Research article

Nursery Propagation of Apple Mangrove *Sonneratia alba*

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Abstract Mangrove rehabilitation conducted on the seafront was a failure because of small survival due to wrong species planted and zonation. Apple mangrove (*Sonneratia alba*), "pagatpat," is the most widely distributed mangrove globally, particularly in coastal regions. The study showed that the *Sonneratia species* bears plenty of fruits, but seedlings rarely grow in the wild. The researcher introduced a ninety-day analysis using various soil media and different watering regimes in a designed concrete tank to determine the survival and growth rates of the nursery propagated apple mangrove seedlings. He observed that the highest average survival rate of S alba seedling was in watering regime Treatment 3 and the type of soil medium was sandy clay. The researcher measured the average survival rate at 23.70% in clay, 52.10% for sandy clay, 44.32% for sandy soil under a watering regime, 37.41% in clay, and 43.21% in sandy clay, and 39.41% in sandy soil. Research showed that the seedlings watered under Treatment 3 observed the highest growth gain (5.41 ± 0.68 cm), while seedlings under Treatment 1 recorded the lowest growth gain (1.87 ± 0.23 cm) under the watering regime. Seedlings planted in sandy-clay soil exhibited the highest growth gain (4.15 ± 0.52 cm), while seedlings planted in clay recorded the lowest growth gain (4.0 ± 0.50 cm) for soil media. Moreover, the researcher observed that growth showed a significant difference in the different watering regimes but had no significant difference in the type of soil media.

Keywords apple mangrove, water regimes, soil media, survival rate, growth rate

INTRODUCTION

The Philippines is ranked fourth out of the 180 countries in the 20 years (2000-2019), following Puerto Rico, Myanmar, and Haiti among the countries most affected by extreme weather according to the Germanwatch report (Global Climate Index, 2021).

Mangroves are a natural coastal defense against violent storms that bring storm surges and flooding. It is one of the most effective mitigating measures against climate change. In addition, mangroves can hold back the sea waves and reduce wave forces with their extensive and dense above-ground roots by an estimated 70-90% on average (Macintosh, 2010). Furthermore, a study conducted by Harada et al. (2012) demonstrated that mangroves are as effective as concrete seawall structures in reducing tsunami-hit house damage behind the forest.

Mangrove systems have contributed significantly to the well-being of coastal communities through a wide array of ecosystem services classified into regulating, provisioning, cultural, and supporting (Manual on Community-Based Mangrove Rehabilitation: Box 1, 2012). Fringing mangroves in the Philippines and the rest of Southeast Asia are naturally lined by a band of *Avicennia marina* and *Sonneratia alba* front-liners with *Rhizophora stylosa* and *R. apiculate* immediately behind (Manual on Community-Based Mangrove Rehabilitation, p. 6, 2012).

Primavera et al. (2014) averred that *Sonneratia alba* (pagatpat) dominates the eastern Panay coastline. The species has been proven superior even to *the Avicennia marina* for the rehabilitation of sandy fringes. Most of the plantations used *Rhizophora species* whose propagules are easy to collect and plant but which cannot withstand wave action. Hence only 10% of these plants survived in open seaward sites in Calauag Bay, Quezon. These activities can best describe as planting by convenience rather than ecology (Primavera, 2005; Primavera and Esteban, 2008).

Avicennia marina and *Sonneratia alba* are the two significant fringing colonizers of the coastlines. However, wildlings are much rarer than the latter, and nursery techniques are relatively undeveloped compared to the first, according to protocols for growing *Sonneratia alba* (Mangrove Manual Series No. 2: Box 7, 2012).

Mangrove rehabilitation/reforestation programs in seafront areas and building coastal greenbelts as a mitigating measure in protecting coastal communities can still be a total failure. Develop the nursery propagation of apple mangrove first since this species is the primary colonizer of the sandy fringing coastlines. It is a suitable mangrove species to be planted in the seafront zone. Moreover, it is bigger, sturdier, and can withstand nature's forces as compared to the usual *Rhizophora species.*

The study used a tide simulation to address the gap using different watering regimes of pure seawater and various soil media. Using a concrete tank regulates the additional watering controls. Inundation of seawater to the seedlings should not be more than 30 percent of the time per day. The production of nursery propagated seedlings will fill the gap of the rareness of apple mangrove seedlings. The establishment of mangrove nurseries can provide mangrove seedlings of the required species in the required numbers and sizes at a given time; otherwise, planting will be highly dependent on the availability of propagules, seeds, or wildlings (Mangrove Manual Series No. 1: Box 3, 2012).

OBJECTIVE

The purpose of this research study is to produce nursery reared apple mangrove seedlings to supply the much-needed right planting materials and to correct the existing practice of coastal mangrove rehabilitation/reforestation using *Rhizophora species*. Specifically, the study aimed to: (1) determine the survival rate of *Sonneratia alba* seedlings reared in three types of soil media using different watering regimes; (2) assess the growth rate of apple mangrove seedlings reared in three types of soil media using different watering regimes; and (3) conduct pilot testing to assess what type of soil media and corresponding watering regime propagated apple mangrove seedlings grow best.

METHODOLOGY

The environment: The researcher conducted apple mangrove (*Sonneratia alba*) nursery propagation research in Daanbantayan, Cebu, Central Philippines.

LEGEND:
T1= watered with seawater once a day (the natural way)
T2= watered once a day (totally submerged for two hours)
T3= watered with seawater twice a day (totally submerged for two hours for each treatment

Fig. 1 The design of the research tank

The concrete tank: The study used a concrete tank measuring 8 meters in length by 2 meters in width by 0.24 meters in depth (8 m x 2 m x 0.24 m.). The tank is further subdivided into 16 compartments; measuring approximately one square meter in area respectively (Fig. 1).

The plant pot and soil media: The research used 18 centimeters in diameter synthetic pots in its top portion by 15 centimeters in height, and it utilized three types of soil media treatments, sandy, sandy clay, and clay. Each treatment used nine pots, each filled with the corresponding soil. Since there will be three treatments with five replications, the total number of banks used was 45 in each treatment or 135 pots for all the three treatments.

Seedling preparation phase: Mature bigger fruits that had no holes bored by insects do not suffer from extreme weather conditions, and were ripe in a good parent tree, were collected early in the morning or late in the afternoon through handpicking. Fruits of *S. alba* will freely fall when ripe and mature and naturally separate from their calyx before dropping to the ground (Fig. 2).

Fig. 2 Ripe fruit and seeds of *Sonneratia alba* ideal for collection

By using the bare hands, macerate the fruits by pressing. Usually, the number of seeds found inside ranged from 80 to 160. The seeds were soaked and washed in a basin with freshwater/rainwater and let stand for a few minutes allowing the viable seeds to float. The seeds were dried for 2 to 3 hours to break seed dormancy. Avoid prolonged drying of sources, for it will affect seed germination.

The study utilized seedboxes measuring 40 x 90 cm. Sandy clay soils were used as soil medium (5-7 cm thickness) and taken from the parent tree area. The seeds were soaked overnight with rainwater to hasten germination. After twenty-four (24) hours, the seeds that showed signs of sprouting were collected and sown in the seedboxes, covered with 2.54 cm-thick soil, and allowed to germinate for one month before transplanting individually. Water the seeds with rainwater diluted with seawater to acclimatize the seeds. After 30 days of propagation from the seedbed, the researcher transplanted the seedlings.

Experimental phase: The tank's 15 compartments should be re-checked carefully for its watertight worthiness by filling the tank with seawater and cross-checking the draining system to see if it functions well. The study closely followed the watering regime scheduled time during the flooding of the tanks. The researcher should do general cleaning of the tank every fifteen days.

Watering regimes: In treatment 1, the plants were watered once, just like ordinary plants. Treatment 2 was submerged once for two hours daily, and Treatment 3 was submerged twice for two hours in each submersion. Two cm above the apex of the seedling's leaves, seawater was inundated. Drain the tank's compartments by pulling out the cover of the drainage pipe after two hours. The researcher simulated treatments like the tide of the sea, which coincides with the study (Kjerfe 1990) that mangroves grow at or above mean sea level or MSL, which is not more than the sea 30% of the time tidally inundated.

Seedling management: The study used three treatments of different soil media and three watering regimes with five replications each. The study needed an adequate and accessible supply of clean seawater to efficiently facilitate the filling-up and drain of the seawater in the tank. The project should strictly follow a watering schedule. After ninety (90) days of managing period, the seedlings are now ready for extension purposes by planting the produced seedlings in the selected rehabilitation areas.

Collection of data: During the initial stage of transplanting, the seedlings had an initial height of 2 centimeters. The researcher measured the seedlings from the top of the soil to the last middle leaf of the plant. Every 15 days, the plant's data, survival, and growth rate were taken and monitored for three months.

Statistical treatment: The study used a Randomized Complete Block Design (RCBD) research design. A two-way ANOVA of SPSS Statistics to get the mean difference to determine if there is a significant difference in survival rate and growth rate in the three watering regimes and three different soil media. The variables studied survival rate and growth rate. The study used following Equation (1) to get the survival rate.

$$\textit{Surviving rate} = \frac{\textit{Number of survivors}}{\textit{Initial number}} \times 100 \quad (1)$$

The growth rate was taken using following Equation (2).

$$\textit{Growth rate} = \textit{Height 1} - \textit{Height 2}/\textit{Height 1} \times 100 \quad (2)$$

RESULTS AND DISCUSSION

Survival rate: Figure 3 showed a significant relationship between the watering regime and Sonneratia alba's survival. The survival rate of *S. alba* was highest in Treatment 3, was increased in Treatment 2, but very low in Treatment 1. The experiment implies that the inundation of seawater twice daily favors the survival of *Sonneratia alba* seedlings as long as the submersion time was not more than 30% of the time. The inundation of fresh seawater brought nutrients to seedlings. The *S. alba* average survival rate in the three watering regimes is highest in sandy-clay soil with 43.21%, sandy soil with 39.41%, and clay with 37.41%.

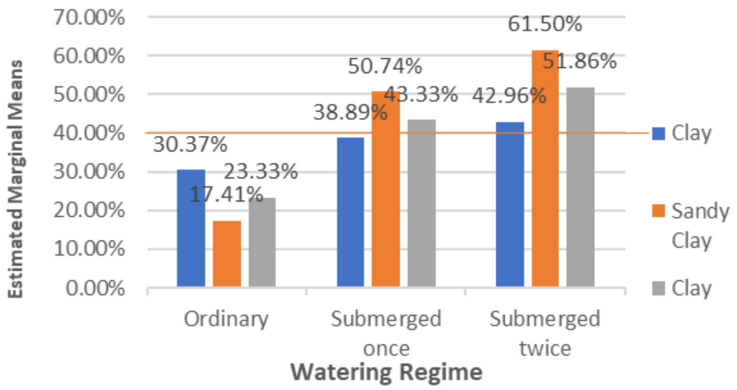

Fig. 3 Survival rate of the apple mangrove seedlings in various treatment

The study implies that in the soil type where most of its parent trees lived, *S. alba* seedlings survive best. However, this is in contrast to Deloffre et al. (2006) and Viles et al. (2008) study, which showed that for both *Aviccenia* and *Sonneratia*, short inundation (5 h day -1) without sediment treatment resulted in 100% survival throughout the experiments.

Results of analysis of variance (ANOVA) computation revealed a significant relationship on the survival of *S. alba* in different watering regimes ($p=.000<0.05$) at a 5% level of probability; but has no meaningful relationship with the survival of *S. alba* in other soil media ($p=0.493 > 0.05$) at 5% level of probability also. Furthermore, it has no significant effect on the survival of *S. alba* seedlings in the different watering regimes and soil type interaction ($p=0.125>0.05$) at a 5% probability level.

ANOVA implies that within the duration of the study the survival of *S. alba* seedlings has a significant difference when watered naturally, submerged once a day, or submerged twice a day but has no significant difference when grown in clay sandy clay or sandy soil. Moreover, the survival of *S. alba* seedlings has no significant difference whether watered naturally, submerged once a day, or submerged twice a day interacted with different soil mediums.

Table 1 Analysis of variance (ANOVA) table on survival rate

Source	Type III Sum of squares	df	Mean square	F	P-value
Corrected model	9720.335[a]	8	1215.042	5.610	.000
Intercept	86577.691	1	86577.691	399.732	.000
Watering regime	7753.435	2	3876.717	17.899	.000
Soil type	311.275	2	155.637	.719	.493
Watering regime * Soil type	1655.626	4	413.906	1.911	.125
Error	9746.515	45	216.589		
Total	106044.541	54			
Corrected total	19466.850	53			

Growth rate: The study used an estimated margin of 4.0 cm to interact with the watering regime and soil type if it affects the growth of the *S. alba* seedlings. All the seedlings planted in different soil media interacted with the watering administration. The study found that Treatment 3 and Treatment 2 were above the estimated marginal means.

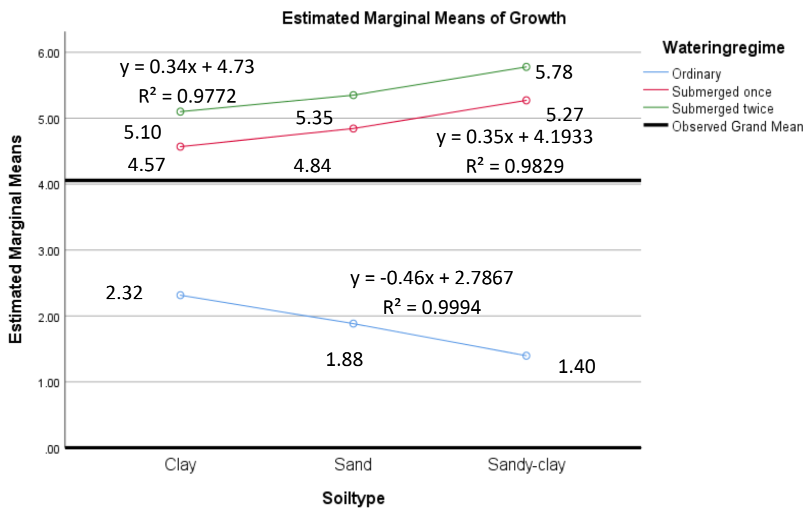

Fig. 4 Growth rate of the apple mangrove seedlings in various treatment

It means that the result of the study coincides with the report of Kjerfe (1990) that mangroves grow at or above mean sea level or MSL, which is not more than 30% of the time tidally inundated.

Results of Analysis of Variance (ANOVA) showed a significant relationship on the growth of *S. alba* in different watering regimes ($p=.000<0.05$) at a 5% level of probability; but has no vital relationship with the survival of *S. alba* in other soil media ($p=0.9777>0.05$) at 5% level of probability also. Furthermore, it has no significant effect on the survival of *S. alba* seedlings in the different watering regimes and soil type interaction ($p=0.909>0.05$) at a 5% probability level.

Table 2 Analysis of variance (ANOVA) table on the growth rate

Source	Type III Sum of squares	df	Mean square	F	P-value
Corrected model	137.488[a]	8	17.186	3.278	.005
Intercept	888.491	1	888.491	169.460	.000
Watering regime	132.035	2	66.018	12.591	.000
Soil type	.240	2	.120	.023	.977
Watering regime * Soil type	5.213	4	1.303	.249	.909
Error	235.939	45	5.243		
Total	1261.918	54			
Corrected total	73.427	53			

It implies that within the span of the study from days 0-90, the growth of *S. alba* seedlings has a significant difference when watered naturally, submerged once a day, or submerged twice a day but has no significant difference when grown in clay, sandy-clay, or sandy soil. Moreover, the growth of *S. alba* seedlings has no significant difference whether watered naturally, submerged once a day, or submerged twice a day interacted with different soil mediums whether grown in clay, sandy clay, or sandy soil.

CONCLUSION

The study can conclude that the soil medium having the highest average survival of *Sonneratia alba* seedlings grown in the concrete tank is the sandy-clay soil. The ideal watering regime for their growth is Treatment 3, in which the seedlings are submerged twice for two hours per submersion. With this study, the production of the correct species of mangrove seedlings is available, and the output can correct the present trend of mangrove rehabilitation/reforestation. Because of this research saves much time, effort, and money. The paper can realize the long-term dream of building coastal greenbelts to make the coastal community well-protected and resilient against the threats of climate change and global warming.

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