# Adaptability and growth performance of Avicennia marina seedling within Silvofishery pond

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# Adaptability and growth performance of *Avicennia marina* seedling within Silvofishery pond

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## 1. Introduction

Integration of mangrove plantation along with aquaculture activities had been conducted in many countries popularly known as silvofishery [1]. Plantation of mangrove was recommended for fishponds area since it used to be mangrove ecosystem in which it was existed [2]. Plantation of mangrove was proposed to develop natural habitat within ponds. Thus, natural aquatic organisms would settle providing economically valuable natural biodiversity [3].

Reforestaion of mangrove ecosystem did not always achieve successfully. The change of habitat condition due to severe coastal degradation often caused unsuitable habitat for mangrove plants [2]. Mangrove ecosystem had been degraded due to conversion to shrimp ponds, agriculture, salt pans and settlements of local community [1]. Coastal area is characterized by tidal activities and inundation [4] while pond is characterized by deep water [5]. Mangrove ecosystem also is also characterized by

sandy and muddy sediment [4,6] while pond is dominated by silt and clay.[7]Thus, both ecosystem had significant differences on its sediment and water characteristics.

Each mangrove species require various environment condition. Aquatic physiochemical quality, soil composition and tidal inundation define the site suitability for particular mangrove species [4]. Preferred habitat for *Avicennia marina* would be coastal area with mudflat and less tidal dinamics [8,9]. Inundation period for *A. marina* should be less than 6 hours [10].

In order to grow optimally, mangrove requires specific environment including salinity, temperature, dissolved oxygen, pH and soil texture [11]. Growth rate of mangrove species varied among locations. Estimation of annual growth rates of *A. marina* was showed the range of 9 to 20 cm.year$^{-1}$ with average increment of 16.4 cm/year [12]. Radial increments of *A. marina* showed the rate of 0 – 5 mm/year [13]. The growth rates might also be affected by season where the rate of 0.95±0.08 cm/year was recorded in July and 0.58±0.058 cm/year was recorded in October [14]. Thus, various factors might affect the growth rate of mangrove.

Rehabilitation of mangrove usually conducted to achieve certain goals. The evidences showed that once established, mangrove directly influence the ecosystem in terms of sediment trapping and organic matter enhancement [15]. Thus, mangrove should achieve optimum growth to provide effective functions in limited period [16]. Thus, species selection should be conducted appropriately to match the existing ecosystem condition. Especially for silvofishery pond, mangrove species should be tolerant to frequent inundation.

In order to achieve optimum ecological function of mangrove plantation in silvofishery ponds, a proper growth is required. Thus, selection of appropriate plant species should be conducted to optimize the ecosystem development [2]. This research aimed to study the survival and growth rate of *A. marina* seedling within silvofishery pond, to analyze its growth performance compared to its natural habitats and to determine the appropriateness of *A. marina* plantation in the silvofishery pond integration.

## 2. Experimental Details

This research was conducted from March 2015 to March 2016 on the silvofishery pond in Semarang City. Mangrove seedling was planted in the silvofishery pond inlet and outlet canals occupying *Avicennia marina*. Plantation was conducted with two structural variations, including single and mixed (polyculture) composition respectively in 9 fish ponds. Three plant samples were selected at each pond resulted 27 plant samples respectively for single and mixed (polyculture) mangrove composition in which the observation conducted during the research. Replantation was conducted to dead seedlings during the research after the observation was conducted.

Observations were conducted with 3 months interval on the selected plants. Observation parameters included the survival, height, and diameter of mangrove stands. Analysis on the monthly growth rate was conducted including height and diameter growth. The growth rate was calculated with the following formula:

$$\Delta h = \frac{h_{t1} - h_{t0}}{t}$$

$$\Delta d = \frac{d_{t1} - d_{t0}}{t}$$

Notations:

$\Delta h$ = monthly height growth rate (mm/month)
$h_{t1}$ = seedling height in the end of observation period (mm)
$h_{t0}$ = seedling height in the beginning of observation period (mm)
$\Delta d$ = monthly diameter growth rate (mm/month)
$d_{t1}$ = seedling diameter in the end of observation period (mm)
$d_{t0}$ = seedling diameter in the beginning of observation period (mm)
$t$ = time interval (month)

Literature studies were conducted to compare the results of another studies either in the wild forest or in the silvofishery ponds all over the world. Thus, ecosystem suitability could be compared to silvofishery pond canals and wild mangrove. Further synthesis was conducted to determine the appropriateness of *A. marina* plantation in the silvofihsery ponds in order to provide scientific consideration in aquaculture application.

## 3. Results

Observations resulted low survival of *A. marina* seedling during the experiment. Minimum survival was only 1 of 27 stands while maximum was only 7 of 27 stands. Detailed observation results of *A. marina* seedling survival and growth in silvofishery ponds during the experiment is presented in Table 1.

Table 1. Survival (stands) and growth rate (mm/month) of *Avicennia marina* seedling in silvofishery pond

| No. | Growth Parameters | Period | | | |
|---|---|---|---|---|---|
| | | I | II | III | IV |
| **A** | **Single (Monoculture)** | | | | |
| 1. | Survival | 7 | 4 | 2 | 1 |
| 2. | Height | | | | |
| | (Min – Max) | 16.13 – 93.55 | 52.75 – 128.57 | 92.31 – 98.90 | 39.56* |
| | (Average ± St.Dev) | 41.94 – 25.19 | 96.43 – 38.29 | 95.60 – 4.66 | 39.56* |
| 3. | Diameter | | | | |
| | (Min – Max) | 0.06 – 1.45 | 0.26 – 4.15 | 0.56 – 3.16 | 1.48* |
| | (Average ± St.Dev) | 0.91 – 0.50 | 1.38 – 1.86 | 1.86 – 1.84 | 1.48* |
| **B** | **Mixed (Polyculture)** | | | | |
| 1. | Survival | 1 | 3 | 2 | 2 |
| 2. | Height | | | | |
| | (Min – Max) | 41.94* | 36.26 – 59.34 | 9.89 – 72.53 | 13.19 – 62.64 |
| | (Average ± St.Dev) | 41.94* | 50.55 – 12.48 | 41.21 – 44.29 | 37.91 – 34.97 |
| 3. | Diameter | | | | |
| | (Min – Max) | 1.10* | 0.73 – 1.38 | 1.12 – 3.13 | 1.42 – 2.41 |
| | (Average ± St.Dev) | 1.10* | 1.03 – 0.33 | 2.13 – 1.42 | 1.91 – 0.70 |

Note: *)only one sample was observed - no variations of data

Table 1 showed that the survival and growth of *A. marina* seedling was fluctuated. The range of height growth rates in pure (monoculture) treatments was higher than in the mixed (polyculture) treatments. The diameter increment in the mixed (polyculture) treatments was generally higher than in the pure (monoculture) treatments. This result indicated that *A. marina* was not suitable for pond plantation.

## 4. Discussions

The survival of *A. marina* seedling in the silvofishery pond was not quite different compared to its natural existence. An observation which was conducted on a wild *A. marina* showed the survival rate only 5% [17]. The long inundation period was considered as the main factor affecting the low survival of *A. marina* in the silvofishery ponds. *A. marina* could survive high salinity range, but it preferred frequent inundation [18]. Thus, silvofishery pond environment which had long inundation period or might be inundated all the time was not suitable for *A. marina*.

Existing environment conditions such as water and sediment quality were also considered to affect the survival of *A. marina* in the study site. Water pollution resulted from anthropogenic and industrial activities also plays important role in the survival of mangrove. A study on mangrove physiological in various environment condition showed that *A. marina* experienced more stress in the environment

with high anthropogenic and industrial activities [19]. The pollutant stress caused leaf damages which further affect the development of *A. marina* stands. Thus, *A.marina* should be planted in the ponds with good water quality in order to achieve good survival. The silvofishery settings should also be optimized such as by creating dikes to limit inundation period.

Seedling growth of *A. marina* both height and diameter during the research showed a better rate compared to previous research. Height increment of *A. marina* in the intertidal zone showed the rate of 1.8 – 32.4 mm/month and diameter increment rate of 0.33 – 0.44 mm/month [20]. However, the results was lower compared to a research conducted in Sri Lanka which showed height increment rate of *A. marina* as 148.6 mm/month [21]. The difference of mangrove growth rates was affected by environment factors such as salinity, nutrient composition and position of intertidal zone [22].

Low survival of *A. marina* within silvofishery pond canals might be caused by inappropriate species. Inappropriate species and site selection is the main factor affecting poor survival of mangrove plantation [2]. The growth of *A. marina* seedling in the silvofishery pond during the research showed that the environment dynamic was supportive for its height and diameter increment. Silvofishery ponds utilize both sea water and fresh water supply for fish cultivation. Thus, salinity conditions dynamically change due to tidal activities and rain occurrences. Sea water was preferred to support height increment of *A. marina* while freshwater was preferred for diameter increment [20].

Plantation of *A. marina* should be conducted with various consideration. Inundation should become main consideration of any mangrove plantation, since it is the main factor site selection of mangrove plantation. Options for mangrove plantation in the coastal area should consider two main factors, suitable environment and suitable species [4]. Ignoring one of these important factors would result in higher treatment cost.

General purpose of of *A. marina* plantation was to assist natural regeneration [16]. *A. marina* is considered as pioneer mangrove species which survive any environment condition in the intertidal area. However, mangrove in the silvofishery pond is proposed to provide natural environment services to achieve aquaculture sustainability. Ponds which were developed in the intertidal area were considered to provide suitable environment condition to *A. marina* plantation. Unfortunately, this research proved that *A. marina* was less suitable for silvofishery integration.

Forcing plantation of specific mangrove species in the silvofishery pond might affect to higher management cost, such as frequent replanting due to high mortality rate or development of appropriate environmental setting. Considering the long inundation period, *Rhizophora mucronata* would be preferred to be planted. Even though the survival might also be low, but it should be higher than *A. marina*. Thus, there should be less replanting activities and environmental setting manipulation. Thus, mangrove would be established faster as well as the environment services it provide.

## 5. Conclusion

The survival rate of mangrove seedling *A. marina* within silvofishery pond was low in all periods indicating its unsuitability for integration. However, the height and diameter increments were acceptable. Thus, the plantation of *A. marina* in the silvofishery pond is not recommended due to its high mortality rate and unsuitable environment condition, especially its inundation pattern. Forcing *A. marina* for silvofishery integration might result expensive treatment costs due to frequent replanting or development of appropriate pond settings.

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