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Growth of *Rhizophora apiculata* and *Rhizophora mucronata* on Different Sediment Types in the Marine Station Area of the Universitas Riau, Dumai

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ABSTRACT

Mangroves play an important role in maintaining coastal stability and supporting ecological functions in coastal waters. This study aimed to analyze differences in the growth of *Rhizophora apiculata* and *R. mucronata* under different sediment types at the Marine Station of Universitas Riau, Dumai. Observations were conducted for 10 weeks at two stations, namely sandy mud and mud sediments, using 24 mangrove seedlings with an initial height of ≥ 60 cm. The results showed significant differences in growth between mangrove species and between observation stations ($p < 0.05$). In sandy mud sediment, *R. apiculata* exhibited better growth (64.33 ± 3.92 mm; 7.20 ± 0.46 mm), whereas in mud sediment, *R. mucronata* showed more optimal growth (72.36 ± 7.54 mm; 7.87 ± 0.52 mm). Seedling survival reached 100% at both stations. These findings indicate that the suitability of mangrove species to sediment characteristics is an important consideration in mangrove rehabilitation efforts.

Keywords: *Rhizophora apiculata*, *Rhizophora mucronata*, Growth, Survival, Sediment Type

1. INTRODUCTION

Mangrove forests are distinctive coastal ecosystems that play a crucial role in maintaining environmental balance. These ecosystems function as natural barriers against coastal abrasion, reduce the impact of tsunamis, provide habitat for various biota, and serve as significant carbon sinks. Indonesia has the largest mangrove forests in the world, covering approximately 3.5 million hectares distributed across 257 districts and cities (Muhtadi, 2020). Nevertheless, mangrove ecosystems are experiencing substantial global degradation. The rate of mangrove loss reaches 1–2% per year and tends to occur more rapidly in developing countries (Carter et al., 2015). These conditions indicate the need for serious attention to mangrove conservation, including rehabilitation programs that consider ecological factors and planting techniques aligned with natural habitat conditions.

Mangrove rehabilitation efforts are influenced not only by seedling availability but also by nursery techniques, seedling preparation, and the suitability of species to local environmental conditions. Proper nurseries are typically located in areas influenced by tidal inundation, allowing seedlings to receive natural water submersion (Wiarta, 2012). The adaptive capacity of mangrove species also determines the success of rehabilitation programs. *Rhizophora apiculata*, for instance, has been reported to exhibit a high survival rate of over 75%, reaching 79.51% in rehabilitation activities (Labuga et al., 2023). Meanwhile, *R. mucronata* is known for its strong adaptability, sturdy prop roots, and effective coastal protection capability, making it a common choice for planting programs (Rosalina, 2021).

Mangrove growth is strongly influenced by environmental conditions, particularly sediment characteristics, which serve as the primary growing medium. Sediment not only supports root anchorage but also serves as a nutrient source and affects oxygen availability. Previous studies reported that *Avicennia marina* seedlings grow optimally in clay–mud, clay, and sandy media at certain salinity levels (Budiadi et al., 2022). In contrast, *R. mucronata* shows optimal growth in mixed media containing sand, mud, and organic charcoal, which enhances nutrient availability (Yuniantika et al., 2023). These findings suggest that each mangrove species has specific habitat preferences, emphasizing the importance of selecting appropriate substrate types to ensure rehabilitation success.

The Marine Station of the Universitas Riau in Dumai is an important location for mangrove ecological studies. This area borders

the Rupat Strait and experiences a mixed, semidiurnal tidal pattern with an average tidal range of approximately 2.3 meters, which influences mangrove zonation and vegetation distribution. Survey results indicate that the region is dominated by the family Rhizophoraceae, particularly *R. apiculata*, along with other species such as *Xylocarpus granatum* and *Bruguiera gymnorrhiza*. However, *R. mucronata* has not been recorded at this location (Siregar, 2024). This condition provides an important justification for examining the growth potential of *R. mucronata* in the local habitat of Dumai while comparing it with *R. apiculata*, which is more commonly found.

Given the ecological importance of mangrove ecosystems and the challenges encountered in rehabilitation efforts, a study on the growth of *R. apiculata* and *R. mucronata* across different sediment types at the Universitas Riau's Marine Station in Dumai is highly relevant. This research aims to determine differences in growth and survival rates of the two species in sandy–mud and mud substrates. The findings are expected to provide scientific insights for more effective mangrove planting zonation and to serve as a reference for coastal ecosystem rehabilitation programs in Dumai and other regions with similar environmental characteristics.

2. RESEARCH METHOD

Time and Place

The research was conducted from February to May 2025 in the mangrove area of Purnama Village, Dumai City, Riau Province. The study site consisted of two stations with different sediment types: Station 1, located in the front zone with sandy–mud sediment, and Station 2, located in the middle zone with mud sediment. The research location map is presented in Figure 1.

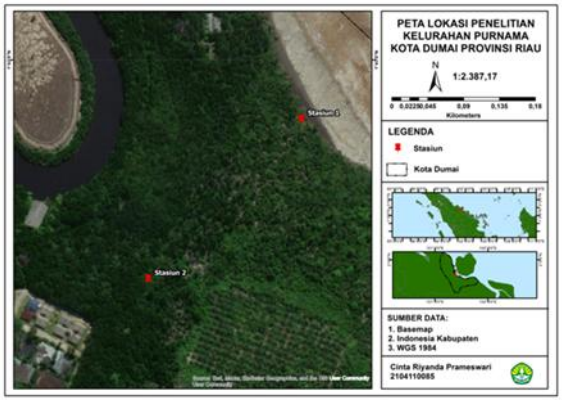


Figure 1. Research Location

Method

The method used in this study was the experimental method. According to Sugiyono (2019), experimental research is a controlled, quantitative approach. It is used to determine the effect of an independent variable (treatment) on a dependent variable (outcome) under controlled conditions. The treatments in this study consisted of two types: 1) Treatment 1: Sandy–mud sediment with a mud fraction of 49.75% at Station 1, 2) Treatment 2: Mud sediment with a mud fraction of 83.33% at Station 2.

Each treatment consisted of 12 replications, and statistical analysis was performed using a paired t-test to compare the growth of *R. apiculata* and *R. mucronata*. At each station, experimental plots measuring 5 × 5 m² were established, with a total of three plots used for sampling, observation, and measurement of seedling parameters, including height and stem diameter of *R. apiculata* and *R. mucronata*.

Procedures

Planting

Mangrove planting was carried out by establishing experimental plots at each station, each with different sediment characteristics. Each plot measured 5 × 5 m² and was planted with *R. apiculata* and *R. mucronata* seedlings, with 12 seedlings of each species arranged alternately to maximize randomization. The seedlings used had a height of ≥ 60 cm, as Gorat (2010) reported that seedlings with heights ≥ 60 cm exhibit significantly greater growth than smaller seedlings because they possess greater food reserves. The mangroves were planted at a spacing of 1 m, in accordance with Irawan (2022), who reported that spacings of 50 cm to 1 m yield optimal outcomes. The planting scheme is shown in Figure 2.

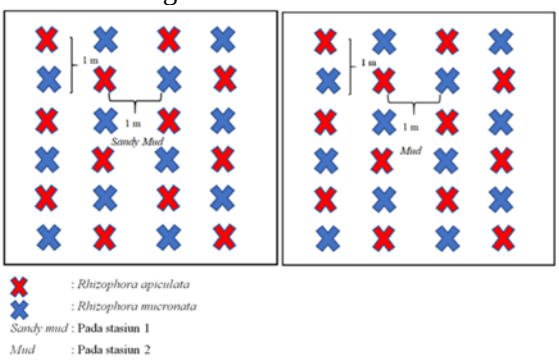


Figure 2. Schematic Layout of Experimental Plots

Growth Observation

Data collection was carried out directly by observing and measuring seedling height and stem diameter. According to Arifin et al. (2015), the measurement of seedling height was taken from the marked base of the shoot up to the growth point. According to Yanti (2011), the stem diameter is measured at 1 cm above the marked shoot base. Following Yuniantika et al. (2023), measurements were conducted every 2 weeks for 10 weeks. After obtaining the height and diameter measurements, the growth values for height and stem diameter were calculated using the following formulas:

$$\text{Growth}=t_1-t_0$$

Description:

t_1 = Plant parameter at the end of the period (mm)

t_0 = Plant parameter at the beginning of the period (mm)

Next, the height growth rate and stem diameter growth rate were calculated using the following formulas:

$$\text{Growth Rate}=\frac{X_t-X_0}{t}$$

Description:

X_t = Plant parameter at the end of the period (mm)

X_0 = Plant parameter at the beginning of the period (mm)

t = Observation duration (weeks)

Mangrove Survival Rate Calculation

Survival rate (SR) is the proportion of individuals that remain alive at the end of a given period, expressed as a percentage. According to Goddaard (1995), the formula for calculating the survival rate is as follows:

$$SR=\frac{Nt}{No}\times 100$$

Description:

SR = Survival rate (%)

N_t = Number of mangrove seedlings alive at the end of the observation (seedlings)

N_0 = Number of mangrove seedlings at the beginning of the observation (seedlings)

Data Analysis

The data were presented in figures and tables and subsequently described descriptively. The obtained data were analyzed using a partial significance test, commonly known as the t-test. The t-test was used to determine differences in the means of the observed variables, allowing identification of whether these differences were statistically significant at $\alpha = 0.05$

3. RESULT AND DISCUSSION

Based on sediment analysis conducted at each station, the identified sediment types were mud and sandy mud. The calculation of sediment fractions is presented in Table 1.

Table 1. Sediment Type Classification

Station	Results of calculations (%)			Sediment Type
	Gravel	Sand	Mud	
1	18,43	31,83	49,75	Sandy Mud
2	0,74	15,93	83,33	Mud

The results of the sediment analysis indicate that Station 1, located in the mangrove zone near the sea, has a sandy–mud sediment type, with gravel at 18.43%, sand at 31.83%, and mud at 49.75%. This condition shows that the substrate at Station 1 is still influenced by tidal dynamics and wave activity, which transport sand and gravel, resulting in a coarser sediment texture than at the other station. Meanwhile, Station 2, located in the middle mangrove zone, has a mud sediment type, with a mud fraction of 83.33%, sand at 15.93%, and gravel at only 0.74%. The dominance of mud at this station reflects a calmer environment with higher deposition of fine particles, resulting in a softer substrate.

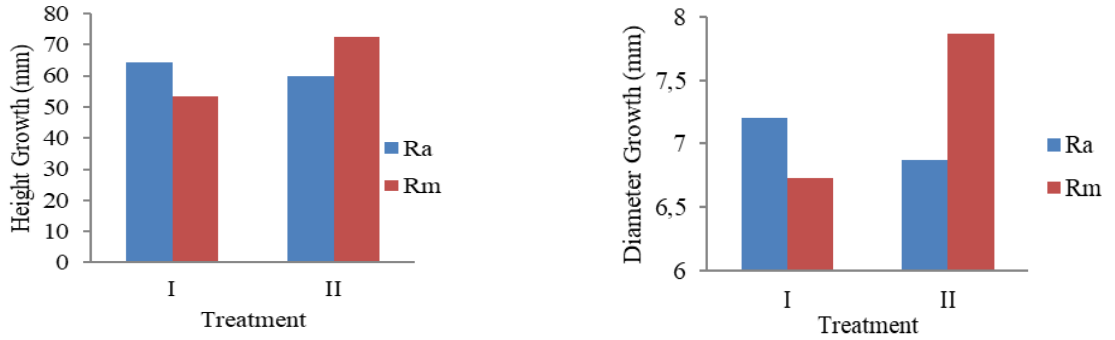
Growth of *R. apiculata* and *R. mucronata* Across Different Sediment Types

The height and diameter growth of *R. apiculata* (Ra) and *R. mucronata* (Rm) at each station, measured every two weeks for 10 weeks from February to May 2025 (Figure 3). The growth of *R. apiculata* and *R.mucronata* seedlings showed clear variation across the two observed sediment types. In mud sediment (Station 2), *R. mucronata* exhibited higher average growth than *R. apiculata*, with mean height increments of 72.36 ± 7.54 mm and 59.83 ± 3.16 mm, respectively. A similar pattern was observed in stem diameter growth, with R. mucronata averaging 7.87 ± 0.52 mm and R. apiculata averaging 6.85 ± 0.52 mm.

In sandy mud sediment (Station 1), *R. apiculata* showed better growth performance

than *R. mucronata*. The mean height increment of *R. apiculata* was 64.33 ± 3.92 mm, higher than that of *R. mucronata* at 53.17 ± 13.64 mm. Stem diameter growth followed a similar trend, with *R. apiculata* averaging 7.20 ± 0.46 mm and *R. mucronata* averaging 6.72 ± 0.32 mm.

The results of the t-test indicated that the differences in growth between the two mangrove species within each sediment type were statistically significant ($p < 0.05$), for both height and stem diameter. These findings suggest that differences in sediment characteristics are associated with different growth responses of the two mangrove species. Variations in sediment texture and environmental conditions at each station are likely to support the adaptive capacity of *R. mucronata* in mud sediments and of *R. apiculata* in sandy mud sediments.



(a) (b)

Figure 3. Average Height (a) and Diameter (b) Growth of *R. apiculata* and *R. mucronata* Based on Stations Over 10 Weeks

The results of this study indicate that *R. apiculata* growth was better at Station 1. This condition was supported by higher nutrient concentrations, with nitrate levels of 0.095 mg/L and phosphate levels of 0.666 mg/L, compared to Station 2. The high availability of these nutrients provides sufficient essential elements to support mangrove growth. Efriyeldi et al. (2018) emphasized that substrate quality and environmental conditions play a crucial role in determining *R. apiculata's* adaptive capacity, with favourable sediment conditions supporting better plant growth. Ecologically, *R. apiculata* is better adapted to the seaward zone, directly adjacent to the ocean and dominated by sandy–mud substrates. This species can survive in more open conditions with strong tidal dynamics and higher sediment aeration. In contrast, *R. mucronata* is better suited to the mid-zone habitat, dominated by fine, organic-rich, water-retaining muddy sediment. Such conditions enhance nutrient availability, thus promoting more optimal long-term growth in *R. mucronata*.

These findings are consistent with Budiadi et al. (2022), who reported better growth of *A.marina* in muddy substrates, and with Yuniantika et al. (2023), who found that *R. mucronata* grows more effectively in mud enriched with organic matter. The adaptation of *R. apiculata* to the front-zone also aligns with studies by Rosalina (2021); Labuga et al. (2023), which note the dominance of this species in coastal areas with sand-influenced sediment.

In conclusion, *R. apiculata* is more suitable for planting in sandy–mud sediments in the front-zone, while *R. mucronata* grows more optimally in muddy sediments in the mid-zone. These habitat preference differences are important considerations for mangrove rehabilitation programs to ensure higher planting success by selecting species that match sediment conditions and habitat zonation.

Survival Rate of *R. apiculata* and *R. mucronata* Based on Different Sediment Types

The survival rate of mangrove seedlings in this study reached 100%, indicating that the environmental conditions at the research site were highly supportive of early mangrove growth. The determination that all seedlings survived was based on their physical and physiological conditions, such as the presence of green leaves, stems that did not dry out, the emergence of new shoots, and the absence of stress symptoms or seedling mortality.

The study by Arifin et al. (2015) showed that *R. apiculata* seedlings had a 100% survival rate across all treatments, regardless of planting

distance. They explained that this high survival rate was influenced by suitable environmental conditions and the healthy physiological condition of the seedlings, which enabled them to adapt well throughout the study period. In addition, the study emphasized that muddy substrates are an appropriate medium for supporting the survival and growth of *Rhizophora* sp. seedlings.

The muddy substrate condition is an important factor supporting the growth and dominance of *R. apiculata* and *R.mucronata*, as these species generally grow optimally on muddy sediments influenced by tidal dynamics. Oktaria et al. (2025) explained that the dominance of *R. apiculata* and *R. mucronata* is closely related to the suitability of muddy substrate conditions, which support the adaptation, growth, and ecological roles of both species within mangrove ecosystems. In addition, muddy and sandy–mud substrates have a high capacity to retain water and organic matter, thereby providing a stable environment that supports mangrove survival.

According to Rahmadhani et al. (2021), soil or sediment type clearly influences the growth of Rhizophora species, with deep, soft, muddy sediments generally dominated by *R.mucronata*. Seedlings of *R. apiculata* were able to maintain their survival and grow in both sediment types throughout the 10-week observation period. This indicates that muddy and sandy–mud sediments provide suitable habitat conditions for the growth of this species. This is further supported by Fauzi et al. (2025), who reported that the most abundant mangrove species in the Marine Station Area of Universitas Riau was *R. apiculata*, with a total of 225 individuals recorded

4. CONCLUSION

Based on the study's results, it can be concluded that the growth of *R. apiculata* and *R. mucronata* differed significantly across the two sediment types. The t-test results confirmed that there was a significant difference in height and diameter growth between stations, with muddy substrates providing more optimal conditions for vegetative development. Accordingly, *R. mucronata* is more suitable for planting in mid-zone areas characterized by muddy sediments, whereas *R. apiculata* is better suited for the frontal zone with sandy–mud substrates, in line with their root characteristics and adaptive capabilities. Both species exhibited 100% survival during the 100-day observation period, indicating high adaptability to the environmental conditions at the study site.

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