Rhizophora mucronata Lamk Seedlings Growth Model with Guludan Planting Technique in Angke Kapuk, Jakarta Coastal Area

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Abstract. Mangrove seedlings planted using the guludan technique are considered to produce optimal growth. Mangrove planting using guludan is an alternative for mangrove rehabilitation in former pond areas with deep water pools (more than 1 m). This study aimed to analyze the growth model of Rhizophora mucronata seedlings (growth in stem diameter and height, number of leaves, number of internodes, number of stilt roots) planted with guludan technique in Angke Kapuk, Jakarta Coastal Area. Measurements were made in the Angke Kapuk Mangrove Forest Area, Jakarta, in January 2019-April 2019. A total of 20 individuals from the 2018 planting year group were chosen as individual samples, were planted with Rhizophora mucronata with a spacing of 0.5 m x 0.5 m. The data taken were the growth of stands, which include stem diameter, height, number of leaves, number of internodes, and number of stilt roots in the guludan. The results showed that the growth of stem diameter and height of R. mucronata seedlings for 12 weeks of observation formed a positive exponential equation. During the observation period (12 weeks) of the 20 R. mucronata seedlings seen, there were 380 leaves, 53 internodes, and four stilt roots growth.

1. Introduction

According to Snedake [1], mangrove forests are a group of plant species that grow along tropical to sub-tropical coastlines, have unique functions in saline-containing environments and coastal forms with an-aerobic soil reactions. Mangroves have an essential role in protecting the coast from waves, wind, and storms. Mangrove stands can protect settlements, buildings, and agriculture from strong winds or seawater intrusion. The various roles of mangrove forests as renewable resources in coastal areas in relation to their functions as providers of valuable products and environmental functions for coastal communities are well recognized, so that damaged mangrove forests are replanted, and mangrove plantations should be built in several coastal areas to enrich productivity land forests are replanted, and mangrove plantations should be built in several coastal areas to enrich productivity land and to improve the quality of the ecosystem environment [2]. Planting using Guludan from bamboo can be a solution to overcome the problem of mangrove rehabilitation on stagnant lands in deep water. The guludan planting technique concept is to create a growing space for mangrove seedlings in the form of a square with bamboo fences filled with sacks containing a mixture of soil and mud at the bottom and then adding bulk soil at the top. Since 2005, the coastal area of DKI Jakarta, Angke Kapuk, has applied this technique to rehabilitate damaged mangrove areas. Until now, around 95 ha of the Angke Kapuk area has been rehabilitated by planting 300,000 mangrove seedlings [3].
The stand of mangrove seedlings planted using guludan technique is considered to create optimal growth rates. Therefore, it is necessary to observe the extent of the increase in height and increment mangrove diameter. The results of this observation can be used as a guide for the rehabilitation of degraded mangrove forests in Indonesia. One type used to rehabilitate mangrove forests is red mangrove (Rhizophora mucronata). One reason that makes this species more preferred for the rehabilitation of mangrove forests is that the fruits are easily obtained, are easily sown, and can grow in higher tidal inundation or lower inundation areas [4]. Therefore, the research is needed to analyze the seedlings growth model of Rhizophora mucronata with guludan planting technique.

This research aimed to analyze the growth model of Rhizophora mucronata seedlings (growth in stem diameter and height, number of leaves, number of internodes, number of stilt roots) planted with guludan technique in Angke Kapuk, Jakarta Coastal Area.

2. Method

2.1. Materials
The primarily used material in this study were seedlings of Rhizophora mucronata. The used equipment in this study was digital caliper, camera, seedling measuring meter, tally sheet, flag tape, stationery, a computer set, and software R.

2.2. Procedure

2.2.1. Sampling Design
Observation of the growth was carried out on 20 R. mucronata seedlings (12 months), which were planted with a guludan technique. The 20 seedlings were randomly selected from 2 different guludan.

2.2.2. The technique of Data Measurement
The technique of Data Measurement are conducted as follows:
1. Preparation stage
At this stage, prepare the equipment and material to be used to measure the stem diameter and height of the mangrove seedlings, and numbering the 20 mangrove seedlings as samples measuring stem diameter, seedling height, number of leaves, number of internodes, and number of stilt roots.
2. Measurement of research parameters
Stem diameter is measured at the height of 10 cm from the highest root boundary, while the height of seedlings is measured from the limit of measurement stem diameter to the center of the growth (marking from the beginning of observation). Stem diameter and height of mangrove seedlings were measured directly using caliper and seedling height measuring meter. The number of leaves is measured by doing total summation on the measurement week. The number of internodes is measured by calculating the total number of branches growing, and the number of stilt roots measured by counting the number of stilt roots that grow or appear. These observations are conducted every week during the observation period (3 months).

2.3. Data Analysis

2.3.1. Making of growth model
The model to be made is an estimation for the variable growth of seedling height and stem diameter. Some leaves, number of internodes and number of stilt roots are presented in the form of descriptive data. The model tested using one independent variable, namely age in nonlinear form. The modeling used nonlinear regression analysis using software R. The models used are listed in Table 2.
Table 1. Comparative model for predicting growth in stem diameter and height of *R. mucronata* seedlings.

| Model     | Equation                                                                 | Source |
|-----------|--------------------------------------------------------------------------|--------|
| Gompertz  | $Y_t = a \exp(-b \exp(-ct))$                                             | [16]   |
| Logistic  | $Y_t = a/(1 + b \exp(-ct))$                                              | [16]   |
| Richard’s | $Y_t = a/(1 + \exp(-bt)) \ 1/c$                                          | [16]   |
| Power     | $Y_t = at^b$                                                             | [18]   |
| Exponential| $Y_t = a \exp (bt)$                                                     | [18]   |
| Polynomial| $Y_t = a(t-b)^2 + c$                                                     | [18]   |

$Y_t$ = Stem diameter (mm) and Height seedlings (cm) at age of $t$

*a, b, c* = Model parameters

2.3.2. Selection of the best model

To choose the best growth model, the model selection criteria are used as follows:

1. **Model Meaning Test**

To test the significance of the model, a t-test is used to see whether there is significance in the effect of independent variables on non-independent variables.

2. **Akaike Information Criteria (AIC)**

Akaike Information Criteria (AIC) is a relatively good measure of the statistical model. This criterion was developed by Hirotugu Akaike and was first published by Akaike in 1974. This criterion describes the relationship between bias and standard deviation in modeling, or in other words, describes the relationship between the degree of accuracy and complexity of a model.

Determination of AIC value can be done using the following formula [17]:

$$AIC = -2 \ln L_{\text{max}} + 2p$$

Information:
Lmax = Maximum value of the function possibilities that can be achieved by the model

p = Number of parameters

3. **Bayesian Information Criteria (BIC)**

Another criterion that measures the relative goodness of a statistical model is the Bayesian Information Criteria (BIC). Gideon E. Schwarz introduced BIC in 1978. This criterion is almost the same as AIC. Determination of BIC value can be done using the following formula [17]:

$$BIC = -2 \ln L_{\text{max}} + p \ln (n)$$

Information:
Lmax = Maximum value of the function possibilities that can be achieved by the model

p = Number of parameters

n = Number of observations

4. **Root Mean Square Error (RMSE)/Standard Deviation (S)**

Standard deviation is a measured magnitude of deviation estimated value to actual value. The smaller the deviation value, then estimator will be higher the accuracy. The narrower distribution of deviation, then higher the accuracy and smaller systematic error, then higher estimator is not biased. Standard deviation value is determined by the formula [5]:

$$S = \sqrt{\frac{\sum(Y_o - Y_t)^2}{(n-p)}}$$
Information:
s = Standard deviation
(n-p) = Residual free degree
Ya = Real value of stem diameter/height seedlings
Yi = Guess value of stem diameter/height seedlings

5. Model Suitability Test

To see the suitability of the model to data, use a coefficient of determination (R^2), and the coefficient of determination is corrected (Radj^2). R^2 is a ratio between the number of squared regression (JKR) and the sum of total squares (JKT), and usually, R^2 is expressed in percent (%). This R^2 value reflects how an independent variable X can explain much diversity of non-free variables Y. R^2 values range from 0% to 100%. Greater R^2 will be the greater total diversity that can be explained by the regression (the higher diversity of non-free variables Y can be explained by independent variable X), meaning that the regression obtained is getting better. The calculation value of R^2 is to see the level of accuracy and closeness relationship between independent and non-independent variables. The coefficient of determination is corrected (Radj^2) is a coefficient determination that has been corrected by the free degrees of JKS and JKT. Calculation the value of R^2 and R^2 adj can be done by the formula [6]:

\[ R^2 = \frac{JKR}{JKT} \times \frac{1}{(n-p)/JKT} \]
\[ R_{adj}^2 = 1 - \frac{(JKS)/(n-p)}{(JKT)/(n-1)} \times 100\% \]

Information:
JKS = Amount of residual squares
(n-p) = DBS = Free degree of residual
JKT = Amount of squares total
(n-l) = DBT = Total free degree

6. Verification of Model Assumption

The assumption of the regression model is the constant range of variance (homoscedasticity). This assumption is verified by the graphing relationship between estimated value as abscissa and remainder as ordinate. The best growth model selected using the following criteria:
1. Value of p-value < 0.05
2. AIC, BIC, and standard deviation values (RMSE) the smallest
3. The R^2 and R^2 adj the biggest
4. The residual spread randomly and not forming a certain pattern (homoscedasticity).

3. Result and Discussion

3.1. Growth Model of R. mucronata

Based on the analysis of overall data processing in observation for 12 weeks, the result showed that the best equation model for diameter and height of R. mucronata seedlings were positive exponential model compared to the other five models (Gompertz, logistic, Richard's, power, polynomial) (Table 3). This is showed from seven values of the best growth model selection criteria that are compared, including p-value, AIC, BIC, RMSE, R^2, R^2 adj, and homoscedasticity conditions from the resulting model can be fulfilled or not.

Positive exponential growth model gives the smallest p-value of 0.000, which mean the coefficient tested on model has a very significant effect on the estimation of stem diameter growth produced. In addition, positive exponential model has the smallest AIC and BIC values of 1274.33 and 1285.02. Error value (RMSE) was low that is generated by several equations, namely positive exponential, polynomial, Richard's, logistics, and Gompertz of 2.77 when compared to the power equation which is worth 5.24.

The best R^2 and R^2 adj values produced by positive exponential equation are classified as low (less than 30%) which means that 30% of variation in stem diameter of R. mucronata seedlings can be explained well by age of plant through the positive exponential model produced. Six models compared
to the growth of *R. mucronata* stem diameter, an overall model equation, was stated to have met the homoscedasticity requirement.

Growth for *R. mucronata* seedling height (Table 4), positive exponential equation is also become the best model. Positive exponential equation fulfilled homoscedasticity rules and have p-value (0.000), AIC (1560.03), BIC (1570.71), and RMSE (4.80) with $R^2$ and $R^2_{adj}$ value which are 16.7% and 16%. P-value, AIC, BIC, and RMSE indicator are preferred in model selection as long as the value produced by $R^2$ and $R^2_{adj}$ are high and not much different so that variation in seedling height can still be explained well by age of plant through the resulting model.

**Table 2.** Results of the comparison of seven best selection criteria as an indicator to estimate stem diameter growth of *R. mucronata* seedlings

| Model     | Coefficient | p-value | AIC    | BIC    | RMSE | $R^2$ | $R^2_{adj}$ | Homocedasticity |
|-----------|-------------|---------|--------|--------|------|-------|-------------|-----------------|
| Gompertz  | a = 60.717  | 0.838   |        |        |      |       |             | Fulfilled       |
|           | b = 1.314   | 0.788   | 1276.28| 1290.52| 2.77 | 0.212 | 0.206       |                 |
|           | c = 0.018   | 0.810   |        |        |      |       |             |                 |
| Logistic  | a = 41.869  | 0.680   |        |        |      |       |             | Fulfilled       |
|           | b = 1.564   | 0.800   | 1276.28| 1290.53| 2.77 | 0.212 | 0.206       |                 |
|           | c = 0.037   | 0.610   |        |        |      |       |             |                 |
| Richard’s | a = 46.000  | 0.791   |        |        |      |       |             | Fulfilled       |
|           | b = 0.031   | 0.804   | 1276.28| 1290.53| 2.77 | 0.212 | 0.206       |                 |
|           | c = 0.669   | 0.783   |        |        |      |       |             |                 |
| Power     | a = 16.130  | 0.000*  |        |        |      |       |             | Fulfilled       |
|           | b = 0.092   | 0.001*  | 1605.51| 1616.20| 5.24 | 0.102 | 0.096       |                 |
| Exponential | a = 16.400  | 0.000*  |        |        |      |       |             | Fulfilled       |
|           | b = 0.021   | 0.000*  | 1274.33| 1285.02| 2.77 | 0.212 | 0.205       |                 |

*Significant at the 5% level. selected model.

**Table 3.** Results of the comparison of seven best selection criteria as an indicator to estimate height growth of *R. mucronata* seedlings

| Model     | Coefficient | p-value | AIC    | BIC    | RMSE | $R^2$ | $R^2_{adj}$ | Homocedasticity |
|-----------|-------------|---------|--------|--------|------|-------|-------------|-----------------|
| Gompertz  | a = 91.653  | 0.278   | 1561.92| 1576.16| 4.80 | 0.167 | 0.161       | Fulfilled       |
|           | b = 0.361   | 0.693   |        |        |      |       |             |                 |
|           | c = 0.028   | 0.740   |        |        |      |       |             |                 |
| Logistic  | a = 88.251  | 0.160   | 1561.92| 1576.16| 4.80 | 0.167 | 0.161       | Fulfilled       |
|           | b = 0.381   | 0.694   |        |        |      |       |             |                 |
|           | c = 0.036   | 0.666   |        |        |      |       |             |                 |
| Richard’s | a = 85.181  | 0.136   | 1561.92| 1576.16| 4.80 | 0.167 | 0.161       | Fulfilled       |
|           | b = 0.048   | 0.716   |        |        |      |       |             |                 |
|           | c = 2.413   | 0.664   |        |        |      |       |             |                 |
| Power     | a = 63.607  | 0.000*  | 2255.74| 2266.42| 18.31| 0.057 | 0.050       | Fulfilled       |
|           | b = 0.038   | 0.126   |        |        |      |       |             |                 |
3.2. Number of leaves growth
Growth in some leaves was observed for 12 weeks. Growth, the number of leaves, was observed to determine the number and the average number of leaves formed, the number of decayed leaves, and the total number of leaves during the observation period. From the calculation, the number of leaves formed, number of decayed leaves, and the total number of leaves during observation period for 20 individuals in a sequence of 217; 10; 380. Besides, the average number of leaves was formed, number of decayed leaves, and the total number of leaves during observation period per individual, respectively 10.85; 0.50; 19.00 (Table 5).

3.3. Number of internodes growth
Based on the results of observation, the number of R. mucronata seedling internodes for 12 weeks, data were obtained on the number and average of internodes formed, and the total number of internodes. The total number of internodes formed for 20 individuals was observed in a row of 49 and 53, while the average number of internodes formed, and the total per individual in the sequence was 2.45 and 2.65. The growing number of R. mucronata internodes is presented in Table 6.

3.4. Number of stilt roots growth
The growing number of R. mucronata stilt roots for 12 weeks was only found in 2 individual seedlings. Observations carried out over 12 weeks resulted in some stilt roots formed as well as the total number of stilt roots that existed at 4. According to [7], the root is the entrance for nutrients and water from the soil, which is very important for the physiological process of trees. Root growth is strongly influenced by physical conditions such as soil compaction and soil water content. The growing number of stilt roots from R. mucronata seedlings is presented in Table 7.

Table 4. The number of leaves growth R. mucronata seedlings for 12 weeks.
Table 4. The number of leaves growth *R. mucronata* seedlings for 12 week (continuation)

| No | Individual | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|----|------------|---|---|---|---|---|---|---|---|---|---|----|----|----|
| 11 | RM11G7     | 8 | 8 | 8 | 10| 10| 10| 10| 16| 16| 16| 16| 8  | 0  |
| 12 | RM12G7     | 7 | 7 | 7 | 7 | 9 | 9 | 9 | 9 | 9 | 9 | 15 | 15 | 8  |
| 13 | RM13G7     | 9 | 9 | 9 | 9 | 9 | 11| 11| 11| 11| 10| 12 | 4  | 1  |
| 14 | RM14G7     | 8 | 8 | 8 | 10| 10| 10| 10| 14| 14| 14| 14 | 6  | 0  |
| 15 | RM15G7     | 7 | 7 | 7 | 9 | 9 | 9 | 9 | 15| 15| 14| 8  | 1  |
| 16 | RM16G8     | 8 | 8 | 8 | 8 | 8 | 8 | 14| 14| 14| 14| 10 | 0  |    |
| 17 | RM17G8     | 8 | 8 | 8 | 8 | 8 | 10| 9 | 9 | 9 | 9 | 2  | 1  |    |
| 18 | RM18G8     | 13| 13| 13| 12| 14| 20| 20| 20| 20| 19| 26 | 30  |
| 19 | RM19G8     | 15| 15| 14| 14| 24| 24| 23| 22| 22| 36| 35  | 24  | 4  |
| 20 | RM20G8     | 10| 10| 10| 10| 12| 16| 16| 16| 26| 26| 26  | 16  | 0  |

Total 217 10 380

Average 10.85 0.50 19.00

Table 5. The number of internodes growth *R. mucronata* seedlings for 12 weeks.

| No | Individual | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|----|------------|---|---|---|---|---|---|---|---|---|---|----|----|----|
| 1  | RM1G7      | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0  | 0  |    |
| 2  | RM2G7      | 0 | 0 | 0 | 2 | 2 | 2 | 2 | 2 | 4 | 4 | 4  | 4  |    |
| 3  | RM3G7      | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 2 | 4  | 4  |    |
| 4  | RM4G7      | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 2  | 2  |    |
| 5  | RM5G7      | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 2 | 4 | 4 | 4  | 4  |    |
| 6  | RM6G7      | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3  | 2  |    |
| 7  | RM7G7      | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 2 | 4  | 4  |    |
| 8  | RM8G7      | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 2  | 2  |    |
| 9  | RM9G7      | 0 | 0 | 0 | 1 | 1 | 1 | 2 | 4 | 4 | 4 | 4  | 4  |    |
| 10 | RM10G7     | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 2  | 2  |    |
| 11 | RM11G7     | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 2  | 2  |    |
| 12 | RM12G7     | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 2  | 2  |    |
| 13 | RM13G7     | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0  | 0  |    |
| 14 | RM14G7     | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1  | 1  |    |
| 15 | RM15G7     | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 2  | 2  |    |
| 16 | RM16G8     | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 2 | 2 | 2  | 2  |    |
| 17 | RM17G8     | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0  | 0  |    |
| 18 | RM18G8     | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 5  | 4  |    |
| 19 | RM19G8     | 2 | 2 | 2 | 2 | 4 | 4 | 4 | 4 | 4 | 4 | 6  | 4  |    |
| 20 | RM20G8     | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 2 | 4 | 4 | 4  | 4  |    |

Total 49 53

Average 2.45 2.65
Table 6. The number of internodes growth *R. mucronata* seedlings for 12 weeks.

| No | Individual | Number of stilt roots per Time period (Week) | Number of stilt roots formed | Total number of stilt roots |
|----|------------|---------------------------------------------|-----------------------------|---------------------------|
| 1  | RM1G7      | 0 0 0 0 0 0 0 0 0 0 0 0                   | 0                           | 0                         |
| 2  | RM2G7      | 0 0 0 0 0 0 0 0 0 0 0 0                   | 0                           | 0                         |
| 3  | RM3G7      | 0 0 0 0 0 0 0 0 0 0 0 0                   | 0                           | 0                         |
| 4  | RM4G7      | 0 0 0 0 0 0 0 0 0 0 0 0                   | 0                           | 0                         |
| 5  | RM5G7      | 0 0 0 0 0 0 0 0 0 0 0 0                   | 0                           | 0                         |
| 6  | RM6G7      | 0 0 0 0 0 0 0 0 0 0 0 0                   | 0                           | 0                         |
| 7  | RM7G7      | 0 0 0 0 0 0 0 0 0 0 0 0                   | 0                           | 0                         |
| 8  | RM8G7      | 0 0 0 0 0 0 0 0 0 0 0 0                   | 0                           | 0                         |
| 9  | RM9G7      | 0 0 0 0 0 0 0 0 0 0 0 0                   | 0                           | 0                         |
| 10 | RM10G7     | 0 0 0 0 0 0 0 0 0 0 0 0                  | 0                           | 0                         |
| 11 | RM11G7     | 0 0 0 0 0 0 0 0 0 0 0 0                  | 0                           | 0                         |
| 12 | RM12G7     | 0 0 0 0 0 0 0 0 0 0 0 0                  | 0                           | 0                         |
| 13 | RM13G7     | 0 0 0 0 0 0 0 0 0 0 0 0                  | 0                           | 0                         |
| 14 | RM14G7     | 0 0 0 0 0 0 0 0 0 0 0 0                  | 0                           | 0                         |
| 15 | RM15G7     | 0 0 0 0 0 0 0 0 0 0 0 0                  | 0                           | 0                         |
| 16 | RM16G8     | 0 0 0 0 0 0 0 0 0 0 0 0                  | 2 2                        | 2 2                       |
| 17 | RM17G8     | 0 0 0 0 0 0 0 0 0 0 0 0                  | 2 2                        | 2 2                       |
| 18 | RM18G8     | 0 0 0 0 0 0 0 0 0 0 0 0                  | 0                         | 0                         |
| 19 | RM19G8     | 0 0 0 0 0 0 0 0 0 0 0 0                  | 0                         | 0                         |
| 20 | RM20G8     | 0 0 0 0 0 0 0 0 0 0 0 0                  | 0                         | 0                         |

Total 4 4

In recent years, a technique for planting mangroves has been developed and tested to rehabilitate land, called guludan technique. Application of guludan technique in the North Coast of Jakarta is one of the efforts to rehabilitate damaged mangrove areas after implementation to become ponds. This technique initiated since 2005 has produced excellent results to present.

Guludan in research location was mixed 5 m x 10 m and planted with *R. mucronata* seedlings. Planting mangroves with guludan technique requires planting with a fairly tight spacing, which is below 1 m x 1 m [8]. One type used to rehabilitate mangroves is red mangrove (*Rhizophora mucronata*). One reason that makes this species more preferred for the rehabilitation of mangrove forests is that the fruits are easily obtained, are easily sown, and can grow in higher tidal inundation or lower inundation areas [4].

In the Elang Laut sub-district, where the research was conducted, old mangrove stands planted with this technique appear to grow healthy, high, and tight while young mangrove stands grow well and have a high percentage of life. According to [9], until the end of 2016, the percentage of *R. mucronata* species in guludan was between 22.00% -56.53%. The range is quite significant because there are differences in the years of planting and occupation by the type *S. caseolaris*.

Growth parameters discussed in this study include stem diameter, seedling height, number of leaves, number of internodes, and number of stilt roots. In mangrove planting system using guludan technique that has been applied in Mangrove Forest Area belongs to DKI Jakarta Forestry, Parks and Cemetery, where the research took place, growth of stem diameter and *R. mucronata* seedling height for 12 weeks showed a positive exponential equation. This is the following Kusmana [8], which states...
the growth of stem diameter and \textit{R. mucronata} seedlings height for ten months produced a positive exponential equation with a spacing of 0.5 m x 0.5 m. Both parameters of \textit{R. mucronata} seedlings had a growth model with a positive exponential equation caused by the growth that forms still, which has not been corrected. An ideal growth model is a sigmoid curve.

Plant diameter depends on growing space, canopy width, relative humidity, and root systems, also depending on climate and site fertility. Growth diameter in plants will occur when the results of photosynthesis used for respiration, leaf turnover, and height growth have been fulfilled [10]. \textit{R. mucronata} can live in a place that contains less mud because mangrove growth is related to the dissolved oxygen content in the mud and optimal thickness of the mud for \textit{R. mucronata} growth was about 30 cm [11].

According to Darmawan [12], height is growth that occurs in the meristem of shoot and root. Meristem tissue that continues to produce linkages between root tissue and stem increases vertically (height). The research conducted by Ha [13] suggested the daily growth of \textit{R. mucronata} seedlings between less than 0.01 cm/day to almost 0.07 cm/day. High growth rates last from April to July.

Leaves are one of the organs that play an essential role in the survival of plants, considering the function of leaves as a place for photosynthesis. The parameter amount of leaves growth is one of the parameters for the growth of \textit{R. mucronata} seedlings. Based on calculations (Table 5), total leaf growth during the observation period in this research resulted in the value of 380 leaves with an average of 19.00 leaves per individual. The number of leaves formed, namely 217, leaves with an average of 10.85 leaves per individual. Besides, there were also resulted in the number of decayed leaves as many as ten leaves of 6 individuals (30% number of individual seedlings was observed).

The essential nutrient in leaf growth and development is nitrogen, and high nitrogen concentrations generally can produce a more significant number of leaves [14]. However, according to Ashari [9], it is just that N value in the guludan at Elang Laut sub-district is in the low and deficient category, influenced by quite a lot of guludan that are submerged in water. Nevertheless, it appears that N has a vital role in mangrove growth in the guludan.

Besides, the internode also includes the observed parameter. An internode is a place where the leaves attach. The higher the number of internodes, then a higher the number of leaves and source of energy for growth vertically (height). Based on the results of observations (Table 6), it can be seen that the total number of internodes growth is 53, with an average of 2.65 per individual. The number of internodes formed during the observation period, which is 49. Internode on the stem is where the leaves grow, so a higher number of internodes, then a higher number of leaves and food sources for growth is higher too [15]

\textit{R. mucronata} has root characteristics such as fiber root (does not have a primary root). Rooted time is seen from the first week to the last week of observation. Based on (Table 7), the number of stilt roots formed value as same as the total number of stilt roots that existed at 4. The appearance of roots occurs in the 8th and 11th weeks. The physical condition of the land in the field that is not many different causes rooted time to start together.

4. Conclusion

Planting system of \textit{R. mucronata} using the Guludan technique that was applied in the Muara Angke Kapuk Mangrove Forest area, Province of DKI Jakarta produced growth in stem diameter and height of \textit{R. mucronata} seedlings forming positive exponential equation. Growth in the number of leaves (380 leaves), number of internodes (53 pieces), and number of stilt roots (4 pieces) varied in number in each observation period.

Acknowledgments

There is a need for further research on the parameter growth number of mangrove stilt roots in order to determine the time emergence of \textit{R. mucronata} lateral roots in general from the morphological appearance with a minimum research period of six months. Besides, it is necessary to conduct research
in the following years regarding increment stem diameter and height of *R. mucronata* seedlings, to further improve the accuracy in selecting growth model for stem diameter and height increment.

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