Growth rate study of mangrove using hydroponic installation system with mol nutrient at Central Processing Plant (CPP) Senoro Banggai Regency - Central Sulawesi

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Abstract. Mangrove plantation is a biodiversity-environmental programs of JOB Tomori that had started since 2012. A total of 117,000 mangrove seedlings were successfully planted. Some innovations programs, more effective and beneficial, had been also carried out. One of it was 5 months experiment by growing mangrove in Hydroponic installation and polybag. Two parameters measured during the study 1) Seedling length and 2) number of seedling leaves. Results showed that additional length of seedling has vary in range with the highest length found on seedling that placed on the natural habitat area which reached 4.4 cm per week, while the highest number of leaves also found in the natural habitat area which reached until 10 leaves per month. Preliminary conclusion has been taken that mangrove that planting in hydroponic installation system using MOL (Local Microorganism – Natural Fertilizer) as nutrient can increase and speed up of seedling growth rate by 30 - 35% with a 100 % of survival rate.

1. Introduction
One of the natural resources that Indonesia has is mangrove forests. Based on Minister of Marine and Fisheries data, the area of mangroves in Indonesia reaches up to 3.49 million hectares with a composition of 2.17 million hectares of forest areas and 1.32 million hectares of non-forest areas. It is about 18% were already damaged [1]. The mangrove forest area in Banggai Regency has also experienced a decline in quality, from 7,387 hectares of its area, 5,652 hectares of which were severely damaged [2]. Various efforts have been made in order to overcome the rate of destruction of mangrove forests. As was done by the KKP, which in 2021 prepared a regular budget for 2021 and scheduled the rehabilitation of mangrove forests covering an area of 391.17 hectares.

JOB Pertamina Medco E&P Tomori Sulawesi is a sub holding of PHE (Pertamina Hulu Energi) which is engaged in oil and gas exploration and operates in Luwuk Banggai Regency, Central Sulawesi Province. In order to apply the responsibility of environmental protection, JOB Tomori always implements innovation programs aimed at preserving the surrounding environment and to participate in contributing to the restoration and rehabilitation of mangrove forests [3]. The JOB Tomori environmental program that is being carried out is mangrove planting which has been started since 2012. A total of 117,000 mangrove seedlings were planted in collaboration with related stakeholders such as the local government, NGOs, and the local community [4]. The purpose of this activity is to conserve mangrove forests around the operational area of JOB Tomori so that its ecological function can be optimized, increase community motivation and awareness to maintain and use mangrove forests.
responsibly, and increase knowledge and application of local wisdom about mangrove forest conservation and preservation. In 2021, JOB Tomori launched an Innovation program for mangrove nurseries using a hydroponic installation system with the addition of MOL nutrient produced by JOB Tomori.

2. Methodology
The research object was mangroves that planted from November 2020 to April 2021. The research location took place at the Nursery house of CPP Senoro, Banggai Regency. A total of 63 mangrove seedlings of the Rhizophora mucronata with a variation of age 0-5 months with details of 40 mangrove seedlings (0 months old) planted on hydroponic installation racks with the addition of MOL nutrient, 16 seedlings (3-5 months old) that have been removed from the hydroponic installation to the natural land, 3 seedlings (3 - 5 months old) and 4 seedlings (0 months old) mangroves as a comparison planted in polybags using a substrate from natural mangrove habitat (Figure 1). Those 56 mangrove seedlings were monitored periodically for growth by measuring the height/length of the seedlings and the number of leaves. The data from the measurement then analyzed to determine the growth rate and the survival rate. We also observed the growth of mangrove seedlings starting from age 0 months in hydroponic installations and in polybags to compare their growth rate. As additional information, the hydroponic installation has added with MOL (Local Micro Organisms – natural fertilizer made from leftover food waste) nutrition as a source of nutrition for mangrove seedlings as an innovation program for this research.

3. Results and discussion
It needs to be clarified beforehand that although this research was carried out starting from November 2021, the displayed data is obtained from the measurement of 5-6 weeks data because mangrove seedlings planted in hydroponic installations must be moved to the natural land after that period to avoid the damage to the dense of roots so that having difficulties in pulling it out form the hydroponic installation planting hole.

From the results of the study, the measurement of seedlings length data showed that the best growth rate was obtained in mangrove seedlings planted in natural land namely 0.2-4.4 cm per week, followed by Seedlings planted on hydroponic media with 0.1-3.6 cm per week, and the lowest growth rate on polybag media with value of 0 - 2 cm per week. For the results, we compare it with the same research on the same species was conducted by Dissanayake et al., (2014) who obtained the growth rate of Rhizophora mucronata seedlings of 0.5-5.3 cm per week. It seems that the results are slightly the same range [5].

Meanwhile, for the calculation of the number of leaves, the highest number of leaves were obtained on mangrove Seedlings that planted on the natural land, namely 10 leaves per month, followed by Seedlings planted on hydroponic media which were 4 leaves per month and in polybags as many as 2 leaves per month.

For growth rate of mangrove seedlings starting at age 0 months, the fastest growth was recorded in Seedlings that planted on hydroponic media with 2 leaves appeared in 2nd week, while for the same number of leaves, Seedlings that planted on polybag media appeared at 6th week. Compared to the research conducted by Rusdiana et al (2019) showed that revealed leaves of R. Mucronata the fastest leaf appearance happened in 7th week [6]. Base on that finding, it can be concluded that the growth rate with the use of hydroponic installation media with the addition of MOL nutrients can increase the growth rate of mangrove seedlings up to 30-35% faster (three times faster).

For mangrove Seedlings age of 0 months that have not grown leaves at week 6, we checked the roots and compare them with Seedlings that planted in hydroponic installations to check whether there is root growth or not. We found it interesting that although the leaves had not yet grown, the roots has already grown well. Another thing is that the form of root growth is different, where the shape of root growth on polybag media shows a lot of tiny branching root while in hydroponic installations the roots tend to be plain and longer in shape (Figure 2).
Table 1. Comparison of length and number of leaves from difference planting media

| Parameter                  | Hidroponik Installation | Polybag     | Natural Land |
|----------------------------|--------------------------|-------------|--------------|
| Length                     | 0.1-3.6 cm/week          | 0-2 cm/week | 0.2-4.4 cm/week |
| Number of leaves           | 2-4 leaves/month         | 0-2 leaves/month | 2-10 leaves/month |
| Appearance of leaves       | 2 leaves at 2nd week     | 2 leaves at 6th week |             |
| from age 0                 |                          |             |              |

In general, the results of this study were quite successful with the discovery of a 100% survival rate, where all 63 seedlings were planted successfully, especially those that had been transferred from hydroponic installation facilities to the natural mangrove land with indicators of increasing of number of leaves and root growth, if compared to what Basyuni et (2018) done which found that the highest of survival rate of R. Mucronata was about 96% [7]. The best growth rate and additional of leaves were found on the seedlings that planted in Natural land. It may happened because supply of sunlight and nutrition from the river were abundance. It is in line with the research from Lopez-Hoffman et al. (2007) said that the light intensity is the key factors which affect mangrove growth significantly [8].

![Figure 1](image1.png)

**Figure 1.** Mangrove seedlings on natural land (a), hydroponic installation (b), and polybag (c)

![Figure 2](image2.png)

**Figure 2.** Root growth model on polybag media (a) and hydroponic installation (b)
| No Tag | Location       | Length (cm) |
|--------|----------------|-------------|
|        | I   | II  | III | IV  | V   |
| 1      | 30  | 31.5| 31.6| 32  | 33  |
| 2      | 36.6| 39.5| 40.5| 41  | 42.2|
| 3      | 26.5| 29.8| 30.8| 31.5| 32.4|
| 4      | 33.5| 34.6| 35.6| 36.2| 37.5|
| 5      | 33  | 34.3| 35.8| 37.2| 38.6|
| 6      | 60.3| 61.2| 62.5| 64  | 67  |
| 7      | 58.3| 59.4| 59.8| 60.5| 61.7|
| 8      | 69.3| 70.3| 70.4| 71  | 71.4|
| 9      | 63.4| 63.5| 63.5| 64  | 65.5|
| 10     | 72.3| 74.3| 75.4| 76  | 76.2|
| 11     | 52.3| 52.4| 53  | 54.7| 55  |
| 12     | 61.3| 61.4| 61.7| 62.5| 63  |
| 13     | 32  | 32.5| 33  | 34.6| 35.3|
| 14     | 45.5| 45.5| 46  | 46  | 48  |
| 15     | 42.5| 42.5| 42.7| 43  | 45  |
| 16     | 46  | 47.5| 48  | 50  | 52.3|
| 17     | 54  | 55.4| 56.5| 57.2| 58.5|
| 18     | 24  | 24.3| 24.3| 24.4| 25  |
| 19     | 13  | 14  | 14.1| 15.2| 16  |
| 20     | 17.6| 18  | 18.1| 19.1| 20.3|
| 21     | 57.8| 58.3| 58.4| 60.4| 61.7|
| 22     | 59  | 60.3| 60.5| 60.9| 61  |
| 23     | 52  | 53.3| 55.3| 56.4| 57  |
| 24     | 60.2| 61.4| 61.5| 62.5| 63.8|
| 25     | 52  | 52.3| 52.4| 53.4| 54  |
| 26     | 48.7| 49.3| 49.3| 49.4| 52  |
| 27     | 54  | 55.3| 56.3| 57.4| 61  |
| 28     | 70  | 71.4| 71.5| 72.4| 75  |
| 29     | 59  | 60.4| 61.4| 62.4| 64  |
| 30     | 59.2| 60.3| 60.4| 61.4| 63.5|
| 31     | 60  | 60.3| 60.4| 61.4| 62.7|
|   | 32   | 33   | 34   | 35   | 36   | 37   | 38   | 39   | 40   |
|---|------|------|------|------|------|------|------|------|------|
|   | 51.4 | 20   | 53.3 | 80.3 | 40   | 60   | 49.5 | 54   | 13.4 |
|   | 52.3 | 20.5 | 53.4 | 80.3 | 40.3 | 60.2 | 50.3 | 54.4 | 14   |
|   | 53.3 | 20.6 | 53.4 | 81.3 | 43.4 | 61.3 | 52.3 | 55.4 | 15.1 |
|   | 54   | 21.1 | 53.4 | 81.4 | 45.4 | 63.3 | 54.4 | 55.5 | 17.3 |
|   | 56   | 22.6 | 24   | 82.5 | 47.4 | 65.2 | 57.8 | 57   | 18.6 |

|   | 41   | 42   | 43   | 44   | 45   | 46   | 47   | 48   | 49   |
|---|------|------|------|------|------|------|------|------|------|
| Masing 1 | 51   | 52   | 53   | 54   | 55   | 56   | 45   | 46   | 47   |
|   | 39   | 39.5 | 35   | 30   | 28.5 | 19   | 32   | 33.5 | 36   |
|   | 42   | 40   | 36.1 | 30.5 | 28.7 | 20.5 | 32.5 | 33.8 | 31.5 |
|   | 43   | 37.5 | 36.4 | 31.1 | 39.3 | 22   | 34   | 35.3 | 37   |
|   | 44   | 39.3 | 37.5 | 31   | 33.7 | 24.5 | 36.8 | 39.7 | 39.6 |
|   | 45   | 45   | 42   | 39.1 | 43.5 | 24.5 | 40.5 | 39.6 | 46   |

|   | 50   | 51   | 52   | 53   | 54   | 55   | 56   | 45   | 46   |
|---|------|------|------|------|------|------|------|------|------|
| Masing 2 | 51   | 52   | 53   | 54   | 55   | 56   | 45   | 46   | 47   |
|   | 36   | 33.4 | 38.5 | 30   | 45.3 | 54   | 54.8 | 32.5 | 42.3 |
|   | 37.2 | 34.1 | 41   | 31.5 | 45.7 | 55.7 | 57.1 | 32.7 | 42.4 |
|   | 39.1 | 37.5 | 43.2 | 33.3 | 48   | 58   | 58.7 | 35.6 | 42.4 |
|   | 40.5 | 40.2 | 45.7 | 53   | 61   | 60.2 | 36.2 | 43   | 43   |
|   | 43.5 | 40.5 | 48   | 50   | 61   | 60.2 | 36.5 | 44   | 44   |

|   | 50   | 51   | 52   | 53   | 54   | 55   | 56   | 45   | 46   |
|---|------|------|------|------|------|------|------|------|------|
| Masing 3 | 51   | 52   | 53   | 54   | 55   | 56   | 45   | 46   | 47   |
|   | 33.4 | 34.1 | 38.5 | 30   | 45.3 | 54   | 54.8 | 32.5 | 42.3 |
| Polybag | 37   | 37.2 | 41   | 31.5 | 45.7 | 55.7 | 57.1 | 32.7 | 42.4 |
|   | 37.5 | 37.5 | 43.2 | 33.3 | 48   | 58   | 58.7 | 35.6 | 42.4 |
|   | 40.5 | 40.8 | 48   | 53   | 61   | 60.2 | 36.2 | 43   | 44   |
|   | 44.1 | 41.7 | 50   | 55   | 62   | 63   | 36.5 | 44   | 44   |
|   | 42.2 | 42.2 | 53   | 55   | 46   | 46.4 | 46.5 | 44   | 44   |
Table 3. Result of Mangrove’s leaves counting

| No Tag | Location          | I  | II | III | IV | V  | VI |
|--------|-------------------|----|----|-----|----|----|----|
| 1      | 0                 | 0  | 0  | 0   | 2  | 2  | 2  |
| 2      | 0                 | 0  | 0  | 2   | 2  | 2  | 4  |
| 3      | 0                 | 2  | 2  | 2   | 2  | 2  | 2  |
| 4      | 0                 | 0  | 0  | 4   | 4  | 4  | 4  |
| 5      | 0                 | 0  | 0  | 2   | 2  | 2  | 2  |
| 6      | 0                 | 0  | 0  | 0   | 2  | 2  | 2  |
| 7      | 0                 | 0  | 0  | 2   | 2  | 4  | 4  |
| 8      | 0                 | 0  | 0  | 0   | 2  | 2  | 2  |
| 9      | 0                 | 0  | 0  | 2   | 2  | 4  | 4  |
| 10     | 0                 | 0  | 0  | 2   | 2  | 2  | 4  |
| 11     | 0                 | 0  | 0  | 2   | 2  | 2  | 4  |
| 12     | 0                 | 2  | 2  | 2   | 2  | 2  | 2  |
| 13     | 0                 | 2  | 2  | 2   | 2  | 2  | 4  |
| 14     | 0                 | 0  | 0  | 2   | 2  | 2  | 4  |
| 15     | 0                 | 0  | 0  | 0   | 2  | 2  | 2  |
| 16     | Nursery house     | 0  | 0  | 0   | 2  | 2  | 2  |
| 17     | 0                 | 0  | 0  | 2   | 2  | 2  | 4  |
| 18     | 0                 | 0  | 2  | 2   | 2  | 2  | 2  |
| 19     | 0                 | 2  | 2  | 2   | 2  | 2  | 4  |
| 20     | 0                 | 0  | 0  | 2   | 2  | 2  | 4  |
| 21     | 0                 | 0  | 0  | 2   | 2  | 4  | 4  |
| 22     | 0                 | 0  | 0  | 2   | 2  | 4  | 4  |
| 23     | 0                 | 2  | 2  | 2   | 2  | 2  | 2  |
| 24     | 0                 | 2  | 2  | 2   | 2  | 2  | 2  |
| 25     | 0                 | 0  | 0  | 2   | 2  | 4  | 4  |
| 26     | 0                 | 0  | 0  | 0   | 2  | 2  | 2  |
| 27     | 0                 | 0  | 0  | 2   | 2  | 4  | 4  |
| 28     | 0                 | 0  | 2  | 2   | 2  | 2  | 2  |
| 29     | 0                 | 0  | 0  | 2   | 2  | 4  | 4  |
| 30     | 0                 | 0  | 2  | 2   | 2  | 2  | 2  |
| 31     | 0                 | 0  | 0  | 0   | 2  | 2  | 2  |
|   |   |   |   |   |   |
|---|---|---|---|---|---|
| 32| 0 | 0 | 0 | 2 | 2 |
| 33| 0 | 2 | 2 | 2 | 2 |
| 34| 0 | 0 | 2 | 2 | 4 |
| 35| 0 | 0 | 2 | 2 | 4 |
| 36| 0 | 0 | 2 | 2 | 4 |
| 37| 0 | 2 | 2 | 2 | 2 |
| 38| 0 | 0 | 2 | 2 | 4 |
| 39| 0 | 2 | 2 | 2 | 2 |
| 40| 0 | 0 | 2 | 2 | 4 |
| 41| 4 | 4 | 8 | 8 | 8 |
| 42| 2 | 4 | 8 | 8 | 10 |
| 43| 4 | 6 | 6 | 8 | 8 |
| 44| 8 | 8 | 8 | 10 | 10 |
| 45| 6 | 8 | 8 | 10 | 1 | 10 |
| 46| 4 | 4 | 4 | 6 | 6 |
| 47| 2 | 2 | 4 | 8 | 8 |
| 48| 6 | 6 | 8 | 10 | 10 |
| 49| 4 | 6 | 8 | 8 | 10 |
| 50| 2 | 4 | 4 | 6 | 8 |
| 51| 8 | 8 | 8 | 9 | 9 |
| 52| 8 | 8 | 8 | 10 | 10 |
| 53| 8 | 8 | 8 | 10 | 10 |
| 54| 4 | 4 | 4 | 6 | 6 |
| 55| 2 | 4 | 4 | 4 | 4 |
| 56| 2 | 2 | 4 | 4 | 4 |
| 57| 2 | 2 | 4 | 4 | 4 |
| 58| 4 | 6 | 6 | 6 | 6 |
| 59| 4 | 4 | 4 | 4 | 4 |
| 60| 0 | 0 | 0 | 0 | 0 |
| 61| 0 | 0 | 0 | 0 | 0 |
| 62| 0 | 0 | 0 | 0 | 0 |
| 63| 0 | 0 | 0 | 0 | 0 |
4. Conclusions and recommendations

Research related to mangrove growth rates has been done before, but using the hydroponic method with the addition of MOL nutrients is quite new. The results obtained are also quite encouraging where the use of this hydroponic installation system can increase the growth rate of mangrove seedlings by 30-35% (three times faster) with a high value of survival rate that reaching 100%. With the discovery of this method, the planting period of mangrove with hydroponic installation is shorter, which if using the conventional method with polybags it takes about 3–4 months before it can be moved to natural habitat. Besides saving time, indirectly this method can also save the cost of purchasing the seedlings on polybags, which so far quite expensive on the mangrove rehabilitation program.

The recommendations that can be conveyed in this study are the need to carry out further research with the addition of environmental and chemical parameters as well as an analysis of the nutritional content of the impact of using MOL. The resistance of seedlings when transferred to different locations need for further study to find the best of acclimatization. It is also necessary to collaborate for research development with higher education institutions and other related agencies to obtain more optimal research results.

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