Evaluation of *Rhizophora Mucronata* Growth at first-year Mangrove Restoration at Abandoned Ponds, Langkat, North Sumatra

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Abstract. Degraded mangrove areas can be restored and rehabilitated. In Indonesia, one of the main recommended of mangrove species for restoration of degraded was *Rhizophora mucronata.* The purpose of the study was to evaluate *R. mucronata* growth at first-year mangrove restoration at abandoned shrimp ponds, Pulau Sembilan village, Langkat, North Sumatera, Indonesia. The recovery area divided into three zones based on the salinity concentration, landward, middle, and seaward zones. The evaluation parameters of mangrove reforestation consist of seedling diameter and height, leaves number, and seedling growth rate. Results showed that 3 of 4 evaluation parameters of *R. mucronata* growth belong to landward zone, namely seedlings diameter, the number of leaves, and percentage of growth. By contrast, height *R. mucronata* seedlings dominated in the middle area. The study also found that the proper zone for mangrove restoration with *R. mucronata* was in the landward with 96% growth rate and 30 part per thousand salinity concentration. The present study, therefore, suggested that the recommended species for the degraded area was the prerequisite for successful mangrove restoration.

1. Introduction

Mangrove forests in North Sumatera, Indonesia are widespread on the east coast of Sumatera Island and commonly found in Asahan, Batubara, Deli Serdang, Tanjung Balai, Nias, Labuhanbatu Serdang Bedagai until Langkat [1]. North Sumatra mangrove area was 59,645.79 ha in 1990 has been degraded to 37,132.62 in 2015, which deforestation rate was 1.51%/year [1]. In Langkat Regency mangrove has been lost from 34,742.12 ha in 1990 to 16,765.96 ha in 2015. The deforestation rate in Langkat was 2.07%, which is higher than in the North Sumatra province. Conversion of mangrove forests to aquaculture and oil palm plantations are responsible for deforestation in Langkat [1].

In spite of mangrove rehabilitation globally or regionally was well documented [2-3]; evaluation of rehabilitation program in Indonesia including North Sumatra is rarely reported especially at Regency or small level district or village. Mangroves are salt tolerant plant and the growth of mangrove seedlings in response to salinity tolerance has been primarily investigated in glass house [4-8]. It is therefore important to get information on the morphological aspects under different salinity in natural field. To get more insight into a better understanding of successful restoration in North Sumatran mangrove forest, Indonesia, the assessment of rehabilitation activity was needed. Here we report on

the evaluation of *R. mucronata* growth at first-year mangrove restoration at abandoned shrimp ponds, Pulau Sembilan village, Langkat, North Sumatera, Indonesia.

2. Materials and Method

2.1. Study area and dataset

The study was carried out in Pulau Sembilan village, North Sumatra, Indonesia, covering an area about 24,000 km^2. The Pulau Sembilan village situated at 04º 08' 39.13" North latitudes and 98º 13' 55.38" East longitudes (Figure 1). Pulau Sembilan regionally sited at the district of Pangkalan Susu, Langkat Regency. Pulau Sembilan village bordered by Pulau Kampe in the North, the Aru bay in the West, Pangkalan Susu district in the South and Malacca Strait is in the East. The restoration in Pulau Sembilan was carried on 21 August 2014 using indirect planting of 1000 *Rhizophora mucronata* seedlings. Two times of assessments, 17 May and 19 August 2015 were done to monitor and evaluate 325 ten months-rehabilitated seedlings.

2.2. Growth measurement

The growth determination of *R. mucronata* seedlings was by the stem height and diameter of the plants. Measurement of stem heights was a ruler with 1 cm precision from the end of the propagule to highest plant tip where the stem shoots grow. Plant diameter was measured using a digital caliper. Thus, the stem heights and diameters of *R. mucronata* for four months developed were the indices of growth in this study as previously reported [4-5].

2.3. Number of leaves and leaf areas measurement

Calculation of the amount of foliage plant was performed simultaneously with data collection of seedling height and diameter [4]. The measurement of leaf area was from the top two expanded leaves which were collected from the landward, middle, and coastal zone. *R. mucronata* seedling leaves were digitally scanned to quantify leaf area using ImageJ software [9].

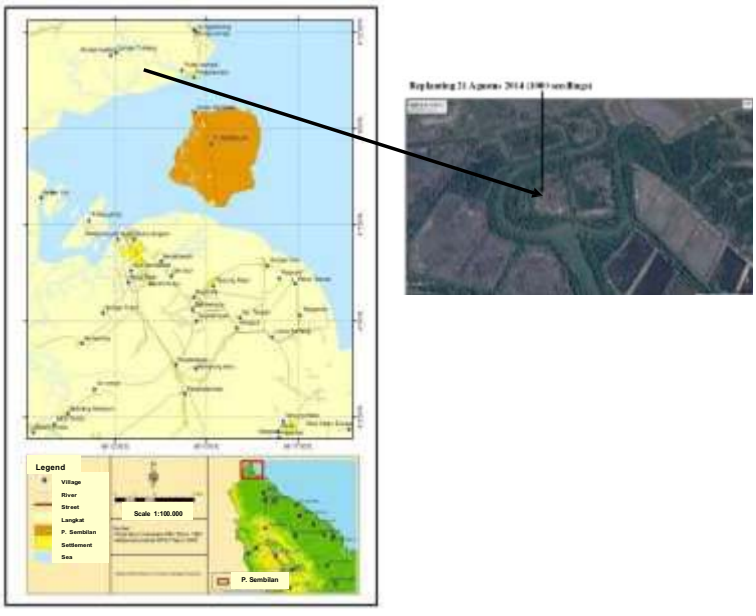

Figure 1. Map showing Pulau Sembilan and rehabilitation sites.

2.4. Growth rate and salinity

The calculation of the percentage of plant growth is by comparing the number of plants present in a plot with the number of plants that should be present in the measuring grid [6]. The calculation refers to the regulation of Ministry of Forestry, Government of Indonesia number P.70/Menhut-II/2008. The water salinity level was measured using digital hand refractometer. The water salinity level is carried out at high tide at three different growth sites, seaward, middle, and landward direction during the assessment.

3. Results and Discussion

Table 1 shows the growth zonation, observation point, and salinity concentration. Salinity is one of the major factors in influencing seedling growth. We, therefore, divided the evaluation based on mangrove zonation on Pulau Sembilan from the seashore to inland. Tables 2-4 show that 3 of 4 evaluation parameters of *R. mucronata* growth belong to landward zone, namely seedlings diameter, many leaves, and percentage of growth. By contrast, height *R. mucronata* seedlings dominated in the middle region (Table 2).

Several studies have been shown that mangrove species growth by salinity varied to the species. The optimum growth of *Bruguiera gymnorrhiza* and *Kandelia candel* was 0.5% salt concentration [4], however, the maturation of both species faintly enhanced after transferring to fresh water [5]. By contrast, the more salt tolerant species, such as *Avicennia marina* and *Rhizophora stylosa,* their growth stimulation at 1.5% salinity [6]. The gradual increase *A. marina* and *R. stylosa* were in re-adaptation to fresh water [7]. Several mangrove plants from Pakistan have been reported to grow optimally at 50% seawater salinity (1.5% salt concentrations) [8]. These studies indicated the significant adaptation of mangroves to salt and water stress.

Table 1. Growth zonation, observation point, and salinity concentration of *R. mucronata* seedlings

Growth zonation	View Point		Salinity concentration
	North latitudes	East longitudes	
Seaward	4° 8'36.37" N	98°14'35.56" E	35 part per thousand (ppt)
	4° 8'36.22"N	98°14'36.01"E	35 ppt
Middle	4° 8'37.49" N	98°14'35.59" E	32 ppt
	4° 8'37.10" N	98°14'35.91" E	32 ppt
Landward	4° 8'38.19" N	98°14'35.63" E	30 ppt
	4° 8'38.73" N	98°14'36.01" E	30 ppt

Table 2. Stem height of *R.mucronata* seedlings grown four months

Plot number	Stem height of seedlings (cm)		
	Seward	Middle	Landward
P1	15.02	28.51	27.40
P2	17.61	17.24	26.54
P3	24.06	33.48	23.62
Mean	18.90	26.41	25.86

Our current study also found that the proper zone for mangrove restoration with *R. mucronata* was in the landward with 96% growth rate and 30 part per thousand salinity concentration (Tables 1 and 5). This finding indicated that the physical zonation might be the suitable growing site for *R. mucronata* plants. *R. mucronata* commonly found in marshy places such as estuaries and edges of mangrove vegetation. These species, therefore, exist in a variety of ground level [2].

Table 3. Diameter of *R. mucronata* seedlings grown four months

Plot number	Diameter of seedlings (mm)		
	Seward	Middle	Landward
P1	0.49	2.60	3.92
P2	1.57	2.32	3.89
P3	3.72	3.83	2.76
Mean	1.93	2.92	3.52

We assessed mangrove restoration in the current year and first year. Percentage of plant growth is advantageous if the rate of germination reaches more than 80% and less successful if the proportion grows less than 80% according to Minister of Forestry Regulation Number P.70 / Menhut-II /2008. By this reference, the ratio of *R. mucronata* growth rate from three different zones to be considered as successful rehabilitation due to the percentage of seedling development reached more than 80% (Table 5).

Salinity concentration at 30 ppt was supposed to be the optimum growth in the landward zone directed to the percentage of growth of *R. mucronata* reached 96%. This increase was lower at salinity 32 ppt (94.67%) and reduced to 93% in the increasing salt concentration (35 ppt). The growth of *R. mucronata* was not suitable at high levels. This study supported previous results on the salt tolerance on other members of Rhizophoraceae family [6-7]. Recently it has suggested considering the incorporation of geomorphic knowledge into site planning and design for restoration activity [3]. In this context, approaching with the geomorphic site, salinity concentration, ecological condition, policy institution, and recommended species will increase successful restoration.

Table 4. Number of *R. mucronata* leaves

Plot number	Leaves number		
	Seward	Middle	Landward
P1	4.76	16.4	22.2
P2	7.68	8.88	31.96
P3	10.36	20.64	17.36
Rata-rata	7.6	15.31	23.84

4. Conclusions

Growth rate *R. mucronata* in the landward zone was 96% and this species for was considered for mangrove rehabilitation with 30 ppt salinity concentration. The present study, therefore, suggested that the recommended species for the degraded area was a prerequisite for successful mangrove restoration.

Table 5. Growth rate of *R. mucronata* grown four months

Plot number	Growth percentage of *R. mucronata* (%)		
	Seward	Middle	Landward
P1	100%	92%	92%
P2	88%	96%	100%
P3	92%	96%	96%
Mean	93%	94.67%	96%

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