Rehabilitation of Sandy Coastal Areas in Kuala Rompin, Pahang

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Abstract. After the tsunami incident that hit the coasts of several countries including Southeast Asia in December 2004, effort to protect the coastal areas has been immense. In Malaysia, a committee focusing in rehabilitation of coastal areas were established since 2007 to conduct planting and rehabilitation of coastal areas nationwide. In this study, mixed mangrove associate species namely Callophyllum inophyllum (Bintangor laut), Casuarina equisetifolia (Rhu), Syzygium grandis (Kelat jambu laut), Terminalia catappa (Ketapang) and Fagraea fragrans (Tembusu padang) were planted in Kuala Rompin, Pahang. The main objective of this study is to rehabilitate coastal areas with mixed species. Combinations of organic soil and slow-release fertilizer were applied as part of the improved fertilising technique. The initial growth and survival of saplings planted were measured and data obtained were analyzed using SPSS program. After 17 months of planting, the survival was 66% and Casuarina equisetifolia recorded the highest mean annual increment for height and diameter.

1. Introduction
Forest areas along the coast has a significant role in the well-being of coastal residents in terms of socioeconomic, environmental and safety. In addition, it is a buffer zone that protects the coastline from natural disaster such as storms and hurricanes as well as prevents and reduces beach erosion rates. After the tsunami incident that hit the coasts of several countries including Southeast Asia in December 2004, effort to protect the coastal areas and has been immense. In Malaysia, a committee focusing in rehabilitation of coastal areas were established since 2007 to conduct planting and rehabilitating coastal areas nationwide. For example, FRIM has previously conducted experimental planting in mudflats area in Sg. Hj. Dorani. Compared to mudflats, experimental planting in sandy coastal area are less studied. Both mudflats and sandy coastal area are as important in terms of protecting the coastline from natural disaster.

Coastal areas along the east coast of Peninsular Malaysia is highly threatened with soil erosion due to the location facing the open South China Sea. Restoration of these areas through planting should also take into account the selection of plant species. Therefore, the aim of this study is to plant mixed species in order to rehabilitate sandy coastal area in Kuala Rompin.

2. Method

2.1 Study area
Kuala Rompin is located at the east coast region of Peninsular Malaysia. Pantai Rantau Panjang is one of the beaches located on the sandy coastal area in Kuala Rompin. Compared to other beaches such as Pantai Hiburan in Kuala Rompin, Pantai Rantau Panjang beach is less famous for recreational activities due to lack of facilities in the area thus making it suitable for planting activities.

Previously, only a few Casuarina equisetifolia were found in the study site. After further investigation, it was found that pre-existing Casuarina equisetifolia were unhealthy. Therefore, the trees
were removed in order to ensure space for experimental planting. In this study, three experimental block were established in a two hectare area along the Pantai Rantau Panjang. Each block were 140 m length x 40 m wide. The perimeter of each block were also gated to avoid attack from animal such as goat that normally roamed the area for food.

2.2 Tree planting
In this study, five different mangrove associate species namely *Callophyllum inophyllum* (Bintangor laut), *Casuarina equisetifolia* (Rhu), *Syzygium grandis* (Kelat jambu laut), *Terminalia catappa* (Ketapang) and *Fagraea fragrans* (Tembusu padang) were planted in the study area. These species were selected based on suggestion from Jabatan Perhutanan Semenanjung Malaysia meanwhile saplings for each species were provided by Jabatan Perhutanan Negeri Pahang.

The number of saplings for each species were divided equally into each block. A total of 1,080 saplings were planted, 360 saplings for each block and 72 saplings for each species in each block. Sequence of the tree planted in every planting line were chose randomly to ensure the random complete block design. Planting activities was carried out from November until December 2016. Planting distance was 3 m × 4 m (3 m spacing between plant and 4 m between row).

2.3 Fertilizer application
Four different media combination consist of rock phosphate, slow release fertilizer (SRF) and organic soil were used as part of the fertilising method (Table 1). Media were only applied once during planting process.

| Media Combination                      |
|---------------------------------------|
| 1 Rock Phosphate 200 g (Control)      |
| 2 Organic soil 1000 g + Slow Release Fertilizer 200 g |
| 3 Organic soil 1000 g + Rock Phosphate 200 g     |
| 4 Organic soil 2000 g + Slow Release fertilizer 100 g |

2.4 Tree growth and survival
Data collection includes survival, height and diameter of the saplings planted. The first data collection were done right after planting to obtain the initial measurements. Growth and survival of tree saplings were observed throughout 17 months of planting. The survival rate for each species were calculated using the formula below:

\[
\text{Survival rate} = \frac{\text{number of survived saplings for each species}}{\text{total number of saplings planted}}
\]

Meanwhile, the height and diameter of each saplings were recorded and the mean increment and mean annual increment (MAI) were calculated using the formula below:

\[
\text{Mean increment} = \frac{\text{final measurement} - \text{first measurement}}{\text{total number of saplings for each species}}
\]

\[
\text{MAI} = \frac{\text{mean increment}}{12 \text{ months}}
\]

The MAI is important in order to monitor the growth of the saplings as well as determining which species has the best growth under the given conditions.
2.5 Soil properties
Soil sampling were conducted prior to planting in order to obtained the general information of the soil properties at the study site. Samples were collected from 3 different point in each block and from two different depth which is between 0-10 cm and 10 - 30 cm. These samples were sent to FRIM Soil Management Division for further analysis.

3. Result and discussion
After 17 months of planting, the survival rate of the planted saplings was 66%. *Calophyllum inophyllum* contributed to the highest survival rate (79%) while *Fagraea fragrans* exhibited the lowest survival rate of 51%. *Casuarina equisetifolia* showed the highest MAI in both height and diameter. While the lowest MAI in height and diameter were seen in *Terminalia catappa* and *Syzygium grandis*, respectively (Table 2).

| Species                        | Mean Height (cm) | MAI | Mean Diameter (mm) | MAI | Survival |
|--------------------------------|------------------|-----|--------------------|-----|----------|
| *Calophyllum inophyllum*       | 68.64            | 10.23| 10.65              | 1.90| 79%      |
| *Casuarina equisetifolia*      | 167.10           | 42.86| 13.27              | 5.42| 65%      |
| *Syzygium grandis*             | 85.96            | 11.89| 7.12               | 1.37| 56%      |
| *Terminalia catappa*           | 93.01            | 14.70| 12.06              | 4.25| 51%      |
| *Fagraea fragrans*             | 87.69            | 4.22 | 14.78              | 2.73| 77%      |
| **Overall**                    | **66%**          |      |                    |     |          |

Rockwood et al. [1] states that species such as *Casuarina equisetifolia* are able tolerate low soil fertility but are quite responsive to fertilization with phosphorus or nitrogen and phosphorus. They are able to reach maximum development in slightly depressional topography as long as adequate moisture is nearly always available. This is shown in high MAI of *Casuarina equisetifolia*.

Meanwhile, saplings planted using media combination of 1000 g organic soil and 200 g SRF showed the highest increment in both height and diameter (Table 3).

| Media | Height Increment (cm) | Diameter Increment (mm) |
|-------|-----------------------|-------------------------|
| 1     | 11.68                 | 1.69                    |
| 2     | 13.01                 | 2.19                    |
| 3     | 13.87                 | 1.45                    |
| 4     | 14.04                 | 1.78                    |

Combination of both organic soil and SRF showed a higher MAI in both height and diameter. Due to lack of nutrients in sandy soil, application of media with SRF helps in term of growth of the saplings. The general description of soil chemical characteristic and physical properties at the study site were as shown in Table 4 & 5.

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Table 5. Soil physical properties in Kuala Rompin

| Depth     | Av.P (ppm) | Coarse Sand (%) | Fine (%) | Silt (%) | Clay (%) |
|-----------|------------|-----------------|----------|----------|----------|
| Block 1   |            |                 |          |          |          |
| 0-10cm    | 1.20       | 96              | 4        | 0        | 6        |
| 10-30cm   | ND         | 96              | 3        | 0        | 7        |
| Block 2   |            |                 |          |          |          |
| 0-10cm    | 1.01       | 95              | 3        | 0        | 7        |
| 10-30cm   | ND         | 95              | 4        | 0        | 7        |
| Block 3   |            |                 |          |          |          |
| 0-10cm    | ND         | 94              | 3        | 0        | 7        |
| 10-30cm   | ND         | 94              | 5        | 0        | 1        |

The inorganic SRF brand Multi-cote used in this study contains 19:10:13% of nitrogen:phosphorus:potassium. Compared to rock phosphate, these elements of SRF and organic soil helps to increased the soil physical characteristic [2]. While rock phosphate is widely used as fertilizer, the SRF is recommended to be used in planting carried out in plot with poor soil mineral and nutrient content [3]. On top of that., they also provide nutrient supply gradually for a long period of time, which improves the nutrient uptake efficiency of fertilizer and reduces leaching of nutrient [4].

On the other hand, unexpected drought also contributed to a low survival rate. Typically, the most appropriate time to plant tree saplings is at the beginning or in the middle of the rainy season [5]. However, with current issues in climate change, it is hard to determine the dry and rainy season throughout the year eventhough weather forecast data was obtained prior to planting. Other than that, fire caused by human activities was also one of the factors affecting the survival rate of saplings in this study. There is a few traces of bon fire as well as cigarette found nearby the study site that affected some of the planted saplings in study site.

4. Conclusion
It can be concluded that Callophyllum inophyllum and Casuarina equisetifolia showed a better growth performance compared to other mangrove associates species planted in this area. Combination of organic soil and SRF also contributed to a better growth performance in this study. Thus, further study using this combination can be applied in future studies regarding sandy coastal areas rehabilitation.

Acknowledgements
The research was funded by the JTRD fund of the Forest Research Institute Malaysia.

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