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Relationship Between Dendrometric of Mango Trees (*Mangifera indica* L.) and Geographic Variations on Critical Land in Jombang Regency

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ABSTRACT
This study aims to determine the dendrometric relationship of mango trees to various elevation variations on critical land. The research method uses a parametric regression approach and the data analysis tool uses Excel. The dendrometric variables analyzed were canopy area, number of branches, and stem diameter. The results of the analysis showed that the correlation value between elevation and strong canopy area (r = 0.64), with a low number of branches (r = 0.38) and with a very strong trunk diameter (r = 0.83). The regression equation was obtained in a linear form from the relationship between elevation and canopy area (R^2 = 0.40) with the regression equation Y = 0.06x + 24.8.. and stem diameter (R^2 = 0.68) with the regression equation Y = 1.165x + 21.84, and nonlinear with the number of branches (R^2 = 0.282) with the regression equation $y = 0.86x^5 – 18.79x^4 + 157.6.x^3 – 634.3.x^2 + 1231x – 869.5$. This shows that the canopy area and the trunk diameter of mango trees have a strong and linear correlation, except for the number of branches.

***Keywords**: Dendrometric; Geographical Variation; Mango Tree; Critical Land.*

INTRODUCTION

Darurejo village, Plandaan sub-district, is one of the areas north of the Brantas River in the Jombang district. Geographically, the northern region is part of the limestone mountains which have less fertile soil, most of which have flat physiology and some are hilly but not too sharp. In general, Darurejo village is classified as a critical land area (Bapedda Jombang, 2018). Although it has a critical area, this area still many annual plants that can grow quite well, especially fruit trees. One of the many fruit trees found in this area is the mango tree (Nasirudin & Yuliana, 2020). Mango (*Mangifera indica* L.) is a horticultural plant that has very high economic value because it has a high nutritional content for human health. The composition of the mango fruit consists of 80% water and 15% to 20% sugar, as well as various vitamins A, B, and C (Iban et al., 2017). Mango is actually not the main commodity that is the prima donna for farmers to develop in the Plandaan sub-district. This is due to the very minimal exploration of mango plants cultivated by local farmers (BPS, 2018). The ignorance of farmers about the potential of the existing land and the rampant price games of middlemen caused this to happen.

The morphology of the mango plant has a hard cambium stem which is very suitable for the topography of the soil in Darurejo village which tends to be hilly. The existence of mango plants can be an alternative to cover the surface with litter and humus. The soil becomes porous, so that water is easily absorbed into the soil and fills the groundwater supply (Sofiah & Putri Fiqa, 2011). The morphology of the mango tree is a form that composes the tree as a whole whose parts are included in the dendrometric tree. Part of the dendrometric tree is the canopy, branching, diameter, and height of the trunk. Existing plant vegetation is able to influence the hydrological cycle through its influence on rainwater that falls from the atmosphere to the earth's surface, to the soil and rocks below. With the existence of mango and litter vegetation, not all of the rainwater becomes surface runoff, but most of it can be converted into subsurface water (groundwater). Such conditions are very important in maintaining soil stability, especially in areas of steep slopes (Sofiah & Putri, 2011).

Canopy or often referred to as tree canopy is a condition formed by overlapping tree branches and leaves (Ajrillah et al, 2021). The density and shape of the mango canopy greatly affect the photosynthesis process, the denser the canopy/canopy, the more difficult it will be for sunlight to penetrate the tree canopy so that the mangoes in the tiller and seedling categories get less sunlight (Purnama et al., 2020). Over time the density must be reduced to provide growth space for the development of the crown and root areas and to promote literal (diameter) growth (Nasirudin & Yuliana, 2020). Canopy development can be used as a basis for regulating stand density because canopy development describes the space required for trees to grow optimally. The space required by the canopy can be the basis for describing tree growth and provide an overview of competition between trees (Sumadi & Siahaan, 2011).

Tree structure formations are classified based on canopy width, tree height, number of branches, and trunk diameter. The canopy represents the proportion of the cover. The following are the results of observing the structure of the mango tree sample (Wahyunah et al., 2016). Therefore, the variation of canopy width and porosity formed by each mango tree needs to be known whether it has implications for the geographical location of the tree's growth. Based on these problems, the research aims to determine the relationship between canopy area, number of branches, and trunk diameter to the height of land on mango trees that grow on critical land.

METHOD

Research sites

This research was conducted in the mango plantation area of Darurejo Village, Plandaan District, Jombang Regency. This observation was carried out in May 2021. Tree samples were taken randomly on a 3 ha garden area. This research was conducted purposively with the parameters of observing canopy width, number of branches, tree height, and trunk diameter. The data is then described to obtain data systematically, factually, and accurately from the observed parameters. This method was chosen because it has advantages such as less time, energy, and costs, with an area coverage that represents the condition of the mango canopy cover in Darurejo village. Determination of the research sample is done by direct observation in the field during the preliminary survey (ground check). Based on the survey results are classified based on the diameter of the mango tree trunk.

Research Tools and Materials

The tools and materials used in this study include paper, ballpoint pen, roll meter, and Haga altimeter. The study was conducted on trees that have a diameter between 10-50 cm that have normal trunks and crowns to determine the size of the tree's growth space. The crown diameter measurement was carried out 3 times, namely the crown farthest from the trunk diameter, the middle distance, and the closest to the tree trunk diameter.

Data Analysis

Data analysis was performed by regressing the independent change in diameter at breast height (Dbh), and the dependent change in crown diameter (Cd). Regression analysis was performed using the Excel program. The regression equation used to describe the relationship between the two variables is as follows:

$$Cd = a_0 + a_1 dbh \ldots\ldots\ldots\ldots$$

$$Cd = a_0 + a_1 dbh^2 \ldots\ldots\ldots\ldots$$

$$Cd = a_0 + a_1 \text{In}\, dbh \ldots\ldots\ldots\ldots$$

$$Cd = a_0 + a_1 dbh + a_2 dbh^2 \ldots\ldots\ldots\ldots$$

Where :

Cd : header diameter
Dbh : trunk diameter at chest height (cm)
A_0 : constant
a_1, a_2: regression coefficient

Best Model Selection

The selection of the best model according to Sumadi & Siahaan (2011) that there are three statistical tests in the evaluation of the best model. The selection of the best models includes the adjusted coefficient of determination (R^2), bias, and the mean square root of the deviation, which is abbreviated as RMSE. The coefficient of determination describes the proportion of total variation around the mean that can be explained by the regression. The use of R^2 is done because the model being tested has a different number of parameters, so it is necessary to adjust the coefficient of determination used.

RESULT AND DISCUSSION

Relationship between Canopy Area and Elevation

The relationship formed between the canopy area and elevation with a correlation of 0.64 includes a moderate relationship. The relationship between canopy area and elevation is shown in the following figure:

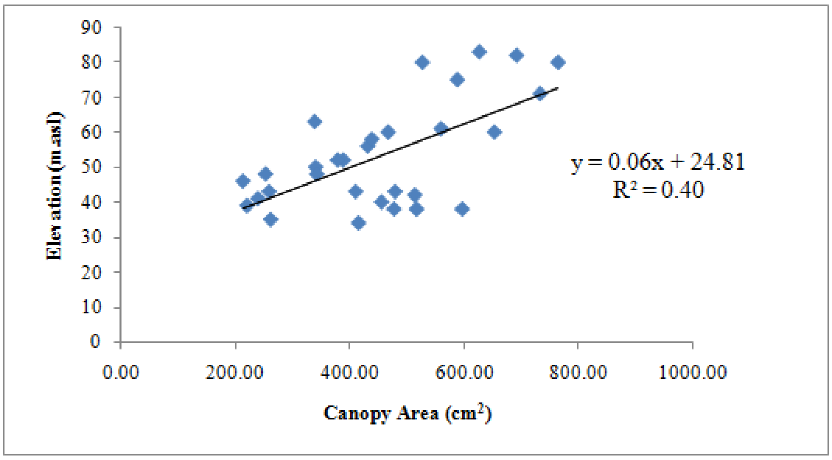

Figure 1. Linear Relationship Between Canopy Area And Elevation With R^2 = 0.40

Figure 1 shows that the relationship between canopy area and elevation is linear with a determinant coefficient of (R^2) 0.40. The relationship formed is not significant because the R^2 value is still low so that the form of this linear relationship is not strong enough to estimate the relationship between canopy and height. The linear regression equation formed is: Y = 0.63x + 24.8. According to Huang (2003) model fitting based on the data used for model preparation does not necessarily reflect the quality of the model's prediction results, so model validation must be carried out to develop the model.

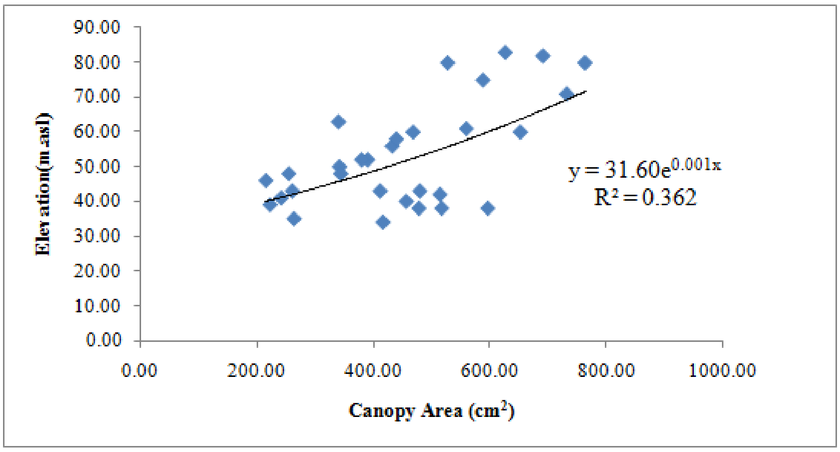

Figure 2. Exponential Nonlinear Relationship Between Canopy Area And Elevation At The Determinant Coefficient (R^2) of 0.362

If it is analyzed with a nonlinear relationship, it shows that the canopy area with elevation gives a lower determinant coefficient value than the linear relationship, which is 0.362. This shows that the estimation of the relationship between canopy area and height is more accurate in the form of a linear relationship because the R^2 value is higher. The canopy area has a role in the shade of a plant to create a growing space that is favorable for plant growth. The space required by the canopy can be the basis for describing tree growth and provide an overview of competition between trees (Sumadi & Siahaan, 2011).

Relationship Number of Branches with Elevation

The magnitude of the correlation between the number of branches and the elevation is 0.38 which means that the relationship formed is low. The resulting relationship form is shown in the following figure:

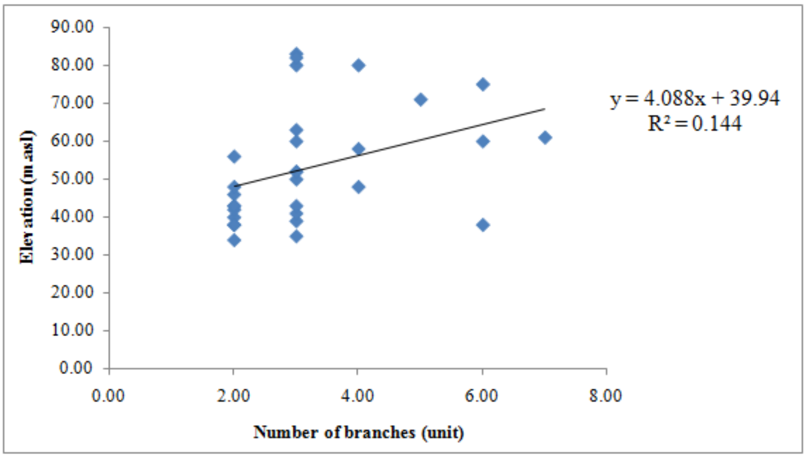

Figure 3. Linear Relationship Between The Number of Branches And Elevation on The Determinant Coefficient (R^2) of 0.144

In Figure 3, it can be seen that the linear relationship formed between the number of branches and the height is not valid because the value of the resulting determinant coefficient is small, namely 0.144. The form of a linear relationship is not precise so it needs to be analyzed with a nonlinear regression approach.

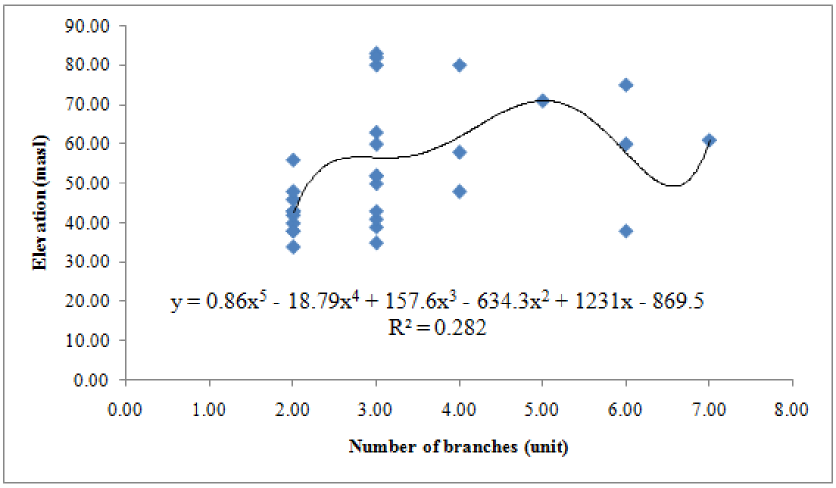

Figure 4. The Nonlinear Relationship Between The Number of Branches and Elevation in The Polynomial Regression Approach of Order 5 With An R^2 value of 0.282

The results of the analysis are in nonlinear form, namely the form of a fifth order polynomial, then the relationship form is obtained with a determinant coefficient of 0.282 which is greater than the linear form. So that the relationship between the number of branches and elevation is more accurately estimated using a fifth-order polynomial approach that produces the equation: $Y = 0.86x^5 – 18.79x^4 + 157.6x^3 – 634.3x^2 + 1231x – 869.5$. This shows that the number of branches does not form a linear relationship with elevation.

Relationship between Tree Diameter and Elevation

The results of the analysis showed that the relationship between stem diameter and elevation obtained a correlation value of 0.825, which means it has a strong relationship. The form of this relationship can be seen in the following figure:

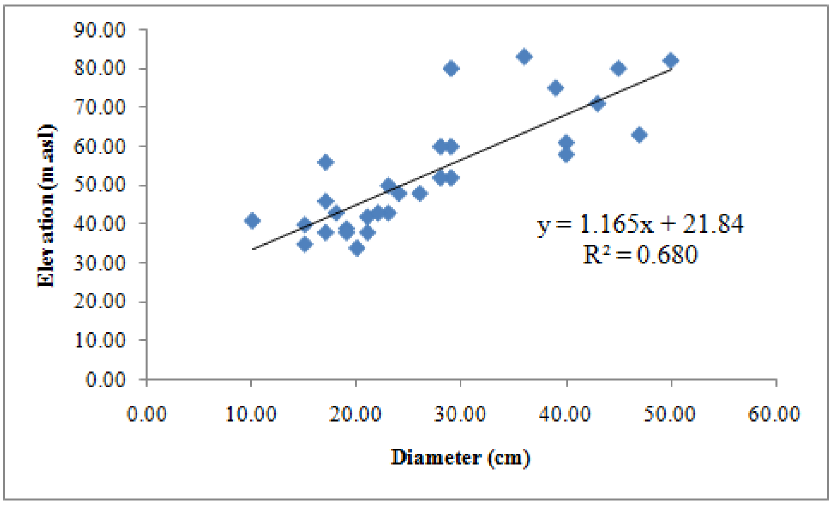

Figure 5. Linear Relationship Between Tree Diameter And Elevation with The Determinant Coefficient (R^2) of 0.68

In Figure 5, it can be seen that the relationship between the diameter of the rod and the elevation is linear with a determinant coefficient of 0.68, which means that the built form is valid. When viewed from the analysis with a nonlinear approach, it shows that the R^2 value is greater, namely 0.69 for the exponential approach and lower than the logarithmic approach with an R^2 value of 0.645.

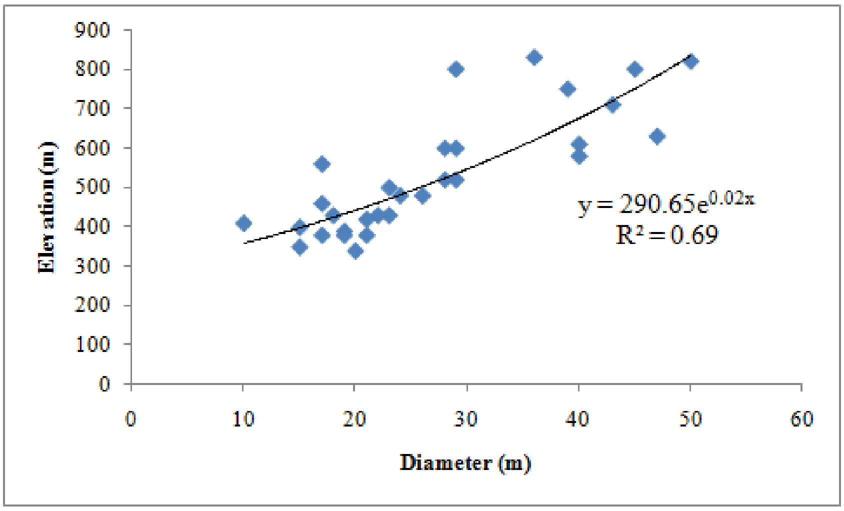

Figure 6. Nonlinear Relationship Between Tree Diameter and Elevation with The Determinant Coefficient (R^2) of 0.69

The best estimate of the relationship is found in the logarithmic regression approach, but because it has almost the same value as the linear form, the relationship can be used with a linear approach. Form a linear equation of the relationship between the diameter of the rod with the elevation is: Y = 1.165x + 21.84.

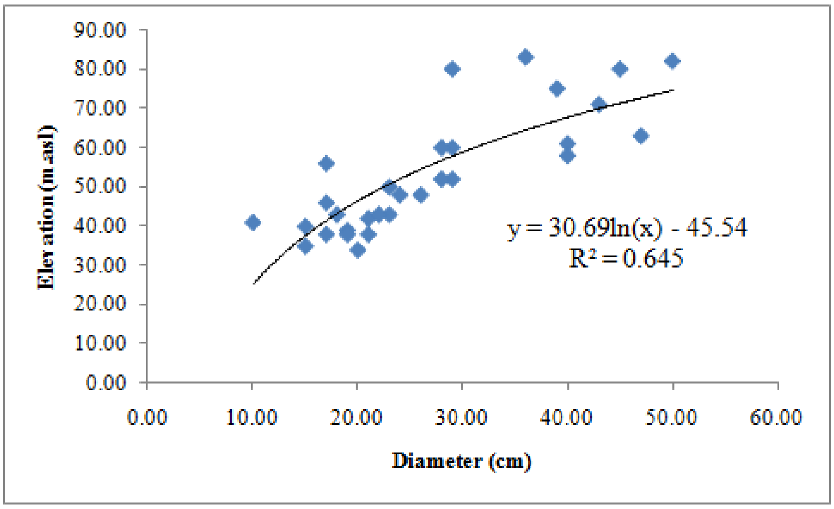

Figure 7. Nonlinear Relationship (Logarithm) Between Tree Diameter and Elevation With A Determinant Coefficient of 0.645

The nonlinear relationship between tree diameter and the number of branches and crowns from the research results is closer to a quadratic pattern. Bechtold (2003) found that the relationship between tree diameter and crown diameter was quadratic for several tree species in the Eastern United States. From the three forms of regression equations, the relationship between tree diameter and elevation approaches exponential (figure 6) and logarithmic approach (figure 7).

Descriptive Analysis of the Dendrometric Value of Mango Trees on Elevation Variations

The results of the descriptive analysis show that the geographical variation of the research location has an average elevation of 53.3 m.asl with a maximum height of 83 m.asl, the lowest is 34 masl at a standard deviation of $\pm$ 15,2002. The analyzed mango tree dendromteric variables are shown in Table 1.

Table 1. Results of Descriptive Analysis of Mango Tree Dendrometric Measurements and Their Relationship with Elevation

Measurements	Elevation (m.asl)	Canopi Area (cm^2)	Branches Number (Unit)	Diameter (cm)
Mean	53.3000	453.312	3.267	27.000
Maximum	83.0000	763.806	7.000	50.000
Minimum	34.0000	214.709	2.000	10.000
SD	$\pm$ 15.2002	$\pm$ 153.749	$\pm$ 1.413	$\pm$ 10.764
Q1	41.2500	341.832	2.000	19.000
Q3	60.7500	551.734	3.750	34.250

Table 1 shows that the average canopy area is 453,312 $\pm$ 153,749,cm2, the number of branches is 3,267 $\pm$ 1,413 units and the trunk diameter is 27 $\pm$ 10,764 cm. This data shows that there are variations in the value of each measured tree dendrometric, so it has something to do with geographical variations where it grows. The magnitude of the dendrometric relationship between mango trees and elevation is shown in table 2, that elevation has a strong correlation to canopy area and trunk diameter and a low correlation to the number of branches. Meanwhile, the relationship between dendrometric variables showed that the canopy area with the number of branches and stem diameter had a moderate correlation in the range of 0.40 – 0.60.

Table 2. Correlation Value Between Mango Tree Dendromertic Measurement Variables and Elevation.

	Elevation (m.asl)	Canopy Area (cm^2)	Branches Number (Unit)	Diameter (cm)
Elevation (m.asl)	0	0.636	0.380	0.825
Canopy area (cm^2)	0.636	0	0.505	0.591
Branches number (unit)	0.380	0.505	0	0.456
diameter (cm)	0.825	0.591	0.456	0

Mango tree dendrometric has a strong relationship with environmental conditions. The space required by the canopy can be the basis for describing tree growth and provide an overview of competition between trees (Sumadi & Siahaan, 2011).

CONCLUSION

Based on the results of data analysis of the dendrometric relationship of mango trees with geographical variations of critical land, it shows that there is a strong correlation between elevation and canopy area and trunk diameter and a low correlation with the number of branches. The regression equation formed between elevation with canopy area and trunk diameter is linear, while the number of branches forms a nonlinear equation with a fifth-order polynomial approach.

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