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Analysis of chlorophyll content of dalugha leaves (Cyrtosperma merkusii (Hassk.) Schott) from several locations, leaf locations, and relationship with production of cormus in north sulawesi

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Abstract
Dalugha (Cyrtosperma merkusii (Hassk.) Schott) is a typical tuber in North Sulawesi. The locations are mostly in the Sangihe and Talaud Islands Regencies. Dalugha is a food source (carbohydrate) of the local community. Scientific studies about dalugha are still limited including the physiological characteristics of this plant. An important physiological characteristic of plants is the chlorophyll content. The purpose of this study was to determine the chlorophyll content of dalugha leaves in several places, the chlorophyll content of dalugha leaves from various leaf locations, and determine the relationship between chlorophyll content and dalugha cormus. The research locations were Pokol and Balane Villages, Sangihe Islands Regency, Bantik Resduk and Moronge Villages, Talaud Islands Regency, and the Experimental Gardens of Laikit and Lotta Villages from September 2019 to May 2020. This study used an observational approach, cross sectional study design or prevalence study. Data analysis of chlorophyll content and location and location of leaves using the statistical analysis method of variance (One Way ANOVA) and further tests of real honest difference (BNJ). Relationship between chlorophyll and dalugha cormus content using simple correlation statistical methods and coefficient of determination. The results showed that there were differences in the chlorophyll content of dalugha leaves between one location and another. Chlorophyll in Moronge Village 54.65 units, Balane 47.19 units, Bantik Resduk 44.19 units, Lotta 41.01 units, Pokol 38.78 units, Laikit 33.50 units. The chlorophyll content of dalugha leaves differs based on the location of the leaves. The upper part of the leaf is 46.89 units, the middle part is 43.89 units, and the lower part is 39.37 units. Chlorophyll content has a relationship with dalugha cormus production.

Keywords: dalugha, chlorophyll, cormus, north sulawesi

Introduction

Dalugha (Cyrtosperma merkusii (Hassk.) Schott) is a typical tuber in North Sulawesi with the most locations in the Sangihe and Talaud Islands Regencies. Dalugha is a food source (carbohydrate) of the local community, this plant has not been cultivated yet it still grows wild. According to Manner (2011: 17)[1] dalugha has high concentrations of iron, zinc, calcium, and β-carotene which help protect against disorders of vitamin A deficiency and anemia. Furthermore, Lintang, *et al* (2016: 84)[2] states that dalugha is one of the local food plants that has important value for the people of Sangihe and surrounding areas in relation to the impacts of climate change and supports government programs to improve food security and independence.

Scientific studies about dalugha are still limited including the physiological characteristics of this plant. An important physiological characteristic of plants is the chlorophyll content. According to Shah *et al*. (2017: 2) chlorophyll content is an important element in monitoring plant stress, fertilizer application in agricultural systems, because the level of productivity is directly related to plant conditions [3]. Chlorophyll is a key variable in characterizing photosynthetic responses and gross primary production in the biosphere, with chlorophyll playing a central role in capturing sunlight, protecting the photosynthetic system, and other growth functions.

Preliminary surveys of field research have been carried out in Sangihe and Talaud Islands Regency. According to the village head of Meyer Maniku (Opo Lao Kampong Pokol, Tamako) dalugha plants are very numerous, growing still naturally, not yet cultivated by the local community. Many people process dalugha into "Ketang-Ketang" (dalugha kormus grated, dried, fried, added palm sugar, shaped like a ball). In the Talaud Islands Regency, Bantik Resduk Village, dalugha has not yet been cultivated and still grows naturally. Previous research on the analysis of the content of chlorophyll dalugha by Ratag (2017: 9) shows that the open conditions covered by trees affect the total chlorophyll content, chlorophyll a, and chlorophyll b [4]. The chlorophyll content of dalugha leaves that grow in several locations has not been much studied. Likewise the chlorophyll content of dalugha leaves from various leaf locations. According to Nio Song and Banyo (2011: 171) chlorophyll content can be used as a reliable indicator to determine the metabolic balance between photosynthesis and production results. By knowing the amount of chlorophyll content the farmers can predict dalugha (cormus) yield. There is no research about the relationship between chlorophyll content and the production of (kormus) dalugha.

Data on chlorophyll content is very important in the context of dalugha cultivation to produce food security products and diversification of other carbohydrate sources besides rice. Therefore, research needs to be done on the analysis of the chlorophyll content of dalugha leaves (C. merkusii (Hassk.) Sott) from several locations, leaf locations, and relationships with cormus production in North Sulawesi.

Research Methods

This study uses an observational approach, cross sectional study design or prevalence studies. According Masturoh and Anggita (2018: 129) [6] Cross sectional research design that is a study that studies the correlation between risk factors (independent) with effects (dependent) with data collection carried out simultaneously simultaneously in a certain time period. Cross sectional research design can be seen in Figure 1.

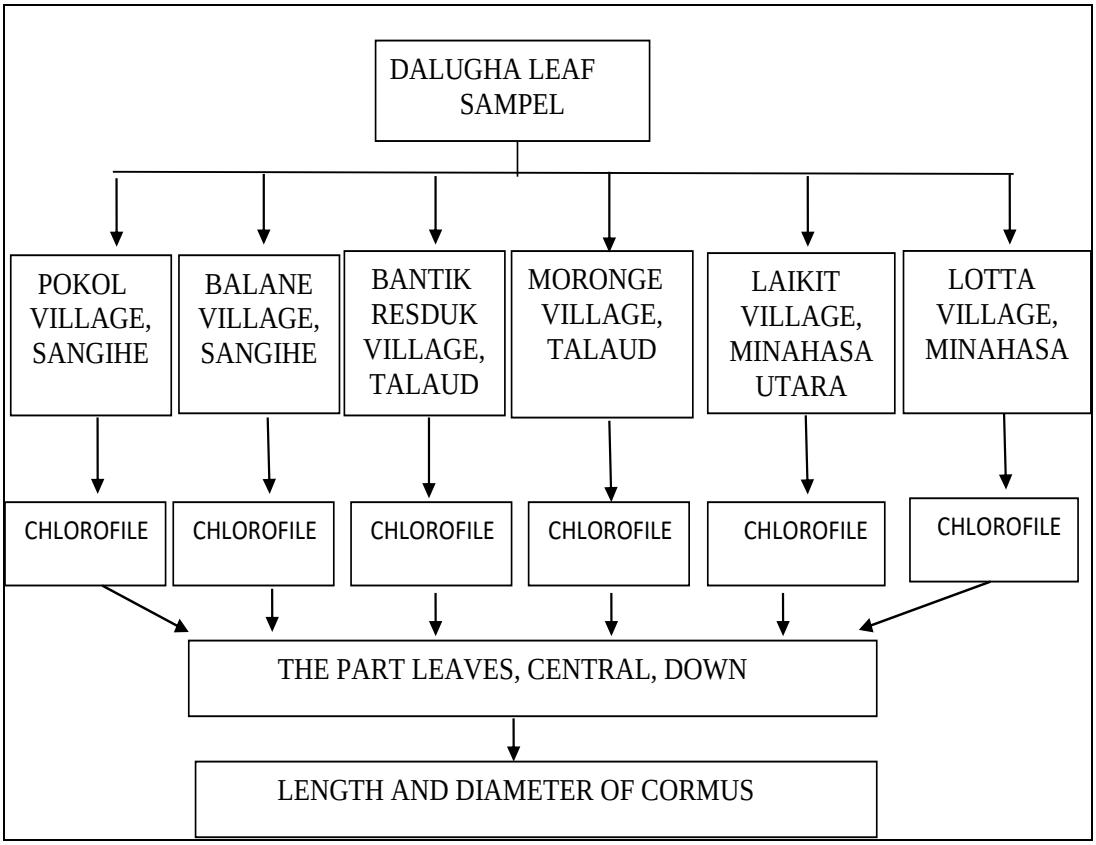

Fig 1: Cross Sectional Research Design or Prevalence Study

This research was conducted in Pokol and Balane Villages, Sangihe Islands Regency, Bantik Resduk Village and Moronge Talaud Islands Regency, Experimental Gardens in Laikit and Lotta Villages in September 2019 to May 2020.

Pokol Village, Tamako District, Sangihe Islands Regency

Pokol Village is administratively located in Tamako District, Sangihe Islands Regency with a geographical location of 3°27'11.54" North Latitude-125°30'29.55" East Longitude and at an altitude of 13 meters above sea level (asl). Pokol Village can be seen in Figure 2.

Fig 2: Pokol Village (Google Earth Pro, 2020)

Balane Village, Tamako District, Sangihe Islands Regency

The Balane Village is administratively located in Tamako District, Sangihe Islands Regency with a geographical location of 3°27'37.11" North Latitude-125°30'36.63" East Longitude and at an altitude of 15 meters above sea level (asl). The village of Balane can be seen in Figure 3.

Fig 3: Balane Village (Google Earth Pro, 2020)

Bantik Resduk Village, Beo District, Talaud Islands Regency

Bantik Resduk Village is administratively located in Beo District, Talaud Islands Regency with a geographical location of 4°14'59.77" North Latitude-126°47'22.92" East Longitude and at an altitude of 14 meters above sea level (asl). Bantik Resduk Village can be seen in Figure 4.

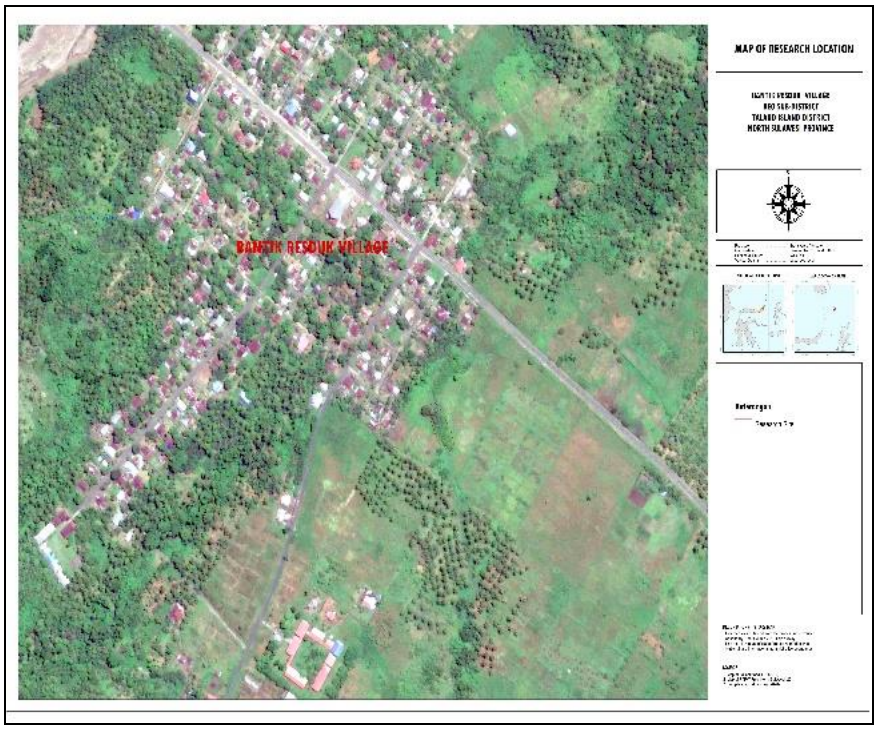

Fig 4: Bantik Resduk Village (Google Earth Pro, 2020)

Moronge Village, Moronge District, Talaud Islands Regency

Moronge Village is administratively located in the District of Moronge, Talaud Islands Regency with a geographical location of 3°54'26.44" North Latitude-126°42'1.44" East Longitude and at an altitude of 47 meters above sea level (asl). Moronge Village can be seen in Figure 5.

Fig 5: Moronge Village (Google Earth Pro, 2020)

Laikit Village, Dimembe District, North Minahasa Regency

Laikit Village is administratively located in Dimembe Subdistrict, North Minahasa Islands Regency with a geographical location of 1°29'35.65" North Latitude-124°57'41.99" East Longitude and at an altitude of 208 meters above sea level (asl). Laikit Village can be seen in Figure 6.

Fig 6: Laikit Village (Google Earth Pro, 2020)

Lotta Village, Pineleng District, Minahasa Regency
Lotta Village is administratively located in Dimembe Subdistrict, North Minahasa Islands Regency with a geographical location of 1°25'8.66" North Latitude-124°50'33.21" East Longitude and at an altitude of 182 meters above sea level (asl). Lotta Village can be seen in Figure 7.

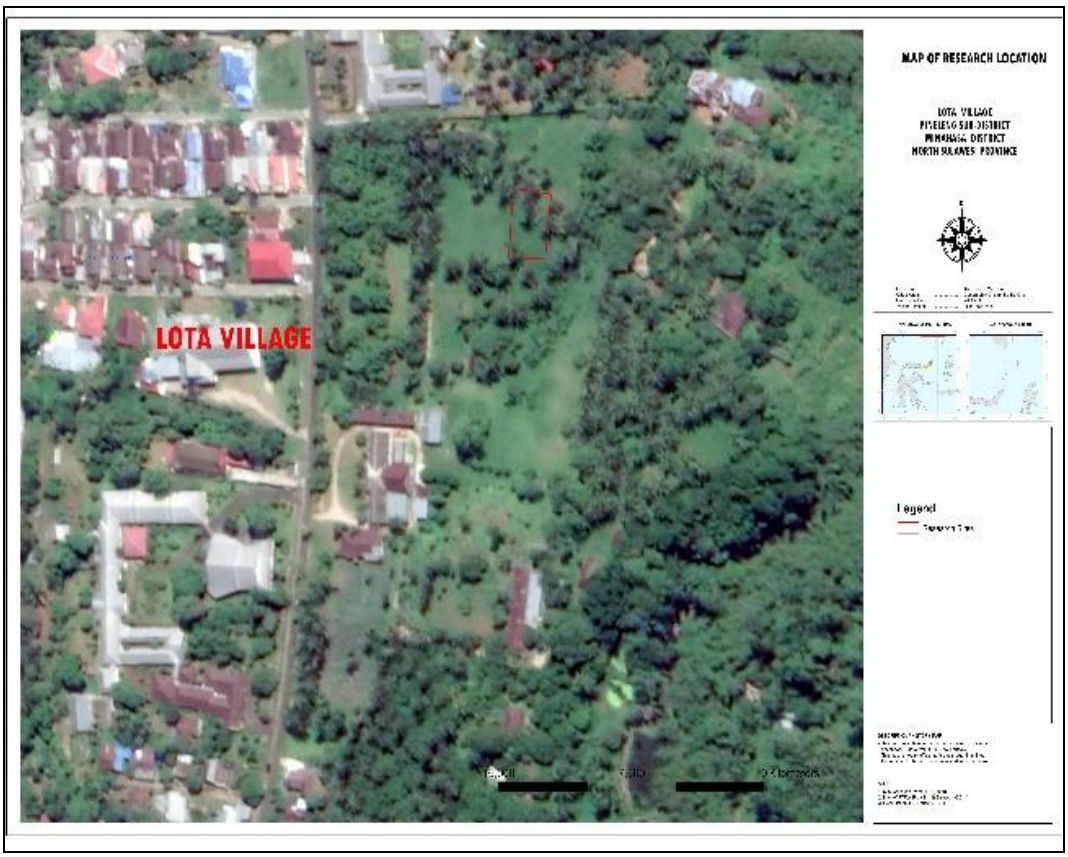

Fig 7: Lotta Village (Google Earth Pro, 2020)

Research procedure
a. Upper dalugha leaves (third leaf), middle (second leaf), and lower (first leaf) the amount of chlorophyll is measured using the SPAD-502 Chloropyll Meter.
b. Each part of the upper, middle, and lower leaves is repeated 6 times and then averaged.
c. 10 plots in each study location using the line transect method. The distance of each plot is 5 meters.
d. Create data for each chlorophyll in the six study locations, namely Pokol, Balane, Bantik Resduk, Moronge, Laikit, and Lotta villages.
e. Measure the length and diameter of the cormus.

Research variable
a. Chlorophyll (dalugha leaf) content
b. Location (Six villages: Pokol, Balane, Bantik Resduk, Moronge, Laikit, and Lotta)
c. Leaf location (top: third leaf, middle: second leaf, bottom: first leaf)
d. Cormus (length and diameter)

Data analysis
a. Data analysis of dalugha leaf chlorophyll content is carried out using statistical analysis method of variance (One Way ANOVA). If the analysis of real variants is then continued with real honest difference (BNJ).
b. Relationship between leaf chlorophyll and dalugha cormus using simple correlation statistical methods and coefficient of determination.

Result and Discussion
Chlorophyll content of various sampling locations
The chlorophyll content of dalugha leaves from several locations in North Sulawesi can be seen in Table 1.

Table 1: Total Chlorophyll Content of Dalugha Leaves from Several Locations in North Sulawesi (Unit)

Location	Chlorophyll Average (unit) *
Laikit	33.50 a
Pokol	38.78 ab
Lotta	41.01 bc
Bantik Resduk	44.19 bc
Balane	47.19 c
Moronge	54.65 d

Note: * Numbers followed by the same letters indicate no significant difference (p> 0.05)

The results of further testing using Honest Real Difference showed that the highest chlorophyll content of dalugha leaves in Moronge Village with a value of 54.65 units and the lowest in Laikit Village with a value of 33.50 units. It can also be said that Moronge with a chlorophyll content value of 54.65 units was significantly different and higher than the chlorophyll content in five other locations namely Balane 47.19 units, Bantik Resduk 44.19 units, Lotta 41.01 units, Pokol 38.78 units, and Laikit 33.50 units. At the Balane location the value of 47.19 units of chlorophyll content was significantly different and lower than the chlorophyll content in Moronge with a value of 54.65 units.

But the chlorophyll content in Balane 47.19 units was not significantly different from the chlorophyll content in the two locations namely Bantik Resduk 44.19 units and Lotta 41.01 units. The chlorophyll content in Balane 47.19 units was significantly different and higher than the chlorophyll content in Pokol Village 38.78 units and Laikit 33.50 units. The chlorophyll content in Bantik Resduk Village was 44.19 units significantly different and lower than the chlorophyll content in Moronge village 54.65 units. But the chlorophyll content in Bantik Resduk Village 44.19 units was not significantly different from the chlorophyll content in the three other locations namely Balane 47.19 units, Lotta 41.01 units, and Pokol 38.78 units.

The chlorophyll content in Bantik Resduk Village was 44.19 units significantly different and higher than the chlorophyll content in Laikit Village 33.50 units. The chlorophyll content in the Lotta Village 41.01 units is significantly different and lower than the chlorophyll content in the Balane Village 47.19 units and Moronge 54.65 units. But the chlorophyll content in Lotta Village 41.01 units was not significantly different from the chlorophyll content in Bantik Resduk Village 44.19 units and Pokol 38.78 units. The chlorophyll content in Lotta Village 41.01 units is significantly different and higher than the chlorophyll content in Laikit Village 33.50 units. The chlorophyll content in Pokol Village was 38.78 units significantly different and lower than the chlorophyll content in Balane Village 47.19 units and Moronge 54.65 units. But the chlorophyll content in Pokol Village 38.78 units was not significantly different from the chlorophyll content in three locations, 41.01 units of Lotta, Bantik Resduk 44.19 units, and 33.5 units Laikit. The chlorophyll content in Laikit Village was 33.50 units significantly different and lower than the chlorophyll content in the four other locations namely Lotta 41.01 units, Bantik Resduk 44.19 units, Balane 47.19 units, and Moronge 54.65 units. But the chlorophyll content in Laikit Village 33.50 units was not significantly different from the chlorophyll content in Pokol Village 38.78 units.

Chlorophyll Content of Various Leaf Locations

The chlorophyll content of various leaf locations namely the upper leaf (third leaf), middle leaf (second leaf), lower leaf (first leaf) can be seen in Table 2.

Table 2: Chlorophyll Content of Dalugha Leaves from Various Leaf Locations

Leaf Locations	Chlorophyll Average (unit) *
Lower	39.37 a
Middle	43.40 ab
Upper	46.89 b

Note: * Numbers followed by the same letters indicate no significant difference (p> 0.05)

Based on the Honestly Significant Difference test the highest leaf chlorophyll content was 46.89 units and the lowest was 39.37 units. It can also be said that the leaf chlorophyll content of the upper leaf 46.89 units is significantly different and higher than the chlorophyll content of the lower leaf 39.37 units. But the chlorophyll content of the upper leaf 46.89 units was not significantly different from the chlorophyll content of the middle leaf 43.40 units. The chlorophyll content of the middle leaf 43.40 units was not significantly different from the chlorophyll content of the upper leaf 46.89 units and the lower leaf 39.37 units. The lower leaf chlorophyll content of 39.37 units was significantly different and lower than the chlorophyll content of the upper leaf 46.89 units. But the chlorophyll content of the lower leaves 39.37 units was not significantly different from the chlorophyll content of the middle leaves 43.40 units.

Relationship between Chlorophyll Content and Dalugha Cormus

Dalugha cormus samples used data at the location of Moronge Village, due to limited data sources. Some locations such as Laikit and Lotta Kormus villages do not yet exist because dalugha in this location have only been planted for about four months. And the presence of COVID-19 Pendemi researchers can no longer go to the Sangihe and Talaud Islands Regency research sites, so for the relationship of chlorophyll and cormus content samples were taken at the Moronge Village research site (cormus data had been taken before the COVID-19 Pandemic). Moronge Village is the location with the highest chlorophyll content of the five other locations. The chlorophyll content of dalugha leaf and cormus in Moronge Village, Moronge District, Talaud Islands Regency can be seen in Table 3.

Table 3: Chlorophyll Content of Leaves and Cormus (length and diameter) of Dalugha in Moronge Village, Moronge District, Talaud Islands Regency

Sample	Chlorophyll Dalugha Leaf		Cormus	
	Leaf Section	Quantity (Unit)	Length (cm)	Diameter (cm)
1	Upper	46.8	23	24
	Middle	46.4		
	Lower	46.1		
2	Upper	52.9	28	28
	Middle	52.8		
	Lower	52.2		
3	Upper	55.6	27	23
	Middle	54.9		
	Lower	54.2		
4	Upper	66.1	32	33
	Middle	65.4		
	Lower	65.3		
5	Upper	75.9	36	36
	Middle	67.8		
	Lower	67.4		
6	Upper	61.4	23	20
	Middle	50.5		
	Lower	19.4		
7	Upper	68.4	22	28
	Middle	42.0		
	Lower	40.2		
8	Upper	49.9	25	27
	Middle	49.3		
	Lower	47.6		
9	Upper	56.3	28	27
	Middle	54.2		
	Lower	53.4		
10	Upper	61.5	28	31
	Middle	58.3		
	Lower	57.2		

a. Relationship between Average Total Chlorophyll Content and Length of Dalugha Cormus

Correlation test results of total chlorophyll content with dalugha cormus length can be seen in Table 4.

Table 4: Correlation Test Results for Total Chlorophyll Content with the Length of the Dalugha Cormus

Correlation coefficient	Sig	Information
0.945	0.000	There is a significant correlation

Based on the correlation test results obtained sig. 0.00 < 0.05 means that the total chlorophyll content has a relationship with the length of the dalugha cormus. The coefficient of determination R^2 = $(0.945)^2$ x 100% = 89.30%. The total chlorophyll content affects the length of the dalugha cormus. This means that there are parts which cannot be explained by the independent variable (total chlorophyll). Variations in the length of the cormus that cannot be explained by total chlorophyll are (1-0.945) x 100% = 10.70%. The remaining diversity is caused by other variables not examined namely environmental factors.

b. Relationship between Average Total Chlorophyll Content and Dalugha Cormus Diameter

Correlation test results of total chlorophyll content with dalugha cormus diameter can be seen in Table 5.

Table 5: Correlation Test Results for Total Chlorophyll Content with the Diameter of the Dalugha Cormus

Correlation coefficient	Sig	Information
0.887	0.001	There is a significant correlation

Based on the correlation test results obtained sig. 0.001 <0.05 means that the total chlorophyll content has a relationship with the diameter of the dalugha cormus. The coefficient of determination R^2 = $(0.887)^2$ x 100% = 78.68% of the total chlorophyll content affects the diameter of the dalugha cormus. This means that there are parts which cannot be explained by the independent variable (total chlorophyll). The diversity of cormus diameter values that cannot be explained by total chlorophyll is (1-0.7868) x 100% = 21.32%. The remaining diversity is caused by other variables not examined namely environmental factors.

c. Relationship between Average Chlorophyll Content of Upper Leaves and Length of the Dalugha Cormus

Correlation test results of chlorophyll content of upper leaves with dalugha cormus length can be seen in Table 6.

Table 6: Correlation Test Results of Upper Leaf Chlorophyll Content with the Length of the Dalugha Cormus

Correlation coefficient	Sig	Information
0.545	0.103	There is no significant correlation

Based on the correlation test results obtained sig. 0.103> 0.05 means that the chlorophyll content of the upper dalugha leaf has no relationship with the length of the dalugha cormus.

d. Relationship between Average Chlorophyll Content of Upper Leaves and the Diameter of the Dalugha Cormus

Correlation test results of chlorophyll content of upper leaves with dalugha corm diameter can be seen in Table 7.

Table 7: Correlation Test Results of Upper Leaf Chlorophyll Content with Dalugha Corm Diameter

Correlation coefficient	Sig	Information
0.620	0.056	There is no significant correlation

Based on the correlation test results obtained sig. 0.056 > 0.05 means that the chlorophyll content of the upper dalugha leaves has no relationship with the diameter of the dalugha cormus.

e. Relationship between Mean Chlorophyll Content of Middle Leaves and Length of the Dalugha Cormus

Correlation test results of the middle leaf chlorophyll content with the dalugha cormus length can be seen in Table 8.

Table 8: Correlation Test Results of the Middle Chlorophyll Leaves with the Length of the Dalugha Cormus

Correlation coefficient	Sig	Information
0.953	0.000	There is a significant correlation

Based on the correlation test results obtained sig. 0.000 < 0.05 means that the chlorophyll content of the middle dalugha leaves has a relationship with the length of the dalugha cormus. The coefficient of determination R^2 = $(0.953)^2$ x 100% = 90.82%. The chlorophyll content of the middle leaf affects the length of the dalugha cormus. This means that there are parts which cannot be explained by the independent variables (middle leaf chlorophyll). Variations in the length of the cormus that could not be explained by the middle leaf chlorophyll (1-0.9082) x 100% = 9.18%. The remaining diversity is caused by other variables not examined namely environmental factors.

f. Relationship between Average Chlorophyll Content of Middle Leaves and Diameter of Dalugha Cormus

Correlation test results of the middle leaf chlorophyll content with dalugha corm diameter can be seen in Table 9.

Table 9: Correlation Test Results of the Middle Chlorophyll Leaves with the Diameter of the Dalugha Cormus

Correlation coefficient	Sig	Information
0.697	0.025	There is a significant correlation

Based on the correlation test results obtained sig. 0.025 <0.05 means that the chlorophyll content of the middle dalugha leaves is related to the diameter of the dalugha cormus. The coefficient of determination R^2 = $(0.697)^2$ x 100% = 48.58% chlorophyll content of the middle leaf affects the diameter of the dalugha cormus. This means that there are parts which cannot be explained by the independent variables (middle leaf chlorophyll). The diversity of cormus diameter values that cannot be explained by the middle leaf chlorophyll (1-0.4858) x 100% = 51.42%. The remaining diversity is caused by other

variables not examined namely environmental factors.

g. Relationship between Average Chlorophyll Content of Lower Leaves with the Length of the Dalugha Cormus

Correlation test results of the lower leaf chlorophyll content with dalugha cormus length can be seen in Table 10.

Table 10: Correlation Test Results of Lower Leaf Chlorophyll Content with the Length of the Dalugha Cormus

Correlation coefficient	Sig	Information
0.820	0.004	There is a significant correlation

Based on the correlation test results obtained sig. 0.004 <0.05 means that the chlorophyll content of the lower dalugha leaf has a relationship with the length of the dalugha cormus. The coefficient of determination R^2 = $(0.820)^2$ x 100% = 67.24% of the chlorophyll content of the lower leaf affects the length of the dalugha cormus. This means that there are parts which cannot be explained by the independent variables (lower leaf chlorophyll). Variation in the length of the cormus that could not be explained by the lower leaf chlorophyll (1-0.6724) x 100% = 32.76%. The remaining diversity is caused by other variables not examined namely environmental factors.

h. Relationship between Average Chlorophyll Content of Lower Leaves with the Diameter of the Dalugha Cormus

The results of the correlation test of the bottom chlorophyll content with the diameter of the dalugha corm can be seen in Table 11.

Table 11: Correlation Test Results of Lower Leaf Chlorophyll Content with the Diameter of the Dalugha Cormus

Correlation coefficient	Sig	Information
0.815	0.004	There is a significant correlation

Based on the correlation test results obtained sig. 0.004 <0.05 means that the chlorophyll content of the lower dalugha leaf has a relationship with the diameter of the dalugha cormus. The coefficient of determination R^2 = $(0.815)^2$ x 100% = 66.42% of the chlorophyll content of the lower leaf affects the diameter of the dalugha cormus. This means that there are parts which cannot be explained by the independent variables (lower leaf chlorophyll). The diversity of cormus diameter values that cannot be explained by the lower leaf chlorophyll (1-0.6642) x 100% = 33.58%. The remaining diversity is caused by other variables not examined namely environmental factors.

Discussion

The chlorophyll content of dalugha leaves in the villages of Moronge, Balane, Bantik Resduk, Lotta, Pokol, and Laikit differ due to differences in temperature, light intensity, humidity, rainfall, elevation of the surface of the sea, as well as conditions in the study where trees are covered, not too shaded by trees (partially shaded) and not shaded by trees (open) in each location. According to Mansur (2011: 36) the rate of photosynthesis in one individual with other individuals in one type will be different. This is caused by external factors (microclimate) such as air temperature, air humidity, light intensity, soil pH, groundwater, and altitude. Then Rohmat, *et al*. (2014: 125) states that differences in temperature result in different chlorophyll content [7].

Moronge Village temperature 26.7ºC, light intensity 67%, humidity 85%, rainfall 165 mm, the height of 47 meters above sea level, the location of the research shaded by trees. This environmental condition causes the chlorophyll content of dalugha leaves in Moronge Village to be the highest of the chlorophyll content in the five other research locations. In addition, the chlorophyll content in shaded areas is higher (Moronge Village) compared to open areas (in other locations) because dalugha leaves in Moronge Village are wider (on average more than 1 meter) compared to other locations. According to Hadisunarso and Djuita (2018: 17) leaves are generally flat and wide in shape. Such leaf shapes are more efficient at capturing the light needed for photosynthesis [8].

The village of Balane has a temperature of 32.4ºC; light intensity 94%, humidity 74%, rainfall 15 mm, location 15 meters above sea level, the location of the study is not too shaded by trees. This environmental condition causes the chlorophyll content in Balane village to be lower than the chlorophyll content in Moronge Village. But the chlorophyll content in Desa Balane is higher than Bantik Resduk, Lotta, Pokol, and Laikit.

Bantik Resduk Village has a temperature of 24ºC, light intensity of 63%, humidity 81%, rainfall 258 mm, the location is 14 meters above sea level, the location of the study is not too shaded by trees. This environmental condition causes the chlorophyll content in Bantik Resduk Village to be lower than the chlorophyll content in Moronge and Balane villages. But the chlorophyll content in Bantik Resduk Village is higher than the chlorophyll content in Lotta, Pokol, and Laikit villages.

Lotta Village temperature 29ºC, light intensity 62%, humidity 87%, rainfall 106 mm, the height of 182 meters above sea level, the location of the study is not too shaded by trees. This environmental condition causes the chlorophyll content in Lotta Village to be lower than the chlorophyll content in Moronge, Balane and Bantik Resduk villages. But the chlorophyll content in Lotta Village is higher than the chlorophyll content in Pokol and Laikit Villages.

Pokol Village temperature 32.4ºC, light intensity 94%, humidity 74%, rainfall 15 mm, the location is 13 meters above sea level, the location of the study is not too shaded by trees. This environmental condition causes the chlorophyll content in Pokol Village to be lower than the chlorophyll content in Moronge, Balane, Bantik Resduk, and Lotta villages. But the chlorophyll content in Pokol Village is higher than Laikit.

Laikit Village temperature 32.2ºC, light intensity 63%, humidity 77%, rainfall 96 mm, the height of the sea surface, the location of the study is not shaded by trees (open). This environmental condition causes the chlorophyll content in Laikit Village to be lower than five other research sites namely Moronge, Balane, Bantik Resduk, Lotta, and Pokol.

According to Ratag, *et al*. (2013: 9) in shaded places the light intensity received by low leaves causes a decrease in the rate of photosynthesis and carbohydrate synthesis [7]. To increase the rate of photosynthesis and carbohydrate synthesis under conditions of low light intensity, dalugha leaves become larger and an increase in the content of

chlorophyll a and b so that the light captured and transferred to the center of photosynthesis reaction is greater. Furthermore, Sulistyowati (2019: 28) states that one form of physiological adaptation of plants to low irradiation is by increasing chlorophyll b [8]. The increase in chlorophyll b has a positive effect on the effectiveness of radiation energy absorption under shaded conditions.

Sopandie (2014: 108) states taro is an adaptive plant at low light intensity [9]. Plants that grow in shaded conditions will increase their tolerance of light deficits (limited light). Plants will decrease the light compensation point (LCP) and decrease the rate of respiration below the LCP. The point of light compensation is the minimum light intensity required by plants so that the rate of photosynthesis is the same as the rate of plant respiration. LCP reduction is done by avoiding damage to the photosynthetic system, through avoidance of decreased enzyme activity and avoidance of pigment damage.

The results of this study are in line with the results of two previous studies conducted by Ratag, *et al*. (2013: 11) states that dalugha are able to adapt and grow well in sheltered conditions [10]. Total chlorophyll in shaded conditions is higher than open conditions. Furthermore, Ratag, *et al*. (2017: 14) states that the open-shaded conditions of trees affect the content of dalugha chlorophyll while the stagnant or not flooded condition of brackish water does not affect the content of dalugha chlorophyll. The highest chlorophyll content is obtained from dalugha plants that grow in shaded conditions [4].

The chlorophyll content of dalugha leaves is the highest compared to the lower leaves because the size of the upper leaves is larger. The chlorophyll content of the upper leaves is the same as the middle part because the age of the leaves is not much different. The chlorophyll content of the middle dalugha leaves is the same as the chlorophyll content of the upper and lower leaves because the age of the middle leaves is not much different from the age of the upper leaves and lower leaves. The chlorophyll content of the lower leaves is lower than the upper chlorophyll content because the lower leaves are older than the upper leaves. The chlorophyll content of the lower leaves is the same as the chlorophyll content of the middle leaves because the age of the leaves is not much different.

The results of this study are in line with the results of four previous studies. Pratama and Laily (2015), which is the age of leaves influences the chlorophyll content in a leaf [11]. Furthermore, Songke *et al*. (2019) leaf age factors and interactions between leaf age and time lead to differences in total chlorophyll conten [12] t. Leaf position affects the chlorophyll content with a moderate relationship, leaf position influences the total chlorophyll content by 35% (Larasati *et al*., 2016). Different leaf positions at the same leaf age also indicate variations in the amount of chlorophyll content in the leaf. So the chlorophyll content also varies seen from the position of the leaves in one plant (Mustafa *et al*., 2015) [13].

Hamim (2018: 175) states the movement of sugars and organic compounds is determined by the existence of a source and sink relationship [14]. The process of translocation occurs from where the compound is formed or the so-called source (source) to the place of metabolism or to a storage area known as a sink (reservoir). Sources (source) include a network of exporting photosynthetic compounds such as leaves that are in full bloom that can produce photosynthates beyond their needs. Sinks include organs that are not photosynthetic or organs that cannot meet their needs such as young leaves that have not fully bloomed, roots, stems, and growing storage networks such as tubers, fruits and seeds.

The total chlorophyll content has a relationship with the length of the cormus which is 89.30% the total chlorophyll content affects the length of the cormus. 10.70% is influenced by environmental factors. The total chlorophyll content also has a relationship with the diameter of the cormus which is 78.68% the total chlorophyll content affects the diameter of the cormus. 21.32% is influenced by environmental factors. The chlorophyll content of the middle leaf has a relationship with the length of the cormus which is 90.82% the chlorophyll content of the middle leaf affects the length of the cormus. 9.18% is influenced by environmental factors. The chlorophyll content of the middle leaf also has a relationship with the diameter of the cormus which is 48.58% of the total chlorophyll content affecting the diameter of the cormus. 51.42% is influenced by environmental factors.

The chlorophyll content of the lower leaf has a relationship with the length of the cormus which is 67.24% the chlorophyll content of the lower leaf affects the length of the cormus. 32.76% is influenced by environmental factors. The chlorophyll content of the lower leaf also has a relationship with the diameter of the cormus which is 66.42% the chlorophyll content of the lower leaf affects the diameter of the cormus. 33.58% is influenced by environmental factors. Environmental factors, namely temperature, humidity, rainfall, light intensity, altitude of sea surface, and nutrient elements in the soil affect the length and diameter of dalugha cormus.

This is in line with research conducted by Ai and Banyo (2011) stating that chlorophyll content can be used as a reliable indicator to determine the metabolic balance between photosynthesis and production results [15]. Also research conducted by Mutrofin, *et al*. (2014) that chlorophyll can be used to carry out the production of sugar cane yield [16]. Furthermore, Mashud (2018) states that chlorophyll has a positive relationship with coconut production [17]. Then the results of research Hidayah, *et al*. (2019) states that there is a relationship between the value of chlorophyll with the production of rice [18]. Four results of the study are in line with the results of this study, namely the chlorophyll content has a relationship and affects the production results (length and diameter of the cormus) dalugha.

The chlorophyll content of the upper leaf (third leaf) has no relationship with the length and diameter of the cormus because even though the chlorophyll content of the upper leaf is highest but the photosynthate of the upper leaf is only on plant growth alone, it has not yet reached the cormus. In other words, the upper leaves have not passed photosynthate into the cormus. While the middle leaf (second leaf) and lower leaf (first leaf) photosynthate have been distributed to the cormus.

Conclusion

1. The highest chlorophyll content of dalugha leaves is in Moronge Village and the lowest is in Laikit Village.
2. The chlorophyll content of dalugha leaves is highest in the upper leaves and lowest in the lower leaves.

3. Total leaf chlorophyll content, middle and lower leaf chlorophyll content has a relationship with dalugha cormus production.

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