Jurnal Silvikultur Tropika
Journal of Tropical Silviculture

Vol. 15 No.01, April 2024, Page 57-64
p-ISSN: 2086-8277
e-ISSN :2807-3282

RESPONSE OF *RHIZOPHORA APICULATA* SEEDLING GROWTH TO THE APPLICATION OF SEVERAL TYPES OF FERTILIZERS IN PULAU SEMBILAN, PANGKALAN SUSU DISTRICT, LANGKAT REGENCY

Respon Pertumbuhan Bibit Rhizophora apiculata Terhadap Penerapan Beberapa Jenis Pupuk di Pulau Sembilan Kecamatan Pangkalan Susu Kabupaten Langkat

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(Received 15 Januari 2024 / Accepted 19 Februari 2024)

ABSTRACT

Influence on the growth of *Rhizopora apiculata* seedlings given fertilizer Beauveria, Mycorrhiza, *Trichoderma* or not given fertilizer. Mangrove forests are the main ecosystem supporting life activities in coastal areas and play an important role in maintaining the balance of biological cycles in the environment. The purpose of this study was to determine the effect of Beauveria fertilizer, *Trichoderma* fertilizer, mycorrhizal fertilizer and not given fertilizer on the growth of *Rhizophora apiculata* seedlings. This study used a complete randomized design (RAL) consisting of 4 treatments with 10 repetitions. The treatment was carried out with P0 = control, P1 = Beauveria, P2 = *Trichoderma*, P3 = Mycorrhiza. From the data of observation of seedling height, seedling diameter, it can be concluded that the effect of fertilizer does not affect plant growth and can be declared insignificant.

Keywords: *Complete randomized design, Fertilizer, Growth assessment, Mangrove forests, Rhizophora apiculata*

ABSTRAK

Pengaruh terhadap pertumbuhan bibit Rhizopora apiculata yang diberi pupuk Beauveria, Mikoriza, Trichoderma maupun tidak diberi pupuk. Hutan bakau merupakan ekosistem utama penunjang aktivitas kehidupan di wilayah pesisir dan berperan penting dalam menjaga keseimbangan siklus biologis pada lingkungan. Tujuan penelitian ini adalah untuk mengetahui pengaruh pemberian pupuk beauveria, pupuk thrichoderma, pupuk mikoriza dan tidak diberikan pupuk terhadap pertumbuhan bibit Rhizophora apiculata. Penelitian ini menggunakan rancangan acak lengkap (RAL) yang terdiri dari 4 perlakuan dengan 10 kali pengulangan. Perlakuan dilakukan dengan P0 = kontrol, P1 = Beauveria, P2 = Trichoderma, P3 = Mikoriza. Dari data hasil pengamatan tinggi bibit, diameter bibit dapat disimpulkan bahwa pengaruh pemberian pupuk tidak mempengaruhi pertumbuhan tanaman dan dapat dinyatakan tidak signifikan.

Kata kunci: Desain acak lengkap, Hutan mangrove, Rhizophora apiculata, Penilaian pertumbuhan, Pupuk

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INTRODUCTION

The island nation of Indonesia has an extremely long coastline, which allows it to have vast mangrove forests. Indonesia's mangrove community is the largest in the world, with a total area of 3,364,076 hectares. The high level of biodiversity, such as in mangrove forests, is now considered an asset that is not only utilized for its ecological function but also its economic function (Mursalam 2021).

Mangrove forests are a primary ecosystem supporting life activities in coastal areas and play an important role in maintaining the balance of biological cycles in their environment. Additionally, mangrove forests have high economic value. Indonesia has a vast mangrove forest resource scattered along the coastlines of various provinces. This natural wealth potential needs to be managed and utilized optimally to support national development implementation and to improve the welfare of communities (Permata *et al.* 2021).

The mangrove forest ecosystem is one of the ecosystems with high productivity compared to other ecosystems due to its high composition of organic matter, making it an important ecological chain for the life of living creatures in the surrounding waters. The organic matter makes the mangrove forest a source of food and a habitat for various organisms such as fish, shrimp, and crabs. The production of fish and shrimp in marine waters is highly dependent on the leaf litter production from the mangrove forest (Mursalam 2021).

The current situation of the mangrove forest area is quite concerning. The area of mangrove forest is known to be declining due to changes in mangrove forests to industrial areas, residential areas, uncontrolled illegal logging, and mangrove forest areas being converted into new land for irresponsible aquaculture. Another function of mangroves is as a primary producer that can support and maintain the stability of marine and terrestrial ecosystems. On the coast of Sumatra, the rate of damage to the mangrove forest ecosystem is increasing rapidly. This has an impact on the social, economic, and environmental conditions of people living around the mangrove forest areas (Hamzah *et al.* 2020).

Pulau Sembilan is a coastal forest and mangrove ecosystem located administratively in Pangkalan Susu District, Langkat Regency, North Sumatra. The island has an area of 24.00 km^2 or 8.84% of the total area of Pangkalan Susu District. The island can be reached from Medan by bus in about 3 hours, followed by water transportation such as a boat for approximately 30 minutes (Onrizal 2008)

Rhizophora apiculata is one of the mangrove species that helps prevent erosion in coastal areas. *Rhizophora apiculata* can grow up to 30 m tall with a stem diameter of up to 50 cm. Its leaves are elliptical and tapering, dark green in color with a light green center and reddish underneath. The flowers are bisexual and the fruit is round, elongated or pear-shaped and brown in color. The propagule length is 18-38 cm and width are 1-2 cm (Wetlands International Indonesia Programe 2017).

Mangrove growth is strongly influenced by the salinity factor. Some mangrove species have good adaptations to their environment so that these species will dominate. Although mangroves have good adaptation, the use of fresh water as a growth medium for *R. apiculata* is certainly very interesting to study (Poedjierahajoe *et al.*2017).

Based on the background described above, the author is very interested in conducting research with the title "Response of *Rhizophora apiculata* Seedling Growth to the Application of Several Types of Fertilizers in Pulau Sembilan, Pangkalan Susu District, Langkat Regency ". The aim of this study is to determine the effect of Beauveria fertilizer, *Trichoderma* fertilizer, mycorrhiza fertilizer, and no fertilizer application on the growth of *Rhizophora apiculata* seedlings.

MATERIAL AND METHODS

Time and place

The research was conducted in the Mangrove Forest of Pulau Sembilan Village, Langkat Regency, North Sumatra, and in the Forest Cultivation Laboratory, Faculty of Forestry, University of Sumatera Utara. The research was carried out from September 2022 to December 2022.

Tools and materials

The tools that will be used in this study are analytical scales, rulers, calipers, writing tools, an oven, a camera, a laptop, and a calculator. Meanwhile, the materials that will be used in this study are *Rhizophora apiculata* seedlings, Beauveria fertilizer, *Trichoderma* fertilizer, mycorrhizal fertilizer, name labels, plastic ties, sample envelopes, and millimetre paper.

Research procedure

This study will use a Completely Randomized Design (CRD) factorial consisting of 4 treatments and 10 replications, resulting in 40 experimental units as follows:

P0 = Without fertilizer application
P1 = Mycorrhiza fertilizer 5g/plant
P2 = Beauveria fertilizer 5g/plant
P3 = *Trichoderma* fertilizer 5g/plant

The linear model of Completely Randomized Design (CRD) is as follows:

$$Yij = \mu + Ʋi + \Sigma ij$$

Where:

Yij = Response or observation value in treatment i and replication j
μ = Population means
Ʋi = Effect of treatment i
Σij = Experimental error of treatment i and replication j

Land preparation. The initial activity that must be carried out before conducting the research is to determine the area to be used by sterilizing or cleaning the research location from weeds, trash, or other dirt that can disturb the plants, so that the research site becomes clean.

Planting. The next step is the planting process. Prior to planting, prepare the *Rhizophora apiculata* seedlings with the same number of leaves, namely 2 pieces, and are 4 months old. The seedlings used are healthy ones, where there are no signs of insect bites on the leaves and are uniform in their growth. The planting activity is done manually by placing the *Rhizophora apiculata* seedlings in each planting hole. The selected seedlings are then planted with a planting distance of 0.5 m x 0.5 m.

Plot preparation. After the planting process, the next step is to create plots with a size of 2 m x 5 m, consisting of 4 treatment levels and 10 replications. The purpose of creating these plots is to facilitate the process of fertilization and data collection.

Fertilizer application. The fertilizers used in this study are mycorrhizal fertilizer at a rate of 5g/plant, Beauveria fertilizer 5g/plant, and *Trichoderma* fertilizer 5g/plant. Fertilization is only done once during the 3 months of observation. The fertilizer is applied during low tide in the afternoon to facilitate digging the soil and then inserting the fertilizer by digging 4 holes around the plant and evenly distributing the provided fertilizer before burying it back with the soil.

Pest and disease control. Every plant is susceptible to the risk of pest and disease attacks; therefore, it is necessary to control these attacks. Control of caterpillar pests is done manually by directly removing the pests from the *Rhizophora apiculata* seedlings that are attacked.

Harvesting. The harvesting process is carried out on *Rhizophora apiculata* seedlings after the 6th observation and is manually pulled out.

Observation and data collection. In this research activity, observations were conducted every two weeks for 3 months. Data collection was carried out 6 times by observing several parameters, namely:

1. Plant height (cm)

   Measurement of plant height was done by measuring the height of the plant from the base of the stem, 3 cm above the soil surface, which was marked as a measuring point, up to the highest point of growth using a meter every two weeks.
2. Plant diameter (mm)

   Measurement of plant diameter was done using a caliper. The diameter was measured at a height of 3 cm above the soil surface every two weeks.
3. Number of leaves (pieces)

   Measurement of the number of leaves was done only on plants that had fully formed and visible leaves. The measurement was conducted every two weeks.
4. Fresh weight of the plant (g)

   Measurement of fresh weight was done by weighing the entire plant, which had been separated into leaves, stem, and roots, using an analytical balance at the time of harvest before being placed in an oven at a temperature of 75°C for 48 hours until it reached a constant state, and was expressed in grams (g) per plant.
5. Dry weight of the plant (g)

   Measurement of dry weight was done by weighing the entire plant using an analytical balance after being removed from the oven.
6. Leaf area (cm^2)

   Measurement of leaf area was done using the millimetre block paper method. The leaf was placed on the paper, and its outline was traced. The number of squares within the area of the leaf was counted to determine the surface area of the leaf. If a square was fully occupied, it was counted as 1; if it was not fully occupied, it was counted as 1/2, and then multiplied by the number of squares occupied. The data collected during the research was primary data. Primary data was taken directly from the field, in the form of measurements conducted on *Rhizophora apiculata* seedlings.
7. Temperature (ºC)

   Measurement of temperature was done by observing the temperature in the field every two weeks.
8. Rainfall

   Measurement of rainfall can be done using a tool called an ombrometer.
9. Humidity

   Measurement of humidity was done by observing the temperature in the field every two weeks.
10. Salinity

    Measurement of salinity can be done using a tool called a hand refractometer.

RESULTS AND DISCUSSION

Seedling height (cm)

The results of the analysis of variance on the height of the seedlings showed that each treatment had no significant effect on the growth that occurred in the increase of *Rhizophora apiculata* seedling height because the Sig value was 0.086 at a significance level of 0.05 with Sig > 0.05.

Table 1 shows that the treatment of P2 (*Trichoderma* fertilizer 5 g/plant) resulted in the highest growth value compared to other fertilizers, with a height of 511.56 and an average of 51.16 cm, while P0 (control) produced the lowest growth value with a height of 452.39 and an average of 45.24. This is due to the availability of nutrients for plants, which are sufficiently available, and the balance of nature or adequate environmental conditions for *Trichoderma* sp to multiply. The microorganisms contained in the fertilizer, especially

Table 1. Parameter observation of *R. apiculata* seedlings for 12 weeks

Parameter	Treatment			
	P0	P1	P2	P3
Seedling height	45,24	46,40	51,16	50,21
Seedling diameter	1,05	1,08	1,12	1,04
Number of leaves	4,39 c	5,99 a	5,06 bc	5,40 ab

Information: The numbers followed by the same letter are not significantly different based on the DMRT test at a significance level of 5%, P0 (Control); P1 (Beauveria fertilizer 5 g/plant); P2 (Trichoderma fertilizer 5 g/plant); P3 (Mycorrhizal fertilizer 5 g/plant)

Trichoderma sp, have the ability to compete with soil-borne pathogens, especially to obtain nitrogen and carbon. Lehar (2012) stated that *Trichoderma* sp's biogenic genes can decompose lignin, cellulose, and chitin from organic matter into nutrient elements that plants can absorb. The response of *Trichoderma* sp at the beginning of plant growth requires time to multiply in organic fertilizer, while also playing a role as a decomposer of organic matter in providing nutrients for plants. The more microorganisms present in organic fertilizer can help metabolism in the soil so that the soil is more capable of providing the necessary nutrients for plants.

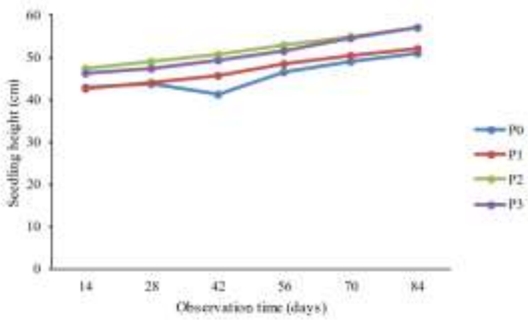
Seedling diameter (cm)

The result of the analysis of variance on the diameter of seedlings showed that each treatment did not have a significant effect on the growth of the diameter of *R. apiculata* seedlings because the Sig value is 0.734 at a significance level of 0.05, with Sig > 0.05.Table 1 shows that treatment P2 (*Trichoderma* fertilizer 5 g/plant) had the highest growth, with a value of 11.16 and an average value of 1.12, while treatment P0 (Control) had the lowest value of seedling growth with a value of 10.46 and an average value of 1.05. This can happen because the seedlings that did not receive treatment had inefficient growth, as they were more quickly attacked by pests and diseases, while the use of *Trichoderma* spp. fertilizer, one of the fungi that can be utilized to reduce plant diseases, can benefit the plant. According to Intan *et al.* (2013), *Trichoderma* spp. in addition to protecting against disease, can also support plant growth such as increasing root length, fruit weight, and seed dry weight, while endomycorrhiza can increase plant height, number of leaves, fresh root weight, dry root weight, and total plant dry weight. Nutrients are essential for improving the growth of sengon plants, but excessive and continuous use of inorganic fertilizers can decrease soil fertility and damage the environment, so the use of inorganic fertilizers must be reduced. One effort to reduce the use of inorganic fertilizers is by using biological and organic fertilizers (Putu MK *et al.* 2020).

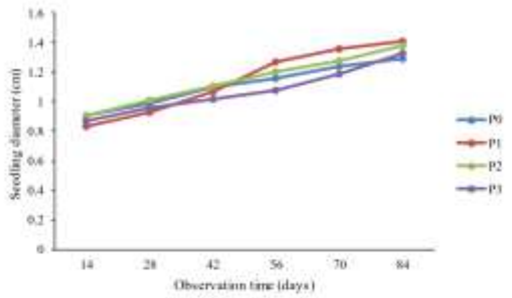
Number of leaves

The result of the analysis of variance on the number of leaves showed that each treatment had a significant effect on the increase in the number of leaves on *R. apiculata* seedlings, with a Sig value of 0.001 at a significance level of 0.05 (Sig < 0.05). Therefore, a further Duncan test was conducted with a 5% error rate, showing that P0 (control/not given fertilizer) was not significantly different from P2 (Beauveria fertilizer 5g/plant), but was significantly different from P3 (*Trichoderma* fertilizer 5g/plant) and P1 (mycorrhiza fertilizer 5g/plant).The highest increase in the number of leaves was observed in treatment P2 (*Trichoderma* fertilizer 5 g/plant) with a value of 59.86 and an average value of 5.99, while in treatment P0 (control), the lowest number of leaves was observed with a value of 43.86 and an average value of 4.39. The increase in the number of leaves is a growth factor for *R. apiculata* seedlings and the shedding of leaves is an adaptation process to the environment. The number of mangrove leaves is an important factor that affects the fertility of mangrove trees because leaves are the site of photosynthesis that produces nutrients for mangrove trees. This is in line with the statement by Hastuti *et al.* (2016) that a large number of leaves can affect the ecological factors of mangrove trees, particularly salinity. The growth rate is directly proportional to the diameter of the xylem vessels. The increase in the number of leaves is also influenced by the diameter of the seedling itself, as the wider the diameter of the seedling, the wider the diameter of the xylem vessels. Other factors that play a role are the substrate, the plant substrate in the embankment area has a harder structure, as it is more frequently disturbed in the form of trampling. This affects the supply of oxygen, water, and other organic factors present in the substrate (Hastuti *et al.* 2016).

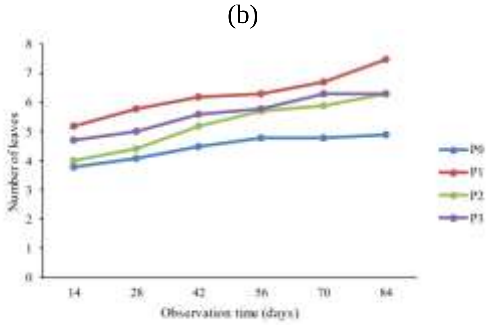
Based on the observations that have been made, the growth rate of *R. apiculata* seedlings with 6 observations over 12 weeks showed an increasing trend in the parameters of seedling height, seedling diameter, and number of leaves (Figure 1). The increase in seedling



(a)



(b)



(c)

Figure 1. Growth rate of *R. apiculata* seedlings based on parameters (a) seedling height, (b) seedling diameter, and (c) number of leaves

height and diameter of *R. apiculata* seedlings that were given treatment P2 (*Trichoderma* fertilizer 5 g/plant) produced the highest value compared to the other treatments with an average increase in seedling height of 1.97 cm/12 weeks and an increase in average diameter seedlings of 0.09 cm/12 weeks. Whereas the number of leaves parameter which had the highest number was in treatment P1 (5g/plant mycorrhiza fertilizer) with an average increase in the number of leaves by 2 strands/12 weeks.

Plant wet weight

The results of the wet weight variance of seedlings stem and leave, and roots of *R. apiculata* seedlings showed that each treatment had no significant effect because the seeds, stems and leaves, and roots each had a value of Sig=0.159, Sig=0.324, and Sig= 0.177 whose value is greater than 0.05. The average fresh weight yields of seedlings, stems and leaves, and roots of *R. apiculata* seedlings are presented in Table 2. It can be observed that in treatment P3 (Mycorrhizal Fertilizer 5 g/plant), the highest fresh weight of seedlings was obtained, which was 54.538 g, while the lowest fresh weight of seedlings was obtained in treatment P1 (Beauveria Fertilizer 5 g/plant), which was 37.652 g. The highest fresh weight of stems and leaves in *R. apiculata* seedlings was found in treatment P3 (Mycorrhizal Fertilizer 5 g/plant), which was 35.382 g, while the lowest was obtained in treatment P1 (Beauveria Fertilizer 5 g/plant), which was 25.28 g. The highest fresh weight of *R. apiculata* seedling roots was found in treatment P2 (*Trichoderma* Fertilizer 5 g/plant), which was 19.589 g, while the lowest was obtained in treatment P1 (Beauveria Fertilizer 5 g/plant), which was 12.372 g.

The application of mycorrhiza fertilizer on *R. apiculata* seedlings resulted in higher fresh weight of seedlings, stems, and leaves compared to the application of Beauveria and *Trichoderma* fertilizers. Mycorrhiza is utilized as a biological agent in mangroves, aiding in their growth process. The role of mycorrhiza in mangrove growth lies in its ability to absorb phosphorus nutrients.

Table 2. Wet and dry weight of *R. apiculata* seedlings for 12 weeks

Parameter	Treatment			
	P0	P1	P2	P3
Total wet weight of seeds	45,454	37,652	52,207	54,538
Wet weight of stems and leaves	28,855	25,28	32,618	35,382
Root wet weight	16,599	12,372	19,589	19,156
Total dry weight of seeds	17,984	16,041	21,452	22,712
Dry weight of stems and leaves	10,89	10,648	13,629	13,704
Root dry weight	7,094	5,393	7,823	9,008
Shoot-root ratio	1,535	1,974	1,742	1,521

Additionally, mycorrhiza roots can absorb both bound and unavailable nutrient forms for plants. The enhanced nutrient uptake facilitated by mycorrhiza fungi leads to increased vegetative growth and improved generative growth in plants (Dharmawan *et al.* 2017). Mycorrhiza significantly enhances the total uptake of N, P, and K. Hence, mycorrhiza plays a crucial role in mangrove ecosystems (Yusuf 2021).

Plant dry weight

The analysis of variance for the dry weight of *R. apiculata* seedlings stems and leaves, and seedling roots showed that none of the treatment applications had a significant effect. This is supported by the fact that the seedlings, stems and leaves, and roots all had Sig values of 0.228, 0.368, and 0.171, respectively, which are greater than 0.05. The average dry weights of the seedlings stems and leaves, and roots of *R. apiculata* are presented in Table 2. It can be observed that the P3 treatment (Mycorrhizal Fertilizer 5 g/plant) resulted in the highest dry weight of the seedlings, measuring 22.712 g, while the lowest dry weight of the seedlings was obtained from the P1 treatment (Beauveria Fertilizer 5 g/plant), measuring 16.041 g.

The highest dry weight of the stems and leaves of *R. apiculata* seedlings was obtained from the P3 treatment (Mycorrhizal Fertilizer 5 g/plant), measuring 13.704 g, while the lowest was obtained from the P1 treatment (Beauveria Fertilizer 5 g/plant), measuring 10.648 g. The highest dry weight of the roots of *R. apiculata* seedlings was also observed in the P3 treatment, measuring 9.008 g, while the lowest was obtained from the P1 treatment, measuring 5.393 g. The application of mycorrhizal fertilizer to *R. apiculata* seedlings resulted in the highest dry weight. Similarly, in terms of wet weight, the application of mycorrhizal fertilizer also yielded the highest values. Higher wet weight in *R. apiculata* seedlings correlates with higher dry weight.

The application of mycorrhiza fertilizer has a significant impact on plant growth parameters, including stem diameter, plant height, shoot dry weight, and root dry weight (Nadeak *et al.* 2015). The application of mycorrhiza provides plants with the necessary elements for their growth processes. Mycorrhiza supplies nutrients such as N, P, K, and other micronutrients. Additionally, mycorrhizae can improve soil aggregation, facilitating better mass flow. This capability of mycorrhiza contributes to increased plant dry weight (Wicaksono *et al.* 2014).

Based on Table 2, the shoot-root ratio of *R. apiculata* seedlings in each treatment is also known. The highest shoot-root ratio is obtained in treatment P1 (5 g Beauveria fertilizer per plant) and P2 (5 g Mycorrhiza fertilizer per plant), which is 1.974, while the lowest ratio is obtained in treatment P3 (5 g Mycorrhiza fertilizer per plant), which is 1.521. A low shoot-root ratio indicates a higher proportion of roots compared to the shoot. This means that with good root growth, nutrient absorption will be more optimal, resulting in sufficient nutrition (Rahmawati 2013). The shoot-root ratio is obtained by comparing the dry weight of the shoot to the dry weight of the root. A high shoot-root ratio indicates a faster distribution of photosynthetic products to the shoot compared to the root, resulting in a lower proportion of roots (Rusmana 2017).

Leaf area (cm)

The results of the leaf area of *R. apiculata* seedlings showed that in treatment P0 (control), the total leaf area was 20.635 cm with an average of 4.217 cm, in P1 (Beauveria fertilizer 5 g/plant) the total leaf area was 20.757 cm with an average of 3.460 cm, in P2 (*Trichoderma* fertilizer 5 g/plant) the total leaf area was 22.251 cm with an average of 3.709 cm, and in P3 (Mycorrhiza fertilizer 5 g/plant) the total leaf area was 36.958 cm with an average of 2.640 cm. Leaf area is a widely used measure to describe the canopy structure of plants. The wider the leaf, the more chlorophyll it contains, which means a higher rate of photosynthesis (Saragih 2019). The leaf area is an important factor for the canopy structure of plants that control the exchange of energy and gas between the land ecosystem, and chloroplasts are the main organ that supports photosynthesis and transpiration in plants, and the leaf area index is a canopy vegetation that controls the exchange of energy and gas between the land ecosystem (Justinianus 2021).

Temperature

Air temperature is a measure of the degree of heat or cold of an object that can be measured using a measuring instrument such as a thermometer with a certain scale, and it is one of the factors that make up several climate elements. Temperature plays an important role in physiological processes such as photosynthesis and respiration. Good mangrove growth requires a minimum average temperature of more than 20°C, and seasonal temperature differences do not exceed 50°C (Adnan 2013). The rate of plant growth and development is greatly influenced by temperature, and each plant has a minimum and optimum temperature range for optimal growth. Extreme temperature events that occur during the summer season will have the most significant impact on crop production. The temperature in the research location is 30-32°C (Table 3) and falls within the range of temperatures that are good for plant growth, in accordance with the statement by Aini (2016) stating that the optimal temperature range for mangrove photosynthesis is 28-32°C, while temperatures above 38°C hinder the photosynthesis process in leaves.

Rainfall

Rainfall is the amount of water that falls on the surface of the earth during a certain period of time measured in a unit of height (mm) above the ground where evaporation, runoff, and infiltration do not occur. According to Wirisoedarmo (2011), the measured rainfall is rainfall that does not experience evaporation, infiltration, and runoff measured on the surface of the ground. Weather conditions with high rainfall and temperature can cause unfavourable conditions in the surrounding environment where there will be intense weathering of parent materials to form highly weathered soils. This high weathering tends to decrease soil quality. Land quality is usually influenced by temperature/moisture conditions, water availability, oxygen availability, rooting media, nutrient retention, nutrient availability, and erosion hazards. The average rainfall on Pulau Sembilan is 2078 mm per year, as shown in Table 4.

Humidity

Air humidity is a climate element that needs to be known. Various plants can grow in high and low humidity conditions with high and low temperatures, such as mangrove plants that are cultivated according to high humidity conditions. Air humidity affects the growth of plants, animals, and humans. High and low humidity conditions greatly affect crop production. Each plant has its own characteristics in terms of resilience to different humidity conditions. According to Hambran *et al.* (2014), the mangrove ecosystem is a plant community that lives in tidal areas with its own characteristic environmental conditions, which are ideal for mangrove growth. The substrate moisture at the research location is 90%.

Salinity

Mangrove vegetation is a type of plant that is resistant to soil conditions containing salt (salt-tolerant plants) that are able to maintain growth under osmotic stress conditions. Salinity at the research site on Pulau Sembilan is 20 ppt where seedlings can grow and experience good growth. According to Kartikasari *et al.* (2015), salinity conditions of 1-22 ppt in mangrove vegetation areas can grow well in these locations, especially with the dominant species of Rhizophora. Low salinity values are influenced by the rainy season, and rainwater intake is greater than seawater. The reduction in plant height is also caused by limited water supply and organic matter in tissues due to salinity influence. Salinity changes due to prolonged high waves are a limiting factor that affects the horizontal distribution of species. According to Septiarusli (2010), mangroves can grow well in saline water with a range of 2‰ - 38‰. Salinity can determine the development of mangrove forests, resulting in the influence of salinity, which can

Table 3. Temperature and humidity of research locations

Observation time (days)	Temperature (°C)	Humidity (%)
0	32°/28°	86
14	31°/29°	72
28	33°/31°	79
42	34°/30°	70
56	32°/29°	67
70	30°/27°	62

Table 4. Rainfall Research Location

Rainfall (mm)												
January	February	March	April	May	June	July	August	September	October	November	December	Annual
188	58	81	146	155	175	164	124	258	348	225	239	2078

divide mangrove forests into several zonation's as an effect on seedling growth.

Conclusion

The application of Beauveria, *Trichoderma*, mycorrhiza fertilizers or no fertilizer at all did not have a significant effect on the height and diameter of *Rhizophora apiculata* seedlings. However, it had a significant effect on the number of leaves. The application of *Trichoderma* fertilizer provided the highest results for the height and diameter of *Rhizophora apiculata* seedlings.

ACKNOWLEDGEMENT

To the Research Institute of the University of North Sumatra in accordance with the TALENTA Research Implementation contract at the University of North Sumatra Number: 257/UN5.2.3.1. R/PPM/KPTALENTA/ 2022, August 9, 2022.

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