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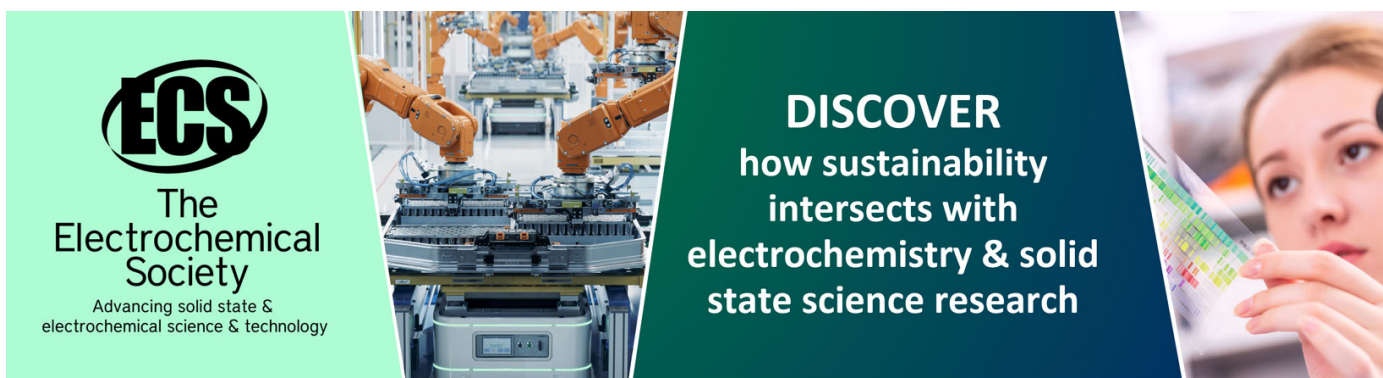
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Effect of altered salinities on the growth and root performance in *Ceriops tagal* seedlings

M Basyuni^{1,2*}, M U Lubis¹ and B Utomo¹

¹ Department of Forestry, Faculty of Forestry, Universitas Sumatera Utara, Medan, North Sumatera 20155, Indonesia

² Center of Excellence for Mangrove, Universitas Sumatera Utara, Medan, North Sumatera 20155, Indonesia

*E-mail: m.basyuni@usu.ac.id

Abstract. Mangrove forests degradation caused by anthropogenic activities leads to a decrease in the composition of mangrove forests. Mangrove forest rehabilitation activities, therefore, are needed to improve mangrove forest ecosystems. Research on the growth and development of true mangrove seedling roots of *Ceriops tagal* on various salinity was examined in a greenhouse, Faculty of Agriculture, Universitas Sumatera Utara. This study used a non-factorial Complete Randomized Design with 5 treatments salinity (0%, 0.5%, 1%, 2%, and 3% concentrations) and repeated with ten replications. Results showed that 0.5% salinity concentration dominated the observed parameters, such as seedling growth height, seedling diameter, number of leaf count, leaf area, leaf thickness, root diameter, canopy water content 0.5%, and root and shoot ratio. By contrast, the highest shoot water content was at 0% salinity and root length at 2.0% salt concentration. This study indicated that the best growth of *C. tagal* seedlings was at 0.5% salinity concentration because more than 80% of parameter measurements were at 0.5% salinity concentration.

1. Introduction

Mangroves are one of the most productive ecosystems on earth compared to other ecosystems [1]. The importance of mangrove forests has been recognized for the global ecosystem, but there is little information that explains why mangrove plants grow in high salinity environments, especially those from North Sumatran mangroves [2-4]. Stress is all environmental conditions that allow will reduce and harm the growth or development of plants in their normal functioning. One of the environmental stresses that occur in mangrove plants is salinity stress [5].

Research on salinity has been widely carried out, but information on the effect of salinity on seedling growth, especially on *C. tagal* species from North Sumatra mangrove forests, has not been conducted. Salinity stress causes the amount of water in plants to decrease [6]. Continuous salinity stress is possible to increase the production of secondary metabolites [7-8]. In order to improve the success of rehabilitation, proper planning for rehabilitation, the use of edible seeds, and adjustment or adaptation of mangrove vegetation should be carried out in accordance with growth factors [9-10]. The study aimed to determine the impact of seedling growth and development roots of *C. tagal* against various salinity concentrations. Therefore, research needs to be conducted on the effect of various salinity levels on growth and root performance in *C. tagal* seedlings.



2. Materials and Method

2.1. Plant materials

Ceriops tagal C.B. Rob. (Rhizophoraceae) propagules were collected from Pulau Sembilan, Langkat, North Sumatra, Indonesia. Planting of the *C. tagal* propagules with various salt concentrations for six months was conducted in the greenhouse of the Faculty of Agriculture, Universitas Sumatra Utara. *C. tagal* propagules were chosen should be physiologically mature with brownish-green propagules and healthy, not attacked by pests and diseases.

2.2. Planting the propagules

Propagule from *C. tagal* was grown in 1.5-liter plastic pots with sand media and given varying salinity in the greenhouse. A seawater solution was prepared by dissolving commercial salt powder to make a salt concentration of 0.5%, 1.5%, 2%, and 3%, as previously reported [11]. In this study, salinity was calculated from the ratio of the mass of salt powder to the mass of the solution [12]. Where the type of salt used from commercial salt powder (marine salt). Salinity concentrations of 0.5%, 1.5%, 2%, and 3%, was prepared by dissolving 5.66 g, 17 g, 22.6 g, and 34 g commercial salt powder for 1 liter of water. Salt concentration in each pot treatment was checked once a week during the experiment with a hand refractometer.

2.3. Parameter observation

Observations were made for six months after planting, and the parameters observed were: (a) Seedling survival percentage was calculated by comparing the number of survival seedlings and the number of seedlings planted at the beginning of the study. Data were collected at the end of the observation after six months. (b) Measurement of seedling height is done by using the ruler. Measurements were made at the bottom of the *C. tagal* seedling to the point where the seedling grew. Height measurements are carried out after harvesting. (c) Measurement of seedling diameter done using calipers. Measurements are made after harvesting [11-12].

(d) Calculation of the number of leaves was done at the beginning of the emergence of leaves starting from the shoots. (e) Leaf area measurements were performed at the end of the data observation. The leaves are drawn on millimeter paper blocks, then scanning the image. After that, the image was calculated by the Image J program [13]. (f) Leaf thickness measurements were performed at the end of the observation using a micro screw meter. (g) Calculation of the number of roots was done manually by using a counter done after harvesting *C. tagal* seedlings at six months. Root number was calculated based on the position of the roots in the root system (level of branching), according to [14].

(h) The root length measurement was performed manually using a crossbar and ruler. Length measurements were taken after harvesting of *C. tagal* seedlings. Root length was measured based on the root position in the root system (branching level) according to the classification of [14]. (i) Root diameter measurements were taken after harvesting of *C. tagal* seedlings. Root diameter measurements were performed on each type of branching using calipers [14].

2.4. Data analysis

This research was evaluated an analytical method with a nonfactorial Complete Randomized Design with five salt concentration treatments in the field with ten replications. Data were analyzed by comparative of all treatments to controls, $P < 0.05$ used as a limit to indicate the effect of treatment. Statistical tests were performed with the SPSS program.

3. Results and Discussion

Table 1 depicted the survival percentage of *C. tagal* seedling growth, displaying success at 0% to 2% salinity concentration. In the case of 3% salinity, the *C. tagal* seedling survival reached only 70%. This study reinforced by [15], which states that *C. tagal* is a salt-tolerant mangrove with the ability to grow in conditions of high salinity and nutrient-poor conditions. The effect of treatment on growth shows a significant difference.

Table 1. Percentage of survival of *C. tagal* seedlings

No	Parameter	Survival percentage (%)	Mortality (%)
1	Salinity 0%	100±0.0	0±0.0
2	Salinity 0.5%	100±0.0	0±0.0
3	Salinity 1.5%	100±0.0	0±0.0
4	Salinity 2.0 %	100±0.0	0±0.0
5	Salinity 3.0%	70±48.3	30±0.0

Data are represented as mean ± SD (n= 10).

The effect of salinity on the growth of *C. tagal* seedlings based on diameter measurements showed in Table 2. It was found that differences in salinity concentrations significantly affected the height and diameter of *C. tagal* seedlings. Table 2 showed that *C. tagal* seedlings grew and showed a very significant difference in height growth. The highest *C. tagal* seedlings were found at the highest salinity concentration of 0.5% at 3.35 (cm) and the lowest at a concentration of 3% at 0.8 cm. *C. tagal* seedlings for height growth can be caused by high salt concentrations so that *C. tagal* seedlings are unable to tolerate absorbed salt. This result is consistent with the previous findings of [11-12,15-17], which shows that each species of the organism has a different level of tolerance to environmental factors, including the high salinity concentration of salt.

Table 2. Growth parameters of *C. tagal* seedlings

Salinity	Height (cm)	Diameter (mm)	Thick leaves (mm)	Number of leaves	Leave are (cm ²)
0%	0.29±0.28	0.33±0.25	0.37±0.24	2.10±0.57	4.49±1.11
0.5%	2.52±0.59*	1.63±0.46*	0.60±0.10*	3.60±0.52	6.29±0.50*
1.5%	0.98±0.60	0.35±0.21	0.35±0.18	1.90±1.10	5.30±3.15
2.0 %	0.95±0.34	0.55±0.36	0.53±0.25	2.00±0.82	5.20±2.07
3.0%	0.29±0.28	0.06±0.08	0.11±0.13	0.50±0.53	0.20±0.63

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

The highest stem diameter of *C. tagal* seedlings was found in the administration of 0.5% salinity. The lowest stem diameter growth of *C. tagal* seedlings at 3% salinity (Table 2). Based on the Dunnet Test at $P < 0.01$ administration of salinity significantly affected the growth of *C. tagal* seedling diameter at 0.5% salinity. Growth of *C. tagal* seedling diameter showed a very significant increase in 0.5% salinity then decreased with increasing salinity (Table 2). Table 2 depicted *C. tagal* seedlings are growing and showing their growth. At a salinity concentration of 1.5%, the diameter of the *C. tagal* seedlings decreases. The decrease that occurs is due to high salt concentrations, seedlings to become stressed to limit the growth [18].

Based on the results of the study, the effect of salinity on the number of leaves, leaf area, and leaf thickness was shown in Table 2 that the highest number of leaves was at a salinity concentration of 0.5%. Based on the Dunnet P test > 0.05 , 0.5% salinity significantly affected the increase in the number of *C. tagal* seedlings. Table 2 showed that the highest leaf area is at 1.5% salinity

concentration, and the lowest was at 3% salinity concentration. The highest average leaf area is at a salinity concentration of 0.5%, and the lowest average is at a salinity concentration of 3%. Based on further testing with the Dunnet's P Test <0.01 that the administration of salinity has no significant effect on the increase in leaf area of *C. tagal*. The effect of salinity on growth and changes in plant structure, among others, smaller leaf size [19-20]. The reduced absorption of nutrients and water will inhibit the rate of photosynthesis, ultimately inhibiting plant growth [21]. Table 2 depicted that *C. tagal* leaf thickness displays that the highest average leaf thickness is at a salinity concentration of 0.5%, and the lowest average leaf thickness is at a salinity concentration of 3%.

Table 3. Growth of root-derived from number, length, and diameter of the root

Salinity	Root number (cm)	Root length (cm)	Root diameter (cm)
0%	0.00±0.00	0.00±0.00	0.00±0.00
0.5%	3.20±1.44	1.92±0.76*	1.18±0.40*
1.5%	3.55±2.99	0.80±0.92	0.23±0.38
2.0 %	5.20±1.95	1.24±0.21	0.97±0.19
3.0%	2.80±3.21	0.45±0.59	0.20±0.27

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

Table 3 displayed the highest average of the measurement parameters for the number of roots is at 2% salinity concentration, and the lowest number of roots is at 0% salinity concentration. *C. tagal* seedling planted at 0% salinity concentration remains to grow, but seedling roots do not develop like other salinity concentrations. This circumstance is because the root of the *C. tagal* seedling does not develop. Only the root spots are visible. According to [22-25] that mangrove roots can bind and stabilize the mud substrate, trees reduce wave energy and slow down currents, while overall vegetation can trap sediments. Based on further testing with Dunnet's test, $P < 0.05$ administration of salinity concentration did not significantly affect the number of *C. tagal* seedlings. Based on Table 3, the highest average root length is found at a salinity concentration of 0.5% and the lowest at a salinity concentration of 0%. Based on further testing with Dunnet's test, $P < 0.05$ giving salinity concentration of 0.5% had a significant effect on the length of *C. tagal* seedlings.

Table 4. Parameters observed in *C. tagal* seedlings

Salinity	Parameter
0%	Shoot water content Height, diameter, number of leaves, leaf area, thick leaf, number of leaves, root diameter, root water content, root, and shoot ratio
0.5%	shoot ratio
1.%	None
2.0%	Root length
3.0%	None

Table 3 shows the highest average root diameter that can be seen in the figure found at a 0.5% salinity concentration of 1.69 mm, and the lowest at 0% salinity concentration is 0. Based on further tests with Dunnet's P Test > 0.05 that administration salinity concentration of 0.5% has a significant effect on the growth of *C. tagal* seedling root diameter. Table 3 summarizes the high growth showed that all. *C. tagal* can grow well at 0.5% salinity concentration. Almost all parameters at the 0.5% salinity concentration obtained the highest average value than the other salinity concentrations. Table

4 showed that the percentage of the highest measurement parameter is a salinity concentration of 0.5%, reaching 81.8%. The total percentage is obtained from the product of the best number of growth measurement parameters divided by the sum of all growth parameters. According to [26-28], *C. tagal* is a salt-tolerant mangrove with the ability to grow in high salinity conditions and deficient nutrients.

4. Conclusions

The salinity level of 0.5% produces the best root growth of *C. tagal* seedlings. These parameters including shoot water content, height, diameter, number of leaves, leaf area, thick leaf, number of leaves, root diameter, root water content, root, and shoot ratio. In order to support the success rate of planting *C. tagal* seedlings, seedlings are planted at a low salinity concentration. This study suggested using *C. tagal* seedlings in a mangrove rehabilitation program,

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