The Growth of *Rhizophora mucronata* and *Avicennia marina* Seedlings Planted Using Guludan Technique in Coastal Area of Jakarta[1]

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Introduction

Recently, more than 50 % of mangroves in Indonesia have been destroyed by various kinds of causes. The prominent causes result in the mangrove degradation as well as mangrove deforestation are over-exploitation, water pollution and mangrove conversion to other non-vegetated uses (Kusmana, 2008). Those degraded mangrove are distributed in many coastal areas all over Indonesia from Aceh in the west to Papua in the east.

One of significantly degraded mangrove ecosystems in Indonesia is mangroves in the coastal area of Jakarta which covered the area amounted to approximately 264.65 Ha. The mangrove in this area were destroyed because of conversion to real estate, electricity facilities, highway, airport infrastructure, and extensive fishpond. The fishpond area is only the chance for mangrove rehabilitation, because this area is still as permanent forest areas belongs to the government under the management of Agriculture and Marine Services of DKI Jakarta. Nevertheless without subject to technology for planting mangrove in this kind of fishpond is rather difficult because of the deep water column (range 1 to 2.5 m). In order to solve this constraint, a simple technique was applied to planted mangrove seedlings in those fishponds, it called guludan[3].

Before this research was done, no information about the growtable of native true mangrove seedlings (*Rhizophora mucronata* or *Avicennia marina*) on the media of mineral soil using guludan technique, it is really a main concern of this research. So that, the research was aimed at measuring stem diameter and height growth carbon content, and survival rate of those two mangrove seedlings planted using the guludan technique.

It is hoped that if those mangrove seedlings able to grow well in the fishpond with the guludan technique, it is the chance for government as well as other sides to guarantee the success of fishpond rehabilitation with mangroves to substitute for already applied techniques using either large cans-filled soil or bamboo basket which were always failed for growing mangrove seedlings well.

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[1] Paper presented at the 5th Kyoto University Southeast Asia Forum, Conference of the Earth and Space Sciences, Bandung Technolgy Institute, 7-8 January 2010, Bandung

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[3] Guludan is a type of media in the certain area bordered by the trunk of bamboo for growing mangrove seedlings. Its consists of the pile of sackfilled soil in the underneath part and soil outpour in the upper part which is constructed in the fishpond.

Research Area

The research is located at the fishpond area in Mangrove Arboretum belonging to Agriculture and Marine Services of DKI Jakarta. This area spreads out between KM 22 and KM 23 along the highway Sedyatmo to International Airport of Soekarno Hatta, Jakarta in the coordinate position of 06^0 06' 45" South Latitude to 106^0 43' 54" East Longitude.

The fishponds in this area have the depth of water column ranged from 2,00 to 3,00 meter with the water salinity 28 to 30 ppt and the pH 6.88 to 7.52. The measure of the fishpond varied from 20 x 25 m to 25 x 50 m which was subjected to the tides through the canal from the sea located at about 300 m from the research area (**Figure 1**).

Figure 1. Research location

Research Method

Research Period

This research was carried out for 10 months (16 October 2008 to 15 August 2009).

Materials and Equipments

The used main materials and equipments in the research were bamboo trunk, nylon rope, sack, soil, mangrove seedlings (*R. mucronata* and *Avicennia marina*) 1 meter iron ruler, stainless micro caliper, and 20 meter tape.

Variabel to be Measured

Variables to be measured in this research were stem diameter and height of seedlings, carbon content of leaf, and the number of dead seedlings.

Research Procedure

The procedure to execute the research was as follows:

a) Construct the six unit of guludan with the measurement of 4.5 m (width) x 6 m (length) x 2 m (depth) each using the design structure presented on **Figure 2**.

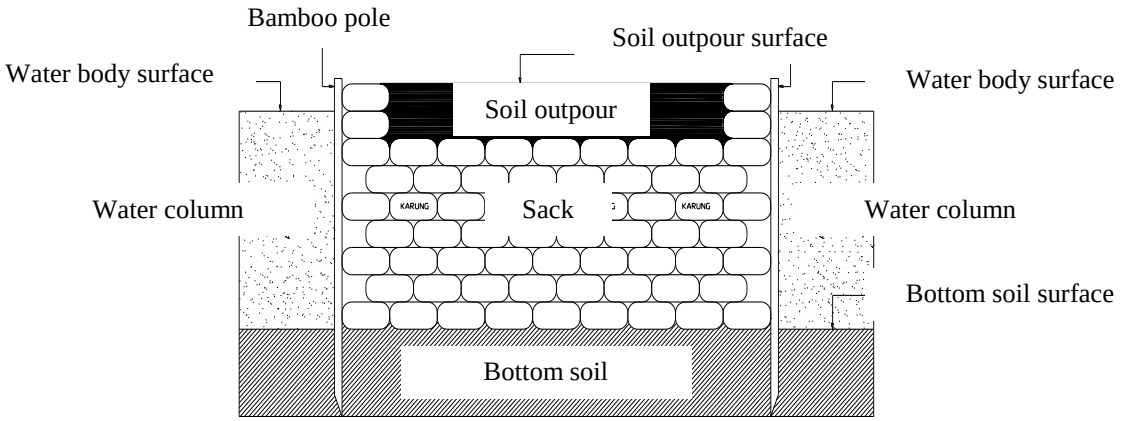

Figure 2. The design and performance of guludan

b) Planting the 5 months seedlings of *R. mucronata* in the three guludans using the spacing of 1 x 1 m, 0.5 x 0.5 m, and 0.25 x 0.25 m in each. While 3 months seedlings of *A. marina* were planted in the three remaining guludans using the same spacing as for *R. mucronata* seedlings. In detail, the performance of guludan planted by two species of mangrove seedlings above can be seen on **Figure 3**.

Figure 3. The performance of guludan planted by the seedlings of *R. mucronata* and *A. marina*

Sampling Unit

The were 140 seedlings to be sampled for measuring the growth of stem diameter and height of the seedlings. Those sampled seedlings consisted of the same number of *R. mucronata* and *A. marina* seedlings. The number of planted seedlings and its sampled seedlings to be measured are showed on **Table 1**.

Table 1. The number of planted seedlings and its sampled seedlings for measuring the growth of stem diameter and height.

Guludan	Species	Number Planted Seedling (Ind)	Sampling Intensity (%)	Number of Sampled Seedling
1	*Rhizophora mucronata*	30	40	12
2	*Rhizophora mucronata*	99	22	22
3	*Rhizophora mucronata*	336	11	36
4	*Avicennia* sp.	336	11	36
5	*Avicennia* sp.	99	22	22
6	*Avicennia* sp.	30	40	12

The number of sampled seedlings for monitoring the survival rate were all seedlings for spacing 1 x 1 m and the same as the number of sampled seedlings for measuring the seedling's growth for remaining spacings. While, the carbon content of the planted seedling's leaf was measured by taking 3 pieces of leaf from randomly planted seedlings for each spacing.

Technique of Data Measurement

In this research the techniques of data measurement were as follows:

a) Stem diameter and height of the seedlings were measured with microcaliper and iron ruler, respectively, with the measurement frequency for 3 to 4 months.
b) Carbon content of seedling's leaf are measured with Gravimetry/Nembius Method.

Data Analysis

Our data were subjected to the analysis as follows:

a) Increment of the stem diameter and height of seedlings was estimated by the formula:

$$I = \frac{X - Y}{t}$$

I = growth increment
X = stem diameter or height measure of seedling at first measurement
Y = stem diameter or height measure of seedling at second measurement
t = periode of time measurement

b) Seedling's survival rate was measured by the formula:

$$SR = \frac{A}{B} \times 100\ \%$$

Where: SR = survival rate of seedling
A = the number of survival seedlings at certain measurement time
B = the number of initial planted seedlings

c) Carbon content of the seedling's leaf was estimated in term of mean of the amount of carbon content from 3 pieces of leaf picked up from 3 sampled seedlings for each spacing for both *R. mucronata* and *A. marina*.

Result and Discussion

Result

Stem Diameter and Height Increment of Seedlings

The growth of stem diameter and height of planted mangrove seedlings in the period from 16 October 2008 to 15 August 2009 (10 months) is shown on **Table 2**.

Table 2. Average growth of stem diameter and height for *R. mucronata* and *A. marina* 10 -month- seedlings

Time of Measurement	Spacing (m)	Average Stem Diameter Growth (mm)		Average Height Growth (cm)	
		R. mucronata	***A. marina***	***R. mucronata***	***A. marina***
16 Oct 2008	1 x 1	7.16	4.95	103.33	62.96
	0.5 x 0.5	7.43	4.83	104.25	57.84
	0.25 x 0.25	7.41	4.88	100.39	55.83
16 Dec 2008	1 x 1	7.99	6.64	104.59	62.18
	0.5 x 0.5	8.05	5.84	106.90	53.68
	0.25 x 0.25	7.93	6.19	102.14	61.04
19 April 2009	1 x 1	12.61	8.74	108.11	62.67
	0.5 x 0.5	11.23	7.34	110.34	67.44
	0.25 x 0.25	11.62	7.44	104.15	71.41
15 August 2009	1 x 1	24.49	9.86	116.63	87.40
	0.5 x 0.5	24.71	9.28	116.78	86.53
	0.25 x 0.25	24.69	9.15	121.31	103.07

In the end of 10 months measurement the growth of stem diameter of seedlings for both species were not showed significant differences. The similar phenomena was also for seedling's height growth, except for the spacing of 0.25 x 0.25 m.

Those growth of both stem diameter and height seedlings for *R. mucronata* and *A. marina* followed the mathematical models of positive exponential (**Table 3**).

Table 3. The mathematical model for the growth of stem diameter and height of *R. mucronata* and *A. marina* 10 –month- seedlings.

Species	Parameter	Spacing (m)	Mathematical Model	S	p	R^2 adj
R. mucronata	Height	1 x 1	$\Delta h = 0{,}692t^{1{,}36}$	0,018	0,017	99,9%
		0,5 x 0,5	$\Delta h = 2{,}691t^{0{,}661}$	0,167	0,295	60,1%
		0,25 x 0,25	$\Delta h = 0{,}460t^{1{,}6}$	0,184	0,143	90,0%
	Diameter	1 x 1	$\Delta d = 4{,}875t^{1{,}88}$	0,094	0,063	98,1%
		0,5 x 0,5	$\Delta d = 0{,}155t^{1{,}96}$	0,152	0,097	95,4%
		0,25 x 0,25	$\Delta d = 0{,}158t^{1{,}98}$	0,120	0,076	97,1%
A. marina	Height	1 x 1	$\Delta h = 0{,}778t^{1{,}34}$	0,412	0,349	45,7%
		0,5 x 0,5	$\Delta h = 1{,}051t^{1{,}44}$	0,066	0,057	98,4%
		0,25 x 0,25	$\Delta h = 2{,}104t^{1{,}29}$	0,117	0,113	93,7%
	Diameter	1 x 1	$\Delta d = 1{,}690t^{0{,}452}$	0,025	0,069	97,6%
		0,5 x 0,5	$\Delta d = 1{,}117t^{0{,}576}$	0,078	0,166	86,8%
		0,25 x 0,25	$\Delta d = 0{,}918t^{0{,}634}$	0,076	0,148	89,5%

Where: Δh = height growth (cm) S = varians
Δd = stem diameter growth (mm) p = significant level
t = time (month)

The Mean Annual Increment (MAI) of stem diameter and height of *R. mucronata* and *A. marina* seedlings is shown on the **Table 4**.

Table 4. MAI of stem diameter and height of *R. mucronata* and *A. marina* seedlings

Species	Spacing (m)	MAI	
		Stem Diameter (mm/yr)	Height (cm/yr)
Rhizophora mucronata	1 x 1	20,94 a	19,23 a
	0,5 x 0,5	20,82 a	15,78 a
	0,25 x 0,25	20,92 a	27,46 b
Avicennia marina	1 x 1	5,93 a	33,36 a
	0,5 x 0,5	5,57 a	37,98 a
	0,25 x 0,25	5,22 a	56,25 b

The same word followed the number indicates no significant difference at significant level of 5%.

Based on data on Table 3, no significant difference of the MAI of stem diameter and height for either *R. mucronata* or *A. marina* seedlings between each spacing, except the height increment for the spacing 0,25 m x 0,25 m. However, the stem diameter increment as well as height increment between the seedlings of *R. mucronata* and *A. marina* each spacing were significantly different.

Carbon Content of Leaf

The average carbon content of seedling's leaf ranged from 50,91% to 55,42% for *A. marina* and 51,16% to 53,52% for *R. mucronata*. It is the tendency that the wider the spacing, the higher the carbon content (**Table 5**).

Table 5. The average carbon content of seddlings's leaf for *R. mucronata* and *A. marina* after 10 months of planting

Spacing (m)	Average Carbon Content (%)	
	R. mucronata	***A. marina***
1 x 1	53,52	55,42
0,5 x 0,5	52,71	53,41
0,25 x 0,25	51,16	50,91

Survival Rate

After 10 months of planting the all sampled seedlings grew well, so the survival rate as large as 100 %.

Discussion

The intraspecific differences for the mean stem diameter and height, except for the mean height of seedlings planted with the spacing of 0.25 x 0.25 m, were not large in both species, however, the interspecific differences in mean stem diameter and mean height were remarkable. Our obtained result showed reverse result obtained by Komiyama (1998) who studied the growth of cut pieces of *R. mucronata* and *R. apiculata* seedlings. This contradiction result might be caused by different treatments. In term of mean stem diameter, our result for *R. mucronata* was higher than of *R. mucronata* intact-seedlings reported by Komiyama et al (2007), however, its mean height was smaller than its reported by Komiyama et al (2007) and Aksornkoae (1975).

Our result obtained for the mean height of *A. marina* for the spacing 1 x 1 m and 0.5 x 0.5 m were similar with the research result reported by Mostafa (2004) who reported the mean height of 7 –year- old *A. marina* in Kuwait was about 35 cm/yr.

The increased growth rate of stem diameter of *R. mucronata* was higher than that of *A. marina*, however, it was vice versa for mean height growth rate in both species. Our result was confirmity with the result obtained by Aksornkoae (1975). Those species showed remarkable survival rate as large as 100 % in the periode for 10 months after planting. Its result was higher than reported in India by Untawale (1996).

The wider spacing result in the higher carbon content of leaf seedlings and stem diameter growth. It seemed that the wider spacing stimulate the higer photosynthetic rate to produce the higher organic materials which is mainly composed by carbon.

Conclusion

The intraspecific differences in mean stem diameter and mean height of *R. mucronata* and *A. marina* 10 –month- seedlings planted using guludan technique were not significantly different. It showed small range in each spacing. Their mean stem diameter ranged from 24.49 – 24.69 mm for *R. mucronata* and 9.15 – 9.86 mm for *A. marina*. While, their mean height ranged from 116.63 – 121.31 cm for *R. mucronata* and 86.53 – 103.07 cm for *A. marina*. The same facts were also occurred for mean annual increment of stem diameter and height for those seedlings. Remarkably, after 10 months of planting the seedlings for both species showed survival rate as large as 100 %. In this condition, the wider a spacing, the higher mean stem diameter and its carbon content of leaf which having the values more than 50 %. The growth of mean stem diameter as well as mean height of seedlings followed mathematical models of positive exponential, where the increases rate of stem diameter of *R. mucronata* was higher than of *A. marina*, however, vice versa for height growth.

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