Effect of varied salt concentration and freshwater adaptation to the growth of *Bruguiera cylindrica* seedlings

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Abstract. Mangroves are recognized as plants growing in the intertidal zone. The early of mangroves growth was affected by environment salinity. This study was purposed to determine the effect of salinity and subsequent freshwater on the growth of *Bruguiera cylindrica*. The study was conducted in a greenhouse for three months using a salinity of 0%, 0.5%, 1.5%, 2%, 3% as many as 10 repetitions. After three months, the seedlings were divided into two treatment groups another three months. Five repetitions were continued with various salt concentration, and five replications underwent freshwater re-adaptation. Parameter measurement used was height seedling, stem diameter, leaf number, leaf area, and wet weight and dry weight (leaf, root, and stem) *B. cylindrica* seedlings. According to the growth parameter of seedlings, *B. cylindrica* showed the best growth at 0.5% and 0.5% to 0%. The higher salinity could inhibit *B. cylindrica* seedlings.

1. Introduction
The mangrove forest is a typical type of forest that is found along the coast or river mouth which is affected by tides, salinity, strong winds, high temperatures, muddy substrates, and anaerobic soil [1]. All plants in this mangrove forest interact with their environment both biotic and abiotic and the whole interdependent system form what we know as mangrove ecosystems. Mangroves occupy 0.7% of the total area of the world total tropical forest [2] and are tolerant of soil and water salinity [3].

Each type of mangrove plant has different adaptability to environmental conditions such as soil conditions, salinity, temperature, rainfall, and tides. This circumstance causes the structure and composition of mangrove plants with distinctive boundaries, starting from zones close to the land to zones close to the ocean, and causing differences in the formation of mangrove plants from one area to another [4]. Information about the ability to adapt mangrove plants to environmental influences is still very limited. Salinity is one of the factors that significantly determines the development of mangrove forests [5]. This study, therefore, aimed to study the effect of variations in salt concentration and adaptation of freshwater to seedling growth of *Bruguiera cylindrica*. 
2. Materials and Method

2.1. Preparation of planting media
Propagule from Bruguiera cylindrica was planted in plastic bottles which are divided into two parts, then filled with sand media that has been sterilized first and provided salinity which varies according to the study. In this study, salinity is a mass ratio of salt powder with a mass of solution [4]. The type of salt used is a powder of commercial salt (marine salt) and salinity concentration of 0%, 0.5%, 1.5%, and 2% made by dissolving 5 g, 15 g, and 20 g of salt powder commercial for 1 liter of water [4].

2.2. Propagule selection and planting
B. cylindrica propagule was derived from parent trees that are five years or older. The selected propagules should be physiologically ripe with brownish-green propagule color and healthy, not attacked by pests and diseases. B. cylindrica propagule was collected from Langkat Regency, North Sumatra, Indonesia. B. cylindrica propagule, which has been provided was planted into plastic bottles that have contained growing media which have been adjusted to their respective treatments. After three months, the seedlings were divided into two treatment groups and grown for three months: one group continuously in salt solution and the other watered with fresh water to remove salt stress [6].

2.3. Observation of salt tolerance response
After six months of cultivation, the plants are harvested by separating the roots, leaves, and stems and then washing. After that, salt tolerance response was measured by measuring growth parameters, namely: plant height (mm), diameter (mm), number of leaves, leaf area, and biomass [6]. Biomass measurement was carried out by oven, stem, and leaf oven for 48 hours at a temperature of 70 °C to obtain a constant dry weight.

Data were analyzed by one-way ANOVA using the Dunnett test for a comparison of all treatments for controls, \( P < 0.05 \) was used as boundaries to show the effect of treatment.

3. Results and Discussion

3.1. Evaluation of rehabilitated mangrove plant B. cylindrica
Seedling growth of B. cylindrica treated with variations in salt concentration and adaptation of freshwater was displayed through seedling measuring parameters, namely height, and diameter. This parameter is a visual that was depicted in experiments conducted as presented in Figure 1.

**Figure 1.** The response of salt concentration and adaptation of freshwater to seedling height (A), and stem diameter (B) seedlings of B. cylindrica. Data were obtained from ± SE (\( n = 5 \)). Signs (*) indicate significantly from controls (0%) at \( P <0.05 \) with the Dunnet test.
Based on the results of the study, it was found that differences in salt concentration and adaptation of freshwater affected the growth of stem height and diameter of *B. cylindrica*. Based on salt concentration, the highest growth of seedlings of *B. cylindrica* was found at 0.5% salinity concentration of 14.08 (cm) and the lowest at 2% salinity of 0.12 (cm). Based on freshwater adaptation, the seedling height of *B. cylindrica* was the highest in adjustments of 0.5% → 0%, namely 14.42 (cm) and the lowest at salinity 2% → 0%, i.e., 2.78 (cm). In the growth of seedlings of *B. cylindrica* stem diameter based on the highest salt concentration at a salinity of 0.5%, namely 9.40 (mm) and the lowest at 2% salinity, i.e., 0.42 (mm), while based on water adaptation.

The highest bargaining in adaptation is 0.5% → 0% which is 9.6 (mm) and the lowest is adaptation of 2% → 0% which is 4.4 (mm). In Figures 1A and 1B it can be seen that the adaptation of freshwater to the growth of seedling height and diameter of *B. cylindrica* has a significant effect, it can be seen that the growth of height and diameter after 3 months was treated with freshwater adaptation always increasing growth in height and diameter compared to concentration salt. This circumstance is due to the loss of salt stress on the seedlings of *B. cylindrica* so that the treatment of adaptation of freshwater such as 0.5% → 0%, 1.5% → 0% will be like 0% treatment which is only treated with fresh water for six months [4,6].

In addition, seedling growth at 3% and 3% - 0% salinity in a few weeks has died due to high salinity stress in the seedling. This finding is consistent with the statement of [7], which reported that salinity plays an important role in the adaptation of mangrove growth. This data is also supported by the statement of [8] who reported that salt stress is all possible environmental conditions that would reduce and adversely affect plant growth or development in its normal function. As stated above, one of the environmental stresses that occur in plants is salinity stress.

These results indicate that seedlings of *B. cylindrica* planted for six months in a greenhouse did not grow well. Growth in seedling height and diameter of *B. cylindrica* is inhibited due to high salt concentrations so that seedlings of *B. cylindrica* are unable to tolerate absorbed salt. This result agreed the previous study of [9] reported that each type of organism has a different tolerance level to environmental factors towards high salinity concentration.

![Figure 2](image_url)

**Figure 2.** The response of salt concentration and adaptation of freshwater to the number of leaves (A), and leaf area (B) of *B. cylindrica* seedlings. Data were obtained from ± SE (n = 5). Signs (*) indicate significantly from controls (0%) at P < 0.05 with the Dunnet test.

The effect of salt concentration and adaptation of freshwater seedlings of *B. cylindrica* was seen in Figure 2. The highest number of leaves based on salt concentration in Figure 2A in this study is 0.5% salinity, which is 8 leaflets, based on freshwater adaptation in the adaptation of 0.5% → 0%, namely 9 leaves and the least number of leaves at 1.5% salinity or it does not even produce leaves which are at salinity of 2% and 3%. Calculation of leaf area produced the most extensive leaves based on salt
concentration at 0.5% salinity was 1.43% mm and based on freshwater adaptation, which is an adaptation of 0.5% → 0% which was 1.55 mm. On the other hand, the leaf area is the least based on salt concentration, and the adaptation of freshwater was 1.43 mm at 1.5% salinity and an adaptation of 1.5% → 0% which was 1.23 mm.

Calculation of the number of leaves and leaf area shows that the higher the salinity, the lower the number and area of leaves obtained. This result is following [10] described the effect of salinity on plant growth and structural changes, among others, smaller leaf size. Nutrient absorption and reduced water will inhibit the rate of photosynthesis, which will ultimately impede plant growth.

3.2. The response of salt concentration and adaptation of freshwater to seedling biomass of B. cylindrica

The calculation of biomass data obtained in Figure 3-4 is based on the calculation of wet weight and dry weight (ovened) on leaves, roots, and stems. In Figures 3 and 4 show that the highest wet and dry weight (leaves, roots, and stems) based on salt concentration is at 0.5% salinity and based on freshwater adaptation on adaptation 0.5% → 0%; lowest dry weight based on salt concentration and freshwater adaptation is at 2% salinity and adaptation of 2% → 0%. The effect of salt concentration and adaptation of freshwater significantly affected the dry weight of plants. This data supported [6] reported that plant dry weight and growth rate were also affected by light intensity and salinity. The ability to live seedlings will be higher at lower salinity and will increase its capacity with optimum light availability [11].

![Figure 3](image-url)

**Figure 3.** The response of salt concentration and adaptation of freshwater to wet leaf weight (A), dry leaf weight (B), wet root weight (C), and dry root weight (D) of B. cylindrica seedlings. Data were obtained from ± SE (n = 5). Signs (*) indicate significantly from controls (0%) at P <0.05 with the Dunnet test.
Figure 4. The response of salt concentration and adaptation of freshwater to stem weight (A), and dry stem weight (B) of B. cylindrica seedlings. Data were obtained from ± SE (n = 5). Signs (*) indicate significantly from controls (0%) at $P < 0.05$ with the Dunnet test.

Salinity plays a vital role in the adaptation of mangrove growth. This result is in accordance with [8] reports that stress is all environmental conditions that allow it to decrease and adversely affect plant growth or development in its normal function. Giving salt concentration and adaptation of freshwater to the number of leaves had a statistically significant effect compared to 0% salinity at $P < 0.05$ with the Dunnet test on the treatment of 1.5% and 1.5% → 0%, while the leaf area had a statistically significant effect compared to 0% at $P < 0.05$ with the Dunnet test on 0.5% treatment only. This data is following the previous reported that the level of salinity affected the number of leaves of R. stylosa and A. marina seedlings, where the higher the salinity, the less the amount of leaves [4].

Based on the results of the measurement parameters, B. cylindrica seedlings for 6 months in a greenhouse with salt concentration and freshwater adaptation only partially grew well, namely 0%, 0.5%, 0.5% → 0%, 1.5%, 1.5% → 0% and some seedlings do not grow well, which is 2%, 2% → 0%, and some even died, namely 3%, and 3% → 0%. The difference in growth occurs due to the level of salinity and environmental conditions [12]. This result was consistent by [13-14] reporting that a variety of extreme environmental conditions in mangrove plants. These conditions, including saline environment, water-saturated soil, lack of oxygen, and solar radiation and high temperatures will disrupt plant metabolism, which in turn will cause low productivity or mangrove growth rate.

4. Conclusions

Based on variations in salt concentration, seedlings of B. cylindrica showed the best growth response at 0.5% salinity and based on re-adaptation of seedlings of B. cylindrica showed the best response to re-adaptation of 0.5% → 0%. The higher salinity inhibited the growth of seedlings of B. cylindrica.

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