀ was accepted. There was a negative correlation between the light intensity below of the tree stand with the content of Brix. [10] stated that the negative correlation of a trait would reduce the intended trait. The growth rate of plants is largely determined by the temperature and humidity, while the reproductive phase is mainly controlled by light intensity [14].

The correlation of each morphological character variable and the environmental factors of sugar palm in the Maros and Sinjai provenances is illustrated in figure 1.

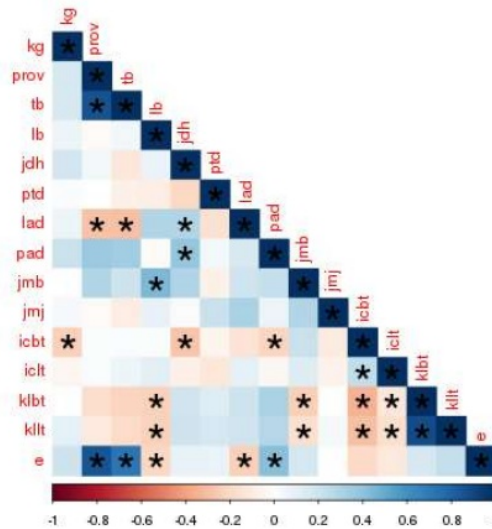


Figure 1. The correlation of each morphological character variable and the environment factors of sugar palm in the Maros and Sinjai provenances

Brix content was arranged in the form of a correlation plot with color visualization and a level of significance. An asterisk indicated the magnitude of influence or significance between each variable tested, whereas the direction of the correlation was shown in the form of a correlation plot matrix figure 2.

Based on the correlation direction between each morphological character variable and environmental factors on Brix content, the right direction in correlation displayed positive correlation, while the left direction was negative correlation. However, the unclear direction does not configure any correlation.



Figure 2. The correlation of each morphological character variable and environmental factor character of brix content of palm sugar aren (*Arenga pinnata, Merr.*) provenans Maros dan Sinjai

Based on the results, the correlations of morphological characteristics and environmental factors with palm Brix content showed a sufficient to a very weak correlation. Morphological characters that showed positive relationships with a correlation value of $r = 0.2$ (enough) were the characters of leaf length, number of leaves, and stem height. While the environmental character that showed sufficient correlation was the light intensity below of tree stand, with a significance value that significantly affected the Brix content. However, the correlation direction for these environmental factors was negative relationship that meant they were not in the same direction. This illustrated that the higher the light intensity below the tree stand, the lower the Brix content would be.

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