Impact of different salt levels on the seedling growth and root development of *Bruguiera sexangula* for the regeneration of mangroves

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**Abstract.** At present mangrove forests have been degraded in North Sumatra, Indonesia. It is therefore the rehabilitation efforts are needed to betterment of mangrove forests. Salinity influences plant growth and development because salinity conditions that are not suitable leading to plant growth and development. This research aims to study the impact of difference salinity concentration on the growth and development of *Bruguiera sexangula* seedlings. The study was performed using five treatments levels of salinity, namely 0%, 0.5%, 1.5%, 2% and 3%, respectively with ten replications for five months in the greenhouse of Faculty of Agriculture, Universitas Sumatera Utara. There were differences in the growth response of *B. sexangula* to variations in salinity concentrations. These results indicated that the best growth and development of *B. sexangula* seedlings at 0.5% salinity concentration of with six best parameters, namely superior height, diameter, number of leaves, number of lateral roots, main root diameter and lateral root diameter.

1. Introduction

Mangrove forests are widely distributed throughout the tropics and subtropics in the world which thrives along the coastline. It is estimated that the total area of mangrove forests in Indonesia is 3.1 million ha, representing about 22.6% of the world’s mangrove forests [1]. At present, the condition of mangroves have been truly in decline, including in North Sumatra Indonesia [2]. For example, high population pressure, conversion of mangroves to agriculture and salt production, mining industry, coastal industrialization and urbanization, and conversion of coastal to aquaculture are the main causes of mangrove ecosystem degradation [2-4].

Mangrove ecosystem degradation have an impact on physical, ecological and economic functions [5-6]. One conservative effort to restore the function of degraded mangrove forests is to carry out rehabilitation of mangrove ecosystems. Mangrove forest rehabilitation is an effort to restore the function of degraded mangrove forests to the conditions that are considered good and able to carry out ecological and economic functions [7-8].

Appropriate salinity on a mangrove species will have a major influence on the growth and development of a plant because the salinity conditions that are not suitable can result in plant growth and development limitation [9]. Therefore, it is important to conduct research on the effect of variations in salinity on growth and root development, especially in the species of *Bruguiera sexangula*. 

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2. Materials and Method

2.1. Plant materials
*Bruguiera sexangula* (Lour.) Poir. (Rhizophoraceae) propagules were collected from Pulau Sembilan, Langkat, North Sumatra, Indonesia (4° 08' 26.54" E, 98° 14' 43.36" N). Planting of the *B. sexangula* propagules with various salt concentrations for five months was conducted in the greenhouse of the Faculty of Agriculture, Universitas Sumatra Utara.

2.2. Propagule selection and planting
*B. sexangula* propagules were used from mother trees aged 5 years or more. The selected propagules should be physiologically mature with a brownish green propagus color and healthy, not attacked by pests and diseases. Ten *B. sexangula* propagules for each salinity concentration of 0%, 0.5%, 1.5%, 2% and 3% were planted in plastic bottles, the filled with sterilized sand media. In this study, salinity is the ratio of the mass of salt powder to the mass of solution [9]. The type of salt used was commercial salt powder (marine salt) and were made by dissolving 5.66, 17, 22.6, and 34 g commercial salt powder for 1 liter of water for 0, 0.5, 1.5, 2 and 3% salinity.

2.3. Observed parameters
The observed parameters were (1) Seedling survival percentage was calculated by comparing the number of survival seedlings and the number of seedlings planted at the beginning of the study. (2) Measurement of seedling height is done using the rule. Measurements were made at the base of the *B. sexangula* seedlings to the point where the seedling growth. Height measurements were carried out at the end of the observation after harvesting. (3) Measurement of seedling diameter was done using callipers. Measurements were made at the end of the observation after harvesting. The diameter was measured at a length of 1.5 cm from the base of the *B. sexangula* seedlings [9]. (3) Calculation of the number of leaves was performed at the end of the observation after harvesting. (4) Leaf thickness measurements were carried out at the end of the observation together with seedling height data collection using a scrub micrometer. (5) Calculation of the number of roots was performed manually using a counter after harvesting of *B. sexangula* seedlings at 5 months. The number of roots was calculated based on the position of the roots in the root system (level of branching) according to the classification of [10-11], which consisted of main and lateral root. (6) Diameter measurements were taken after harvesting *B. sexangula* seedlings at 5 months. Root diameter provided important information related to soil pore size and root penetration potential [12]. Root diameter measurements were performed on each branching type using callipers [10-11].

2.4. Statistical analysis
Data were analyzed by one-way ANOVA using the Dunnett test for comparison of all treatments to controls using SAS software version 9.4 (SAS Institute 2013). Data are shown as mean ± SD (n= 10). P values <0.05 was used as a limit to indicate the effect of treatment.

3. Results and Discussion
Seedling survival percentage is calculated by comparing the number of life seedlings and the number of seedling planted at the beginning of the study (Table 1). Data was collected at the end of the observation after 5 months cultivations. Table 1 showed the growth of *B. sexangula* in good seedling survival except in 3% salinity concentration which causes 20% mortalities. This is partly because *B. sexangula* was one type of mangrove that does not have a salt gland structure [13-14], so that seedling growth is inhibited at high salinity concentrations.
Based on the research results obtained that the salinity concentration is very influential in decreasing the height and diameter of B. sexangula seedlings (Table 2). From each given treatment it turns out that height and diameter growth in seedlings is better in treatments with 0% salinity concentration compared to other salinity concentration treatments. The highest seedlings at 0% salinity was 18.7 cm and the lowest at 3% salinity was 2.8 cm (Table 2). This phenomena happened because mangrove plants are not plants that salt demand but plants that are salt tolerant [15-16].

Based on the Dunnet test, it can be seen that the 1.5, 2, and 3% salinity concentrations had a significant effect on the growth of B. sexangula seedlings compared to 0 and 0.5% salinity concentrations (Table 2). Height Growth at 0% and 0.5% concentrations showed good height growth than other salinity concentrations. This result showed that the higher salinity concentration, the higher growth decrease. This is consistent with another study [17] which indicated that each mangrove plant has a different level of tolerance to environmental factors including the high salinity concentration of salt [17].

| Table 2. Growth parameters of R. mucronata seedlings |
|------------------------------------------------------|
| Salinity | Height (cm) | Diameter (mm) | Thick leaves (mm) | Number of leaves |
|----------|-------------|----------------|-------------------|-----------------|
| 0%       | 18.74±2.08  | 3.50±0.40      | 0.24±0.03         | 7.00±0.94       |
| 0.5%     | 17.37±2.25  | 3.95±0.48      | 0.46±0.14         | 7.70±0.95       |
| 1.5%     | 12.69±1.81* | 3.29±0.32      | 0.55±0.15*        | 7.50±0.71       |
| 2.0%     | 8.10±2.84*  | 2.57±0.41*     | 0.51±0.32*        | 4.80±2.82       |
| 3.0%     | 3.48±0.87*  | 1.22±0.17*     | 0.04±0.12         | 0.20±0.63       |

Data are represented as mean ± SD (n= 10). The sign (*) indicates statistically significant control (0%) at P <0.05 with the Dunnett's test.

High salinity is basically not a prerequisite for mangroves growth, as evidenced by several mangrove species that can grow well in freshwater environments [18-20]. This is also in accordance with the conditions of growth of diameter B. sexangula seedlings. The highest diameter growth is in the administration of 0.5% salinity that is 3.9 mm and the lowest in the salinity of 3% is 0.9 mm.

Salinity concentration also affects the number, thickness and area of leaves of B. sexangula seedlings which provide different growth responses. From the observations, growth in the number, thickness and leaf area of B. sexangula seedlings is better at low concentrations and at high concentrations of growth will decrease. Calculation results of analysis of variance and Dunnett's test on the parameters of the number and diameter of each treatment continued while the differences in the growth of number and diameter seedling leaves shown in Table 2.

Based on the results of the study in Table 2 showed that the highest number of leaves is at the level of 0.5% salinity, to eight leaves and none of B. sexangula seedlings have leaves at salinity of 3%. This matter interrelated and can be proven by the condition of height and diameter of B. sexangula seedlings growth. Because the number of leaves shows the ability of mangrove plant to carry out the process of photosynthesis, more the number of leaves of B. sexangula seedling perform photosynthesis well in good growth at low salinity concentration [21-22].
Table 3. Growth of root number and root diameter

| Salinity | Main Root (cm) | Lateral root (cm) | Main Root (cm) | Lateral root (cm) |
|----------|----------------|-------------------|----------------|-------------------|
| 0%       | 3.50±1.35      | 61.50±18.00       | 3.76±0.82      | 0.52±0.18         |
| 0.5%     | 4.30±1.49      | 68.00±20.12       | 3.67±0.99      | 0.63±0.22         |
| 1.5%     | 3.90±1.29      | 50.80±14.70       | 2.78±0.82      | 0.48±0.24         |
| 2.0%     | 3.10±1.79      | 19.80±6.97        | 2.21±0.78      | 0.55±0.28         |
| 3.0%     | 1.40±1.17*     | 1.90±2.81*        | 1.18±0.70      | 0.22±0.30         |

Data are represented as mean ± SD (n= 10). The sign (*) indicates statistically significant control (0%) at P <0.05 with the Dunnett's Test.

Table 4. Parameters observed in B. sexangula seedlings

| Parameters                  | Salinity (%) |
|-----------------------------|--------------|
| Height                      | 0 and 0.5    |
| Diameter                    | 0.5          |
| Number of leaf              | 0.5          |
| Thick leaf                  | 1.5          |
| Number of main root         | 0            |
| Number of lateral root      | 0.5          |
| Length of main root         | 0            |
| Length of lateral root      | 0            |
| Diameter of main root       | 0.5          |
| Diameter of lateral root    | 0.5          |
| Canopy content              | 3            |
| Root water content          | 3            |
| Canopy root ratio           | 2            |
| Leaf area                   | 0            |

The growth of B. sexangula seedlings in various salinity has an influence on the development of the thickness of the seedlings (Table 2). Table 2 showed better leaf area development was found at low salinity concentrations. Analysis of variance shows that there is a significant influence between number of leaves. This is in accordance with the research of [23] which states that the broader the leaves of the plant, the acceptance of sunlight will also be greater, where light as a source of solar energy functions in the formation of photosynthesis. This result shows that the growth rate of number leaves is not in line with the increase in salinity concentration.

Table 2 showed a statistically significant difference of 0% at P <0.05 with Dunnett's test follow up that the administration of 1.5% and 2% salinity concentrations had a significant influence on the B. sexangula seedlings growth compared with 0% and 0.5% salinity concentrations, high salinity concentrations reduce the development of B. sexangula seedlings. [24] reported that in general the transpiration of mangrove species is low, while the roots are constantly absorbing salt water. This causes the accumulation of salt in the leaves so that the level of leaf thickness increases at high salinity concentrations. Table 2 showed that B. sexangula was able to grow and develop well at low salinity concentrations. This is reinforced from the result of [25] studied mangrove plants grow best in freshwater and seawater environments in a balanced ratio (1:1). High salinity is basically not a prerequisite for mangroves growth, as evidenced by several mangrove species that can grow well in freshwater environments [26].

Table 3 depicted the growth and development of lateral roots in B. sexangula seedlings also occurs at low salinity, i.e. at 0.5% salinity both diameter, length and number of lateral roots. The development
of roots at high salinity concentrations inhibited growth and development root in absorbing other important ions because at high salinity concentrations the Na$^+$ ions and Cl$^-$ ions are very dominant. This result is consistent with the previous findings [27-28] which reported that the relationship of growth rate and ion absorption is important, especially in the initial stages of adjusting the salt content when there was an increase in the concentration of solution in the liquid.

Growth and development of B. sexangula seedling leaves significantly decreases when grows in high salinity conditions. This is consistent with the previous result [28] which states that the effect of salinity on growth and changes in plant structure, showing smaller leaf size in the absorption of nutrients and water. This circumstance was reduced to inhibit the rate of photosynthesis will ultimately inhibit plant growth [14, 29].

4. Conclusions
The best growth and development of B. sexangula seedlings at 0.5% salinity concentration of with six best parameters, superior height, diameter, number of leaves, number of lateral roots, main root diameter and lateral root diameter.

Acknowledgment
This study was in part supported by Program Pengembangan Desa Mitra (PPDM) 2019 from the Directorate for Research and Community Service, Ministry of Research, Technology and Higher Education, Republic of Indonesia.

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