Application of different various species of fungi to increase growth of *Avicennia marina* 300 m from the coastline in Belawan and Pulau Sembilan

Yunasfi*1*, D E Sitorus1 and B Utomo1

1 Faculty of Forestry, Universitas Sumatera Utara, Medan, Indonesia

*E-mail: yunasfijamhar@yahoo.co.id

Abstract. Mangrove is a typical ecosystem that lives in areas with high salinity and tidal effects. Mangrove has the ability to absorb organic and non-organic matter produced by decomposing microorganisms derived from decomposition of leaf litter or other decomposed material. This research can provide information on the species of fungi are able to increase growth of *A. marina*. This research was conducted from August to October 2017 using a completely randomized design (CRD) which consists of 4 treatments with ten replicates and with two locations. Fungal species used were *Aspergillus niger*, *Aspergillus* sp. 2, *Aspergillus* sp. 1 and the control as a comparison. Fungi give effect to the height increase of *A. marina* plants with an average height of 24.64 cm on Pulau Sembilan and 27 cm in Belawan. The total dry weight of plants has an average value of 11.77 g on Pulau Sembilan and 11.97 g in Belawan. The average diameter obtained from fungi treatment on Pulau Sembilan is 0.48 cm and in Belawan is 0.56 cm. The average leaf width that occurred on Pulau Sembilan was 4.82 cm and 5.03 cm in Belawan. *Aspergillus niger* is the most influential fungus on the growth of *A. marina* seedlings.

1. Introduction
Mangrove forest is a unique and typical forest ecosystem, found in tidal areas in coastal areas, beaches and small islands, which is a potential natural resource. Mangrove forests have economic value and are ecologically important, despite its vulnerability to any physical and anthropogenic activities if not properly managed or conserved. It is estimated that the current condition of mangrove forests are being pressured by the prolonged economical crisis which lead to the overexploitation or conversion of natural mangrove sites [1].

Local community who live around the mangrove forest depend their living on the mangrove resources. The existence of mangrove forests support and increase the population of fish which occupy the roots of mangrove species. Mangrove forest also provides food ingredients for human life, especially in the needs of fish, shrimp, shellfish, crabs, and other types of aquatic organisms. However, if the utilization of mangrove forests is not carried out sustainably, it will then reduce the ecological service of the mangrove forests even when there exists some tools at the coastline to mitigate the floods and erosions [2,3].
The rehabilitation of mangrove forest may be initiated by inoculating plant growth promoting microorganisms to certain mangrove species to increase their growth performance. This study then investigates and compares the growth performance provided by some marine fungal species namely *Aspergillus niger*, *Aspergillus* sp.2, and *Aspergillus* sp.1 which can improve the growth of *Avicennia marina* in the field.

2. Methodology

2.1. Study sites

The field study was conducted at *Avicennia marina* planting sites at the coastal area of Kampung Nelayan, Belawan, North Sumatra as one of the heavy metals-contaminated sites and at Pulau Sembilan as the control site. Laboratory investigation was conducted at laboratory of forest product and technology, Universitas Sumatera Utara, Medan, Indonesia.

2.2. Culture maintenance

Three strains of *Aspergillus* namely *Aspergillus* sp.1, *Aspergillus* sp.2, and *Aspergillus niger* maintained in potato dextrose agar (PDA) agar slants were regrown into by inoculating each agar plug fresh PDA medium. Cultures were incubated at ambient temperature for 1 wk to reach its maximum mycelial growth.

2.3. Experimental design

This study used a completely randomized design with 4 treatments (1 control, 3 fungal treatments) and 10 replications. Seedlings of *A. marina* are healthy without any symptom of disease onset, 15-days old, and have 4 leaves. Planting holes of 10×10×15 cm were made as many as 40 holes for each plot. Seedlings of *A. marina* were then inserted into the holes. Spore suspension of each fungal strain were prepared by suspending an agar plug (1 cm$^2$) into a 10-mL test tube containing 2.5 mL of sterile distilled water. The solutions were homogenized using a vortex then the suspensions were poured evenly to the root environment of seedlings. The growth performance was observed from each treatment at 15, 30, 45, 60, 75, and 90 d after planting.

2.4. Data analysis

The parameters of *A. marina* seedlings such as stem diameter, stem height, number of leaves, widest leaf width, and plant dry weight were analyzed using a statistical program. Stems and roots were dried in an oven and separated according to each treatment. The dry weight of each part was measured using following formula.

\[ Y_{ij} = \mu + \alpha_i + \sum_{ij} \]

Where

- $Y_{ij}$ = Observation on the fungal treatment
- $\mu$ = Average growth value
- $\alpha_i$ = Factor of the $i$-function; $i = 1, 2, ..., t$ and repeat $j = 1, 2, ..., r$
- $i$ = Fungal strains, *Aspergillus* sp.1, *Aspergillus* sp.2, *Aspergillus niger*
- $\sum_{ij}$ = Effect of the error on the provision of the $i$ function and the-$j$ test

3. Results and Discussion

The growth performance of *A. marina* seedlings after 12 wk showed differences in height, diameter, widest leaf area, number of leaves, and total dry weight. Observation data of *A. marina* seedlings is presented in Table 1 and Table 2.
3.1. Seedling height
From the measurements carried out for 12 weeks, the highest data on seedling *A. marina* were found in *A. marina* seedlings at Pulau Sembilan location with *Aspergillus niger* treatment with an average height of 24.62 cm while the lowest in seedlings was treated with fungi *Aspergillus* sp. 2 with a height of 24.38 cm and the difference with the height of the seedlings without treatment with a height of 24.39 cm. The graphs obtained for high increase every week can be seen in Figure 1.

| Table 1. Observation Results of Seedling *A. marina* 12 Weeks After planting on Pulau Sembilan |
|---------------------------------------------------------------|
| **Observation Parameters**                         | **Treatment** |
| **Control** | **Aspergillus niger** | **Aspergillus. sp. 2** | **Aspergillus. sp. 1** |
| --- | --- | --- | --- |
| Average height (cm) | 24.39 | 24.62 | 24.38 | 24.57 |
| Average diameter* (cm) | 0.48 | 0.45 | 0.43 | 0.41 |
| Widest leaf width (cm) | 4.58 | 4.72 | 4.82 | 4.34 |
| Total dry weight* (g) | 10.6 | 11.7 | 10.62 | 9.6 |
| total leaf (sheet) | 9 | 9 | 10 | 9 |

Description: * Effectively based on analysis of variance at the level of 5%

| Table 2. Observation Results of Seedling *A. marina* 12 Weeks After Planting in Belawan |
|---------------------------------------------------------------|
| **Observation Parameters**                         | **Treatment** |
| **Control** | **Aspergillus niger** | **Aspergillus. sp. 2** | **Aspergillus. sp. 1** |
| --- | --- | --- | --- |
| Average height (cm) | 27.2 | 27 | 27.25 | 25.52 |
| Average diameter* (cm) | 0.55 | 0.55 | 0.56 | 0.54 |
| Widest leaf width (cm) | 4.61 | 4.91 | 5.03 | 4.67 |
| Total dry weight* (g) | 10.99 | 11.97 | 10.04 | 10.73 |
| total leaf (sheet) | 9 | 10 | 10 | 10 |

Description: * Effectively based on analysis of variance at the level of 5%

Figure 1. Graph of High Addition of Seeds *A. marina* on Pulau Sembilan

The high increase of *A. marina* seedlings at Belawan location was obtained by *A. marina* seedlings with higher height increase found in *A. marina* seedlings given fungal treatment of *Aspergillus* sp. 2 with an average height of 27.25 cm, while for the lowest height increase was obtained in *A. marina* seedlings treated with *Aspergillus* sp.1 with an average height increase of 25.52 cm. The graph obtained from the height increase of *A. marina* seeds can be seen in Figure 2.
Based on the results of observations of the height of plants carried out on Pulau Sembilan, the height of *A. marina* which was given fungi treatment were planted with *Aspergillus niger* fungi treatment with a plant height of 24.62 cm. This is because the level of nutrients needed by plants increases with the role of decomposition of organic matter carried out by these fungi.

The decomposition of organic matter carried out by the fungus is derived from the results of the organic matter remodeling process carried out by *Aspergillus niger* fungi. [4] State that *Aspergillus niger* is one of the fungi belonging to the type of fungus that acts as a remover of organic material in the form of N nutrients that are broken down into the soil. The function of the nutrient element N is used by plants to stimulate vegetative growth which is the addition of plant height.

For the results of observations carried out in Belawan, *A. marina* seeds which had the highest height were *A. marina* seedlings which were treated with fungi *Aspergillus* sp. 2 with a height of 27.25 cm. Based on high observations carried out in Belawan the application of fungi did not give a significant effect on the height increase of *A. marina* plants. This can be caused by environmental conditions of planting seeds close to community settlements.

In the process of plant growth, it is in desperate need of nutrient intake to grow and develop. One of the things that can be done besides providing fertilizer is by utilizing the types of microorganisms that can play a role in providing the types of nutrients needed by plants through the decomposition process. This is under the statement [5] states that fungi play a direct role in maintaining the fertility of soil ecosystems with their role in decomposing organic matter.

At the Belawan location, the highest growth rate was found in *A. marina* seedlings which were treated with *Aspergillus niger* fungi with 7.74 cm / 12 weeks. *Aspergillus* spp fungi produced from litter decomposition, based on [6] research, have a high ability to dissolve P so that plants can absorb phosphate ions in the form of $\text{H}_2\text{PO}_4^-$. Elements of phosphorus are needed by plants in the process of stimulating plant growth.

### 3.2. Seedling diameter

The provision of fungi at the location on Pulau Sembilan gives a significant effect on the diameter of *A. marina* seeds. The highest diameter measurements were found in *A. marina* seedlings which were not given a treatment of 0.48 cm. While the smallest diameter is found in the seedlings treated with fungi *Aspergillus* sp. 1 with a diameter of 0.41 cm. The graph that can be obtained can be seen in Figure 3.

![Graph of High Addition of Seeds A. marina Seeds in Belawan](image-url)
The diameter measurements of *A. marina* seedlings were carried out at the Belawan site with the highest diameter average with a value of 0.56 cm in *A. marina* seedlings which were given *Aspergillus niger* fungi treatment. Whereas for the lowest diameter results obtained in *A. marina* seedlings with diameter of 0.54 cm in seedlings given fungal treatment of *Aspergillus* sp. 1. The diameter growth of *A. marina* seedlings in Belawan location can be seen in Figure 4.

![Graph Growth of Seed Diameter *A. marina* on Pulau Sembilan](image1)

**Figure 3.** Graph Growth of Seed Diameter *A. marina* on Pulau Sembilan

Based on the results of Pulau Sembilan observation conducted in the field for 12 weeks, the highest average diameter growth occurred in the seedlings without the treatment of giving fungi with an average diameter of 0.48 cm, while the *A. marina* seeds which had the lowest diameter were found in the seedlings. *A. marina* has given a fungal treatment of *Aspergillus* sp. 1 with an average diameter of 0.41 cm. However, by analyzing the variance analysis of 5%, it was proven that there was a significant effect of fungi administration on the growth of *A. marina* seed diameter. And after doing it advanced BNT test with a level of 5% of the diameter of *A. marina* seeds, giving fungi *Aspergillus* sp. 2 and *Aspergillus niger* give real influence but do not have different significant values.

According to [7] fungi can produce α-amylase and glucoamylase enzymes which act to break down starch into simple glucose or sugar. In this case, with the role of the fungus, the seedlings can carry out photosynthesis with the availability of a form of glucose absorbed by the seedlings from around the growth site. glucose is absorbed by the seeds from around the place of growth.

Based on the growth rate table observed in Pulau Sembilan, the seeds with *Aspergillus niger* fungi increased the diameter growth rate of *A. marina* seeds by 0.162 cm / 12 weeks. This is certainly attributed to *Aspergillus niger* fungus which can dissolve the type of nutrient N which comes from the decomposition of organic material that will be used by plants to meet the needs of its nutrients. This is due to the nature of the saprophytic fungi. The growth rate observed in Belawan seedling of *A. marina* treated with fungi *Aspergillus* sp. 1 can increase the increase in diameter of *A. marina* seedlings by 0.094 cm/12 weeks.

![Graph Growth of *A. Marina* Diameter in Belawan](image2)

**Figure 4.** Graph Growth of *A. Marina* Diameter in Belawan

Based on the growth rate table observed in Pulau Sembilan, the seeds with *Aspergillus niger* fungi increased the diameter growth rate of *A. marina* seeds by 0.162 cm / 12 weeks. This is certainly attributed to *Aspergillus niger* fungus which can dissolve the type of nutrient N which comes from the decomposition of organic material that will be used by plants to meet the needs of its nutrients. This is due to the nature of the saprophytic fungi. The growth rate observed in Belawan seedling of *A. marina* treated with fungi *Aspergillus* sp. 1 can increase the increase in diameter of *A. marina* seedlings by 0.094 cm/12 weeks.
Diameter increase is the addition of cleavage results in the process of vegetative growth in plants. The *A. marina* seedlings were given a higher diameter treatment compared to the control. *Aspergillus* sp. can change P on land that is not available to be available. This is consistent with [8] statement that *A. marina* growth can also be increased by utilizing fungi, one of which is *Aspergillus* sp. which can dissolve P ions on the soil and reduce Al's toxins.

### 3.3. Leaf width

At the location of Pulau Sembilan, the highest leaf width was found in *A. marina* seedlings which were given fungi *Aspergillus* sp. 2 of 4.82 cm. Whereas the lowest leaf width was found in *A. marina* seedlings which were treated with fungi *Aspergillus* sp. 1 with a leaf width of 4.34 cm. The widest leaf width measurement results of *A. marina* can be seen in Figure 5.

![Figure 5](image)

**Figure 5.** Graph of leaf width of *A. marina* on Pulau Sembilan

The width increase of *A. marina* seedling leaves at Belawan location is the same as the previous location which is measured using calipers. The highest leaf width is found in *A. marina* seedlings with *Aspergillus* sp. 2 is 5.03 cm, while the lowest leaf width is in the control with a leaf width of 4.61 cm. The difference in leaf width for each treatment can be seen in Figure 6.

![Figure 6](image)

**Figure 6.** Graph of leaf width of *A. marina* in Belawan
Based on observations that have been carried out on Pulau Sembilan, the highest leaf width is in plants with the fungal treatment of *Aspergillus* sp. 2 with a leaf width of 4.82 cm, while for the lowest leaf width is the plant with the fungal treatment of *Aspergillus* sp. 1 with a leaf width of 4.34 cm. In the analysis of variance analysis of 5%, it was known that the administration of fungi to increase the width of the leaves of *A. marina* seeds did not give a real effect.

The highest growth rate of *A. marina* seedlings occurred in the seedlings given fungi *Aspergillus niger* type with a value of 1.449 cm / 12 weeks. Leaf development in plants is influenced by the type of nutrient N. With the provision of fungal treatment, it can increase the availability of nutrients absorbed by plants through the reform process carried out by fungal activity. That observation was performed at Belawan location, the largest leaf width was found in *A. marina* seedlings with the fungal treatment of *Aspergillus* sp. 2 with a leaf width of 5.03 cm, while the lowest leaf width of *A. marina* seedlings was not given fungi treatment with a leaf width of 4.61 cm. In the analysis of variance analysis, it was found that the width of the leaves was not affected by the presence of fungi, or the fungi did not give a significant effect on the width of *A. marina* leaves. Furthermore, the analysis of variance analysis was carried out with a level of 5%, and it was obtained that the administration of fungi did not give a significant effect on the width of the leaves of *A. marina* seedlings.

The highest growth rate in the Belawan area occurred in *A. marina* seedlings which were given the fungal treatment of *Aspergillus* sp. 2 with a value of 1.013 cm / 12 weeks. So that the wider the leaf surface used by plants in photosynthesis the more forms of energy and food intake that will be obtained by the plant. Based on the observations made by *A. marina* seedlings which were given fungus treatment, the growth of the leaf width was higher compared to the seedlings which were not treated. In this case, the fungus can provide the form of nutrients that have been described through the nutrient roasting process. In this case, the growth meant for vegetative growth of *A. marina* seedlings. With the N nutrient elements, *A. marina* seeds have chlorophyll leaf constituents and the presence of leaf green matter used in photosynthesis.

### 3.4. Number of leaves

The highest number of leaves obtained from observations on Pulau Sembilan were 10 leaves on *A. marina* seedlings which were treated with fungi *Aspergillus* sp. 1, while the *A. marina* seed which was given another treatment showed the same number of leaves, namely 9 sheets. Based on the variance test, the number of leaves was influenced by the presence of fungi to improve the ability of *A. marina* seeds to obtain the growth of new leaves. Measurements made on the number of leaves can be seen in Figure 7.

![Figure 7. Total leaves of *A. marina* in Pulau Sembilan](image-url)
The increase in the number of leaves in *A. marina* seedlings located in Belawan shows an increase in the number of leaves with the provision of various types of fungi. The highest number of leaves was found in *A. marina* seedlings treated with *Aspergillus niger*, *Aspergillus* sp. 2, *Aspergillus* sp. 1 has the same number of leaves with 10 strands, while the lowest is in *A. marina* seeds which are not treated. Adding the number of leaves can be seen in Figure 8.

![Figure 8. Total leaves of *A. marina* in Belawan](image)

In observations carried out on Pulau Sembilan, the highest number of leaves was found in *A. marina* seedlings with the fungal treatment of *Aspergillus* sp. 2 with several 10 leaves while for *A. marina* seedlings with other treatments had the same number of leaves, namely 9 leaves. Furthermore, the analysis of variance of the fingerprints was carried out with a level of 5%, and it was found that the administration of fungi did not have a significant effect on the increase in the number of *A. marina* leaves.

Based on the calculation of the rate of growth carried out, *A. marina* seedlings were given the fungal treatment of *Aspergillus* sp. 2 can increase the number of leaves by 6 sheets / 12 weeks. Nutrients that play a role in leaf growth are N nutrients. By giving fungi treatment, it can increase the nutrient N needed by plants. This is consistent with the previous statement [5] regarding the ability of *Aspergillus* sp. in remodeling the type of nutrients, especially N so that it is available in the soil.

Observation conducted in the Belawan area obtained the number of leaves of *A. marina* seeds with several 10 leaves, and *A. marina* seedlings which were treated with fungi *Aspergillus niger*, *Aspergillus* sp. 2, and *Aspergillus* sp. 1. And the lowest is *A. marina* seedlings which were not treated with 9 leaves. In the analysis of variance analysis with a level of 5%, it was found that the administration of fungi had a significant effect on the increase in the number of *A. marina* seedlings. Then performed further BNT test with a level of 5% and obtained that the fungi *Aspergillus* sp. 1 has a significant difference with *Aspergillus niger* and *Aspergillus* sp. 2. However, for the treatment of *Aspergillus niger* fungi, it has no significant effect on the fungal treatment of *Aspergillus* sp. 2.

Belawan area is considered as an area that contains a lot of heavy metals obtained from factory activities or forms of regional processing carried out by the community. The provision of fungi can provide N nutrients needed by plants to form leaves. This is consistent with the statement of [4] that *Aspergillus niger* fungi are a microorganism that acts as a remover of organic material which is then broken down into minerals that are returned to the soil.

The highest leaf growth rate occurred in *A. marina* seedlings which were given *Aspergillus niger* fungus treatment which was able to increase the number of leaves by 5 strands / 12 weeks. Leaves are a form of vegetative growth that is influenced by nutrient elements N obtained by seeds from the air or in the soil. Fungi of *Aspergillus niger* type are fungi that are capable of producing N nutrient elements in the soil. Nitrogen is a very important element in plant growth.
3.5. Total dry weight
The highest total dry weight at the location on Pulau Sembilan was found in the seedlings with *Aspergillus niger* fungi treatment at 11.77 g and the lowest was in the seeds with the fungal treatment of *Aspergillus* sp. 1 is 9.6 g. The difference in total dry weight in each treatment can be seen in Figure 9. Comparison of the total dry weight of *A. marina* seedlings at Belawan the highest total dry weight was found in *A. marina* seedlings which were treated with *Aspergillus niger* fungi weighing 11.97 g while the lowest occurred in seedlings. *marina* treated with fungi *Aspergillus* sp. 2 with a weight of 10.04 g. The difference in total dry weight can be seen in Figure 10. The overall difference in observations of *A.marina* seedlings at the location in Pulau Sembilan occurs in each treatment of various types of fungi that can be seen in Figure 11A. The results of observations made in Belawan as a whole are of various effects of giving the type of fungi that occurs in each seed of *A. marina* which can be seen in Figure 11B.

![Figure 9. Dry weight of A. marina in Pulau Sembilan](image)

![Figure 10. Dry weight of A. marina in Belawan](image)
Figure 11. Growth condition of A. marina at (A) Pulau Sembilan, (B) Belawan of (a) control, (b) Aspergillus niger, (c) Aspergillus sp.2, (d) Aspergillus sp.1 treatment.

Based on observations that have been made, it can be seen the value of the growth rate of A. marina seeds with 6 observations for 12 weeks. Value The growth rate is only calculated on the form of vegetative growth of plants that are irreversible or can’t be returned as before, namely the height, diameter, width of leaves, and the number of leaves. Data regarding the growth rate can be seen in Table 3 and Table 4.

Table 3. Growth Rate of seedlings. marina for 12 Weeks on Pulau Sembilan

| Observation Parameters                  | Control | Aspergillus niger | Aspergillus. sp. 2 | Aspergillus. sp. 1 |
|----------------------------------------|---------|-------------------|-------------------|-------------------|
| Average height (cm/12 week)            | 7.53    | 7.74              | 7.53              | 7.45              |
| Average diameter* (cm/12 week)         | 0.092   | 0.088             | 0.092             | 0.094             |
| Widest leaf width (cm/12 week)         | 0.789   | 0.749             | 1.013             | 0.862             |
| Total dry weight* (g/12 week)          | 4       | 5                 | 4                 | 3                 |

Table 4. Growth Rate of seedlings. marina for 12 Weeks in Belawan

| Observation Parameters                  | Perlakuan | Control | Aspergillus niger | Aspergillus. sp. 2 | Aspergillus. sp. 1 |
|----------------------------------------|-----------|---------|-------------------|-------------------|-------------------|
| Average height (cm/12 week)            | 11.69     | 8.12    | 8.02              | 8.38              |
| Average diameter* (cm/12 week)         | 0.123     | 0.162   | 0.146             | 0.138             |
| Widest leaf width (cm/12 week)         | 1.169     | 1.449   | 1.226             | 1.161             |
| Total dry weight* (g/12 week)          | 5         | 5       | 6                 | 5                 |

Observations made for the total dry weight of plants at the highest Pulau Sembilan location were A. marina seedlings with Aspergillus niger fungi with a total dry weight of 11.77 g and the lowest in A. marina seeds with fungi treatment of Aspergillus sp. 1 with a dry weight of 9.6g. Furthermore, analysis of variance analysis was carried out with a level of 5% and the administration of fungi gave a significant effect on the total dry weight of A. marina plants. Then performed further BNT test with a level of 5% of the total dry weight of A. marina seeds and obtained that the fungal treatment of Aspergillus sp. 1 does not have a significant effect with seeds that are not treated. Fungal treatment of Aspergillus sp. 2 has a significant difference with Aspergillus niger fungi treatment.
The highest dry weight was observed in Belawan in *A. marina* seedlings which were treated with *Aspergillus niger* fungi with a total dry weight of 11.97 g and the lowest total dry weight was seedlings with the fungal treatment of *Aspergillus* sp. 1 is 10.04 g. The total dry weight obtained at the location of the spot is due to the presence of environmental pressure due to heavy metals in that location.

The analysis of variance with a 5% level was carried out and it was found that the administration of fungi had a significant effect on the dry weight of plants. Then performed the BNT Advanced test with a level of 5% of the total dry weight of *A. marina* plants. Through these further tests, it is known that the fungal treatment of *Aspergillus* sp. 1 and *Aspergillus* sp. 2 did not have significant significance, but was significantly different from *Aspergillus niger* fungi. Total dry weight shows that the plant's ability to absorb organic material used for plant growth processes. Plant Growth and development require nutrients and good water absorption through plant roots. In this case with the provision of fungi treatment efforts to improve the ability of *A. marina* plants to absorb nutrients better than plants that are not given treatment.

The role of fungi in providing nutrients needed by plants in the form of nutrients N, P, and K are broken down into the soil so that it stimulates vegetative growth of plants, such as roots. Based on the results of observations and measurements made on *A. marina* seedlings which were given fungus treatment were able to increase the growth of *A. marina* seedlings planted in the Sembilan Island area which was considered as an area not exposed to heavy metals compared to *A. marina* seeds in Belawan area. The type of fungi that most influences the growth of *A. marina* seedlings is *Aspergillus niger* fungi. So that for the best planting of *A. marina* seeds, the seeds that are planted far from the reach of community activities and protected from areas that are not contaminated by heavy metals.

4. Conclusion
The application of fungi gives effect and increases the growth of *A. marina* seedlings which is shown by increasing the growth of height, diameter, or width of *A. marina* seedlings. The ability of each fungus is different, with *Aspergillus niger* fungus treatment can increase the growth of plant height and total dry weight of plants, while for fungi *Aspergillus* sp. 2 can increase plant diameter and leaf width, the last is fungus *Aspergillus* sp. 1 does not have a significant effect when compared to controls. *Aspergillus niger* fungus application is better used in increasing the growth of *A. marina* seedlings in the location of Sembilan Island compared to Belawan and is the type of fungi that most influences the growth of *A. marina* seedlings.

Acknowledgements
The authors would like to thank Universitas Sumatera Utara for funding this study through TALENTA scheme of research implementation with contract number: 5338/UNS.I.R/PPM/2017 on May 22, 2017.

References
[1] Novianty RS, Sastrawibawa, and Prihadi DJ 2011 Identification of damage and efforts to rehabilitate mangrove ecosystems in the North Coast of Subang Regency. *Journal of Aquatics*. 2.
[2] Bismark M, Subiandono E, and Heriyanto NM 2008 Diversity and potential species and carbon content of mangrove forests in the Siberut Subelen River, West Sumatra. *Journal of Forest Research and Nature Conservation* 5 297-306.
[3] Mulyadi EO, Hendriyanto, and Nurfitriani. 2010. Conservation of Mangrove forests as Ecotourism. Environmental Engineering, 1 51-57.
[4] Saraswati R and Sumarno S 2015 Utilization of soil fertility microbes as a component of agricultural technology. *Food Crops Science* 3
[5] Ilyas M 2007 Isolation and Identification of Mold Microflora in Plant Leaf Litter Samples in the Gunung Lawu Region, Surakarta, Central Java. *Biodiversity*, 8 105-110.
[6] Sihite ED 2014 Types of fungi and the effect of their application on the growth of Avicennia marina seedlings [Thesis]. Field. Forest Cultivation Department. Faculty of Agriculture. The University of Northern Sumatra. Field.

[7] Widyastuti SM, Sumardi, and Harjono 2005 Forest Pathology. Gadjah Mada University Press. Yogyakarta.

[8] Sihombing IK, Yunasfi, and Utomo B 2015 Effect of Aspergillus Flavus, Aspergillus Terreus, and Trichoderma Harzianum on the growth of Avicennia officinalis seedlings. Peronema Forestry Science Journal 4 178-185.