Growth analysis of mangrove (*Rhizophora apiculata* bl) propagule toward differences in types of water and planting media at Makassar mangrove center

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Abstract. Mangrove cultivation is currently hard to find due to many aspects that needed to be observed. The success of mangrove to grow and develop from seeds, nursery, and planting are depending on water salinity and mangroves planting media. The objectives of this study were to investigate the planting media, water types, as well as the combination of planting media and water used, which were the best for mangrove's growth. The method used in this study was an experimental field approach with a Complete Randomized Design (SRD) factorial experiment and Duncan's Multiple Range Test as its posthoc test. The growing media used were mud and mud added with compost in a ratio 1:1, and the water types used for watering were seawater, freshwater, and the mixture of seawater and fresh water in a ratio 1:1. The observation variables in this study included the increase of propagule height (measurement from cotyledon's neck up to the tips of plant shoots), an increase in diameter, and percentages of growing propagules. Watering with freshwater showed the most significant increase in height and diameter of propagules. Meanwhile, for planting media, the most appropriate one was mud added with compost. For treatment combinations, the combination of freshwater with mud added with compost provided a better effect on propagule growth. However, all of the combinations had shown growth.

1. Introduction
Mangrove (*Rhizophora apiculata* BL) is a species from Rhizophoraceae family that grows in mangrove forests [1]. This plant is able to grow to a height of 3 meters with 50 cm in diameter. One of *Rhizophora apiculata* BL characterizations is the leaf size, which tends to be smaller, dark green color in the middle, and reddish at the bottom. It grows in muddy soil, smooth, deep, and waterlogged on normal tides [2].

Mangrove plants have fruits that can stick and float in the mud [3]. Those fruits will become propagules if they have germinated and released along the root with spear-shaped. Type of *Rhizophora apiculata* BL propagule is vivipary, which means a propagule that has germinated...
before falling off the tree. This type of propagule has a diameter of 1.3 - 2.0 cm and 20 - 40 cm in length [4].

Mangrove cultivation is hard to find due to many aspects that needed to be observed in its cultivation processes, together with the long period of growth of the mangrove itself, including mangrove. The success of growth and the development of mangrove plants from seed, nursery, and planting are very depending on water salinity and its planting media. The difference in the level of water salinity will affect the growth and development of the mangrove *Rhizophora apiculata* BL seedling roots [5]. Besides, Susiana (2015) [6] stated the fertility of mangroves in Indonesia is also supported by the location and its planting media such as tropical climates, high rainfall, as well as mud or coastal sediments which are suitable for mangrove to grow including mangrove species. As explained above, nowadays, mangroves are one of the trees in which cultivation is challenging to perform. Many factors need to be considered, such as water types for watering and also the planting media that become the main factors for the lack of mangrove cultivation. Therefore, this study was conducted in order to investigate the most appropriate and effective planting media along with the types of watering water for the growth of mangrove propagules.

2. **Research method**

2.1. **Time and Place**
This research was conducted from July to October 2019 at mangrove nursery at Lantebung street, Bira, Tamalanrea, Makassar City, South Sulawesi (Figure 1). For Laboratory analysis, it was performed at Silviculture and Tree Physiology Laboratory, Faculty of Forestry and Chemical Engineering Laboratory of Ujung Pandang State Polytechnic.

![Figure 1. Map of the research area](image)

2.2. **research procedures**
The preparation steps included data collection that related to the study, such as literature reviews, completing the tools that used for study, and conducting preliminary surveys to ensure the location which performing mangrove (*Rhizophora apiculata* BL) nursery.

Stage of field observation activities:

2.2.1. **Determination coordinate of the location for observation using Avenza maps.**

2.2.2. **Preparation of research plants that were mangrove seedlings.**
2.2.3. Preparation of planting media in the field. The treatment consisted of 2 factors, namely the planting media (m) and types of water for watering (a) that consisted of 3 levels of each. The levels planting media were mud, compost, a combination of mud and compost with ratio 1:1, while that of types of water were seawater, freshwater, and combination of freshwater and seawater with ratio 1:1. Hence the treatment combinations were six treatments, which are presented in table 1.

| Table 1. Treatment Combinations |
|--------------------------------|
| M  | a1  | a2  | a3  |
| m1 | a1m1| a2m1| a3m1|
| m2 | a1m2| a2m2| a3m2|

Note:
- m1: Mud (1): Compost Organic Fertilizer (1), or 500 g of mud: 500 g of Compost Organic Fertilizer.
- m2: Mud
- a1: Freshwater
- a2: Seawater
- a3: Fresh Water (1): Seawater (1), or 600 ml of freshwater: 600 ml of seawater

2.2.3.1. Mangrove propagules were planted in polybags. The planting was conducted after the polybags, and planting media readied in the field that accordance with study design. Each mangrove propagule was planted in 6 different planting media compositions. Each polybag was filled with a mangrove propagule and watered with water. The experimental unit was six treatment combinations with five replications, and the total experimental units were 30 units.

2.2.3.2. Data collection of mangrove growth consisted of plant height (the measurement was from cotyledon neck to the tips of plant shoots), plant diameter, and the percentages of growing propagules in each treatment. Retrieval data were obtained from direct observation on the experimental units every two weeks for eight times of observation. Observations were conducted at each repetition.

2.3. data analysis
The research data obtained were processed using ANOVA analysis of Completely Randomized Design (CRD) factorial experiment. The statistical model used in this research activity was:

\[ Y_{ij} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \varepsilon_{ijk} \]

Note:
- \( Y_{ij} \): the response variable due to the influence of propagule that was independent to i-th and propagule to j-th.
- \( \mu \): average value
- \( \alpha_i \): treatment effect of A
- \( \beta_j \): treatment effect of B
- \( (\alpha\beta)_{ij} \): interaction effect between treatments A and B
- \( \varepsilon_{ijk} \): the effect of treatment error (trial error)

The F Test at \( \alpha = 5\% \) was used to determine the effect of a single factor and its interactions on the growth of propagule and seedlings. If there is a significant effect from different
treatments on observed variables, then every level of treatment is compared using Duncan test at 5% level error.

3. Results and discussion

3.1. The results of laboratory analysis
The results on the laboratory analysis of water used were presented in table 2.

Table 2. The results of laboratory analysis

| Observation Variable | Object of Observation |
|----------------------|-----------------------|
| Salinity             | Freshwater 1.33 ppt    | Seawater 3.34 ppt |
| pH                   | 7                     | 6.5                |
| Temperature          | 32°C                  | 34°C               |

3.1.1. Water Salinity. In general, a good mangrove growth response is obtained at lower salinity. *Rhizophora* can grow at 0.0-30.0 ppt salinity. However, the most optimal level of salinity for *Rhizophora* growth is 12.0-30.0 ppt. This situation is due to mangroves are not plants that need to salt (salt demand), but it is tolerant of salt (salt tolerance) [7]

3.1.2. Watering pH. According to Bengen (2001) [8], between 5 - 7.8 of water pH is a pH value that supports the growth of mangrove.

3.1.3. Watering Temperature. The range of optimal temperatures for mangrove photosynthesis is 28-32°C, meanwhile temperature of >38°C resulting in the cessation of photosynthesis in leaves (Andarani et al., 2016).

3.2. The percentage of growth
Growth percent is the percentage of fruits that lived at the end of the observation period compared to the total number of planted fruits. The results study at Makassar mangrove nursery center showed that mud treatment, which added compost with a ratio of 1:1 and watered with a combination of freshwater and seawater with ratio 1:1 (a3m1) resulting in at the least of life percentage among five other treatments. Those data are presented in figure 2.
Figure 2. Graph percentage of mangrove propagules growth

There was a death of mangrove propagule on a3m1 treatment combination (mud growth medium added fertilizer and watered with a combination of seawater and freshwater). Hence the results showed the least growth percentage among experimental combinations. It caused by pests such as crabs that ate most of the hypocotyl bodies from the propagule and ultimately inhibited the growth of propagule, which led to death. The death of the propagule was not related to the treatment that had been performed. Some propagules with different treatment combinations also had crab's bite marks on their hypocotyl bodies. Nevertheless, it did not lead to death because crabs only ate 10% - 15% of the hypocotyl. Thus propagules still showed growth, although the growth became slow. This is in line with the statement of Pribadi, et al. (2014) [9] that predatory fauna Graspidae which mainly from Sesarma sp has a massive influence on the growth process of mangrove propagule. The damage of Rhizophora propagule is a consequence of predation, which characterized by a defect (either in hole formation or sores) at the hypocotyl area. The damage in the interior side of the propagule will eliminate its ability to grow[3].

Besides, in the diagram above showed there was a growth in freshwater treatment for mangrove propagule. Mangrove plants, especially R.apiculata is included in a non-salt excreting mangrove group where these mangrove plants absorb water, but they prevent the entry of salt through the filtration process (ultrafilter) that present in the roots; as a result R.apiculata propagule is able to grow in freshwater [2].

3.3. The increase in height
Research at the Makassar mangrove nursery center showed that mud treatment added with compost in a ratio 1:1 and watered with freshwater produced the highest of height increase during the research period. The trend height increase of propagule can be seen in Figures 3, 4, 5, 6, 7, 8, and 9.
Figure 3. The trend of height increase in propagule at a1m1 treatment combination.

Figure 4. The trend of height increase in propagule at a1m2 treatment combination.

Figure 5. The trend of height increase in propagule at a2m1 treatment combination.
**Figure 6.** The trend of height increase in propagule at a2m2 treatment combination

**Figure 7.** The trend of height increase in propagule at a3m1 treatment combination

**Figure 8.** The trend of height increase in propagule at a3m2 treatment combination
Figure 9. The height increase of propagule in each treatment

Mud treatment, which was added compost fertilizer in a ratio 1:1 and watered with freshwater, produced the highest of height increase during the study, and the lowest in height increase was at a2m2 treatment combination (watered with seawater and mud planting medium).

This was due to the a1m1 treatment combination using mud planting medium and organic fertilizer, which was compost fertilizer. The compost planting medium is capable of increasing the plant height as compost possess nutrient substances such as nitrogen and phosphate in the form of complex compounds argon, protein, and humic which are difficult to be absorbed by plants [10].

Fertilization can affect the quality of seedlings. This is because, during the nursery period, all plant nutritional needs are mostly supplied from fertilizer [11], which given to the planting medium [12]. Sumarna (2012) [13] stated that the need for fertilizer physically aims to increase plant growth (height and diameter) as well as plant health. The factors, such as the presence of nutrients in the soil, extremely influence the difference in plant height at each treatment. Compost fertilizer produces carbon dioxide (CO2), water (H2O), and minerals. The produced mineral is a source of nutrients that can be absorbed by plants as food substances. The number of nutrients absorbed by plants will possess a good effect on plant growth [14]. This was supported by ANOVA results on the height increase of Rhizophora apiculata propagule that is depicted in table 3.

| Source of Diversity | Sum of squares | Degree of Freedom | Mean Squares | F       | Sig. 5% |
|---------------------|----------------|------------------|--------------|---------|---------|
| Type of Water       | 2342.001       | 2                | 1171.000     | 36.181  | .000    |
| Planting media     | 1217.307       | 1                | 1217.305     | 37.612  | .000    |
| Interaction        | 1259.102       | 2                | 629.551      | 19.452  | .000    |
| error              | 776.752        | 24               | 32.365       |         |         |
The ANOVA table above shows that type of water for watering, planting media, and interaction between both treatments had significant effects on the height increase of *Rhizophora apiculata* propagule. Duncan's test is presented in table 4.

**Table 4. Duncan's Multiple Range Test on the height increase of *Rhizophora* propagule**

| The Average | Duncan | Notation |
|-------------|--------|----------|
| a2 56.6     | Rp2 (7.41) | a |
| m1 54.6     |         | a |
| a3 55.8     | Rp3 (7.78) | b |
| a1 38.4     |         | a |
| a2 26.2     | Rp3 (7.78) | b |
| m2 29.2     |         | b |

*Duncan's Multiple Range Test* showed that watering with freshwater into mud planting medium, which added an organic fertilizer in a ratio 1:1 (a1m1), had a different effect on the height increase of mangrove propagule. The mud planting medium that was added with seawater and freshwater in a ratio of 1:1 (a3m2) produced a different effect on mangrove propagule growth. All treatment combinations that were watered with freshwater, as well as freshwater mixed with seawater, showed different effects. *Rhizophora* mangrove is a type of mangrove that can inhibit the entry of salt through its roots and requires an adequate supply of fresh water for its growth[2]. If all treatment combinations were given in a balanced manner, then it will produce a positive effect on the growth of the propagule as long as the treatment can provide sufficient and stable nutrients. Many environmental factors affect mangrove swamps, such as air temperature, humidity, and other factors. However, the most critical factors are appropriate interaction between soil types (its planting media) along with water salinity [15].

### 3.4. Increase in Diameter

Study results at Makassar mangrove center nursery showed that during the study, mud treatment added with compost at a ratio 1:1 and watered with freshwater obtained the highest increase in propagule diameter. The trend of increase in propagule diameter can be seen in figures 10, 11, 12, 13, 14, 15, and 16.
**Figure 10.** The trend of increase in diameter propagule at a1m1 treatment combination

![Graph showing trend of increase in diameter propagule at a1m1 treatment combination.](image)

**Figure 11.** The trend of increase in propagule diameter at a1m2 treatment combination

![Graph showing trend of increase in propagule diameter at a1m2 treatment combination.](image)

**Figure 12.** The trend of increase in propagule diameter at a2m1 treatment combination

![Graph showing trend of increase in propagule diameter at a2m1 treatment combination.](image)

**Figure 13.** The trend of increase in diameter propagule at a2m2 treatment combination

![Graph showing trend of increase in diameter propagule at a2m2 treatment combination.](image)
Figure 14. The trend of increase in propagule diameter at a3m1 treatment combination

Figure 15. The trend of increase in propagule diameter at a3m2 treatment combination

Figure 16. The increasing of propagule diameter in each treatment combination
Mud treatment added compost fertilizer with a ratio 1:1 and watered with freshwater produced the highest increase in diameter during the study, and the lowest increase in diameter propagule was in treatment combination of a2m2 (watered with seawater and mud planting medium).

Planting media are significant factors in terms of diameter differences in propagules. The high diameter value of propagule when using mud as planting medium and fertilizer are due to the presence of nutrients containing in the fertilizer, which gives a better effect on the increasing diameter of any plants [16].

However, the trend above depicts there was no significant increase in propagule diameter during the experimental study. This data also supported by the results of the CRD factorial experimental test by using SPSS presented in table 5.

| Source of Diversity | Sum of squares | Degree of Freedom | Mean Squares | F     | Sig. 5% |
|---------------------|----------------|-------------------|--------------|-------|---------|
| Watering use        | .037           | 2                 | .019         | 1.011 | .379    |
| Growth media        | .042           | 1                 | .042         | 2.276 | .144    |
| Interaction         | .045           | 2                 | .022         | 1.211 | .315    |
| Error               | .441           | 24                | .018         |       |         |
| Total               | 5.429          | 30                |              |       |         |

The ANOVA table above presents that the water treatment for watering, planting media, and interactions between them did not significantly affect the increased diameter of *Rhizophora apiculata* propagules. This was in line with the trend of the increasing diameter that had been previously presented, in which the previous trend showed there was no significant increase in diameter.

These data were supported by Nugroho (2009) [17] stated that the increase of propagules diameter when it planted is classified as very slow and not significant. In the nursery period, the increasing diameter was not optimal whether the fertilizer was given or not. Optimal growth is expected to occur when propagules are still present on the tree, and this is because *Rhizophora* fruit is a viviparous (seeds germinate while still on the parent tree, and are not closed/out of the seeds coat).

4. Conclusions
1. All experimental units that were watered with fresh water, seawater and a combination of them demonstrated the growth. For their height and diameter increase showed linear results. In this study, watered with freshwater was the best of water used for *Rhizophora apiculata* propagules' growth at Makassar Mangrove Center.
2. The results of the previous study showed that the fertilizer addition on mud planting media for *Rhizophora apiculata* propagules provided a better growth compared to mud sorely as planting media, both were in terms of height and diameter increase.
3. All treatment combinations of *Rhizophora apiculata* propagules demonstrated the presence of growth. The best growth performance was shown by giving freshwater for watering and mud added with fertilizer as a planting medium.

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