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Observations on the Growth and Survival of Nipa (Nypa fruticans Wurmb) Seedlings under Different Salinity Concentrations

The primary objective of this study was to determine the effects of salinity on the growth and morphology of the nipa palm (*Nypa fruticans*). The field study was done in Binicuil, Kabankalan, Negros Occidental, in the months of January to October, 2007. Six plots each measuring 10m x 10m and separated from each other for 100m were observed during this period of time. The physico-chemical parameters measured were soil and water salinity, soil and water pH, and soil texture. Laboratory experiment on nipa seedlings was also conducted for 34 weeks to observe the effects of salinity on the growth of nipa seedlings. In the field, the mature nipa palms in the six plots showed variations in morphological characteristics, but these variations were not significant. The results of the field survey showed that most seedlings were found in plots with 0-15 ppt, but no seedlings were found in the sampling plots with 30-42 ppt salinity. The results in the field are confirmed by the experimental results showing that the growth was fastest at 0 ppt salinity in terms of the increase in the number and length of petioles, leaves, and roots. The growth of young seedlings of Nipa palms appears to be most rapid at salinities much lower than 30 ppt., especially from 0-15 ppt. It is recommended that nipa farmers plant nipa at lower salinities in silty to sandy loam soils.

INTRODUCTION

Nipa or nypa palms, in association with few mangrove tree and animal species, are considered an important feature of the mangrove forest (Macnae, 1968). Thus, any attempt to study the mangrove forest must consider a review of the present status of both the nipa palm and mangrove. The earliest publications on mangroves appear to be that by Brown and Fisher (1918). Primavera (2000) estimated the area of this ecosystem at 120,000 hectares in 1994. In 1986, the area had been reduced to about 88,000 ha (Fortes, 1988), but Calumpong (1994) further estimated the area dominated by

Rhizophora spp. to be 70,000 ha, which would probably be realistic at that time. The reason for this large decline is conversion of mangroves into fishponds and other uses requiring the cutting of mangrove trees. There is evidence that, despite the prohibitions against mangrove cutting and conversion, loss of mangrove forest is still going on, and therefore the area of mangrove forest must have declined further (Alcala, 2001).

In the papers cited above, the focus was on mangrove trees variously estimated at 20-25 to about 50 species (Arroyo, 1979; Fernando & Pancho, 1980; and Calumpong, 1994) but not on nipa palms (*Nypa fruticans*). This species as part of the mangrove ecosystem appears to have received little attention from scientific workers. Macnae (1969) adopted the term "Nypa Association" proposed by Schimper in 1981. This association, which occurs toward the landward edge of mangrove forests, is composed of the nipa palm, a few species of mangrove trees with mounds of Thalassina anomala. In the Philippines and elsewhere in the Indo-West Pacific Region, nipa palms often grow luxuriantly along banks of rivers reached by tidal flows. The habitat may be characterized by a lower salinity.

Nipa palms have been observed to be very useful plants in the Philippines. They have a variety of human uses and are therefore protected and even planted. The mature leaves are used as thatch, especially for roofing, and other household items. From its flowers come a syrup convertible to sugar or a drink often after fermentation. Associated with nipa palms are some species of bivalves, fish, and crabs all of which are regularly harvested by local communities. Being an ecotone between the beach or terrestrial communities and the seaward portions of mangrove forests, the nipa palms host other vertebrate species including frogs, reptiles, birds, and small mammals (Alcala, 2001) in addition to marine species. However, nipa palms, under conditions of human exploitation, appear to thrive luxuriantly only when associated with mangrove tree species and if periodically flooded by both fresh and sea water (Alcala, A., personal communication). Why this is so is a good area for investigation.

Only few uncontrolled, inconclusive observations on the effect of salinity and certain physico-chemical conditions on nipa seed germination have been reported in the Internet (Bamroongrusa, 1991 and Kaewsinuan, 1996). Hence, there is a need for more studies. The current study—with field and laboratory components—was conducted to determine the effects of different levels of salinity on the growth and survival of nipa seedlings.

DESCRIPTION OF THE STUDY AREA

The study was conducted in Kabankalan City, province of Negros Occidental on Negros Island, Philippines (Figure 1.1), for 34 weeks, from January 22 to September 23, 2007. Fieldwork was done in a 10-ha mangrove located in the barangay of Binicuil, 5 km north of Kabankalan. The area was previously dominated by mangrove vegetation but these were later cut and replaced with nipa. The area is dominated with nipa along with few other species of mangrove such as *Rhizophora* sp. and *Excoecaria* interspersed within the nipa grove along the river, the leaves of which are regularly harvested for thatch. Most of the nipa plantations are privately owned. For purposes of this research, the nipa owners were paid the value of their harvest for a period of nine months, January 2007 to September 2007. During this time the area was not disturbed except for research purposes. The laboratory experiments on nipa seedlings were conducted at the Fellowship Baptist College in Kabankalan City.

METHODS AND MATERIALS

Field study. Six plots (10m x 10m) were established in the field on January 22, 2007 along the banks of Paniqui River in Barangay Binicuil (Figure 1.2), with Plot 1 located in the upstream, followed by five plots in the seaward direction (Figure 2). The salinity concentrations in these plots were determined by Atago S/MILL- E, No. 2442, a portable refractometer, resulting in the salinity readings of the water squeezed from the moist soil during the three sampling periods (Table 1). The pH of the water was determined by portable pH meter (Lutron, pH 201). The water was squeezed from the soil using cheesecloth.

Table 1.

Water salinity profile of sampled plots in Brgy. Binicuil, Kabankalan City.

Plot	22-Jan-07		21-May-07		23-Sep-07	
	Low (in ppt)	High (in ppt)	Low (in ppt)	High (in ppt)	Low (in ppt)	High (in ppt)
1	0.00	36.25	3.00	36.25	0.00	25.00
2	0.00	39.00	3.00	39.50	0.00	28.00
3	15.00	39.40	15.00	39.40	5.00	32.00
4	15.00	39.20	18.00	39.20	8.00	36.00
5	30.00	42.00	30.00	42.00	10.00	38.00
6	30.00	40.00	32.00	40.00	15.00	38.00

The soil texture was determined by the Ribbon Testing Method. The soil sample was obtained to form a half-inch ball. The sample was worked between the fingers until uniformly moist and any grittiness that indicated sand was noted. The following guide serves to narrow down the choice of texture (Plaster, 1997): no ribboning - loamy sand; ribbon shorter than 1 inch - sandy loam, silt, silt loam, sandy loam; ribbon 1 to 2 inches long - sandy clay loam, silty loam and clay; and ribbons 2 to 3 inches long - sandy clay, silty clay and clay.

Stem density in plots was determined by counting the number of plants per plot. Ten plants per plot were selected at random and the morphological characteristics of each plant were determined.

Laboratory study. The fresh fruits of nipa collected from the field site were brought to the laboratory and placed in 100-150 mm plastic containers filled with water (Figure 3) with salinities of 0 ppt, 15 ppt, and 30 ppt. Distilled water was considered freshwater as having 0 ppt salinity and seawater as having 30 ppt salinity. Seawater was diluted with freshwater to make the 15 ppt salinity. Each salinity treatment had 30 replicates.

Seedlings were laid out in a shaded area to simulate field conditions and arranged according to the completely randomized design. The CRD design was used to make sure that each treatment will be exposed to the same other environmental parameters like sunlight and temperature. Because nipa is viviparous, the seedlings used were the fresh fruits with pre-emerging plumules with length averaging 0.62 cm. collected from the field site. These seedlings were placed in containers filled with 50 ml water.

The salinities of the water were maintained by dilution with distilled water once a week. Seedling growth was monitored twice a month for nine months. The circumference and weight of seedlings; width and number of leaves, petioles and roots; and length of roots, petiole and leaves were taken and recorded. Weights of seedlings were obtained by using the Lutron GM-501 Electronic Scale (Table 10.A and 10.B).

RESULTS

Field study. Salinities varied from 0 ppt to 42 ppt. and plots 1 and 2 tended to have the lowest levels of salinity (0-39 ppt) compared to the other four plots (5-42 ppt). Plots 5 and 6 particularly stood out as having the highest range of salinity (10-42 ppt), being nearest the seawater source. The result of the SNK Test revealed significant differences in salinities in the different plots: Plot 5 > Plot 6 > Plot 4 > Plot 3 > 2 > Plot 1.

Table 2.

No. of nipa seedlings/plot observed during the three sampling periods in Barangay Binicuil, Kabankalan City.

Plot	22-Jan-07	21-May-07	23-Sep-07
1	1	1	6
2	1	1	5
3	2	2	3
4	1	1	4
5	0	0	0
6	0	0	0
Average	0.83	0.83	3.00
S.D.	0.75	0.75	2.53

Seedlings were observed in the field in Plots 1, 2, 3 and 4 and none in Plots 5 and 6 (Table 2). The absence of seedlings in the two plots during the period of observation (9 months) seems to correlate with the higher salinities in these plots (Table 8.A). The Chi-Square Goodness of Fit test was used to check if the survival distribution in the different salinities differed. The results of the Chi-Square analysis did not show any significant difference. The number of surviving seedlings in the different salinity set-up (0, 15 and 30 ppt) did not significantly differ (X^2= 0.09001, P 0.95563). So the field results as far as the presence or absence of seedlings in the field study cannot explain the laboratory experiment. Plot 5 had the highest modal salinity at 42 while Plot 6 was second highest at 40 ppt during high tide. The salinity of plots 5 & 6 were both at 30 ppt during low tide. Plots 1 & 2 had the lowest water salinity during low tide of 0 ppt.

Table 3.

No. of petioles/plant observed from the sampled plots 1-6 during the three sampling periods in Barangay Binicuil, Kabankalan City.

Plot	22-Jan-07		21-May-07		23-Sep-07	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
1	6.90	2.02	7.00	2.11	7.70	1.83
2	6.90	2.38	7.10	2.28	7.70	2.06
3	7.80	2.94	8.10	3.63	8.30	3.50
4	7.10	3.03	7.90	2.85	8.80	2.57
5	9.10	2.08	10.00	2.91	10.10	2.85
6	11.00	2.00	10.10	3.48	10.20	3.29

Results showed the numbers of cut and uncut leaves in the six plots (Tables 3 and 4), petiole lengths (Table 5), number of leaflets per leaf (Table 6), and lengths of leaflets/leaf (Table 7). The differences of these variables (taken as indicators of growth) among nipa plants in the six plots were tested and found not significant, using the Kruskal-Wallis and ANOVA tests of significance. No correlation with levels of salinity was found.

Table 4.

No. of uncut petioles/plant observed from the sampled plots 1-6 during the three sampling periods in Barangay Binicuil, Kabankalan City.

Plot	22-Jan-07		21-May-07		23-Sep-07	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
1	2.50	0.71	2.80	0.79	2.90	0.74
2	3.00	0.67	3.30	0.67	4.10	1.10
3	2.50	0.85	3.10	0.99	3.70	0.67
4	2.00	0.47	2.20	0.42	2.60	0.52
5	2.30	0.48	2.20	0.42	2.70	0.67
6	1.60	0.70	2.20	0.63	2.70	0.67

* Mean of ten plants.

Table 5.

Length of pertioles/plant (in cm.) observed from each plant in the sampling plots 1-6 in Barangay Binicuil, Kabankalan City.

Plot	22-Jan-07		21-May-07		23-Sep-07	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
1	102.10	27.57	103.85	28.94	116.74	24.43
2	79.50	11.11	84.77	9.26	95.76	13.21
3	76.89	19.48	89.49	17.46	110.63	35.96
4	70.20	14.64	76.80	11.03	89.72	14.09
5	53.10	8.10	59.30	9.59	72.37	12.95
6	84.90	27.57	82.63	23.15	103.77	20.77

*Mean of ten plants

Table 6.

No. of leaflets/leaf/plant observed from each sampling plot in Barangay Binicuil, Kabankalan City.

Plo t	22-Jan-07		21-May-07		23-Sep-07	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
1	92.70	9.42	88.00	10.41	94.40	15.17
2	86.70	7.13	88.60	7.01	91.50	5.84
3	74.40	16.70	88.20	22.54	91.40	19.98
4	91.80	6.43	99.10	11.67	104.20	11.98
5	86.00	15.02	94.80	12.02	96.20	11.94
6	85.10	10.61	88.00	15.90	91.20	16.77

*Mean of ten plants

Table 7.

Length of the leaflets/leaf (in cm) in data collected from 10 plants in plots 1-6 in Barangay Binicuil, Kabankalan City.

Plot	22-Jan-07		21-May-07		23-Sep-07	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
1	100.34	19.10	102.58	20.26	99.35	16.63
2	81.10	9.34	83.42	9.87	84.19	10.24
3	78.77	15.23	84.78	17.39	86.87	17.03
4	85.58	9.80	93.24	11.20	94.40	11.39
5	87.78	13.25	99.81	16.65	100.50	16.54
6	84.19	13.44	87.09	18.43	89.74	18.81

*Mean of ten plants

Laboratory study. The number of surviving seedlings in the different salinity set-up (0, 15 and 30 ppt) did not significantly differ (X^2= 0.09001, p=0.95563) (Table 8.A & B). The Chi-Square Goodness of Fit test was used to check if the survival distribution in the different salinity differed. The results of the Chi-Square analysis did not show any significant difference. The field results as far as the presence or absence of seedlings in the field study cannot explain the laboratory experiment. The initial and final circumference of seedlings (Tables 9.A & 9.B) did not significantly differ. Neither did the seedlings show significant differences in weight.

Table 8.A.

Nipa seedlings survival rates after a 34-week period of observation.

Salinity	Weeks								
	0	2	4	6	8	10	12	14	16
0 ppt	100	100	100	100	100	96	96	96	90
15 ppt	100	100	100	93	93	90	90	90	90
30 ppt	100	100	100	100	100	96	93	90	83

Table 8.B.

Nipa seedlings survival rates after a 34-week period of observation.

Salinity	Weeks								
	18	20	22	24	26	28	30	32	34
0 ppt	90	86	87	77	77	77	77	77	73
15 ppt	83	80	80	77	77	77	77	77	77
30 ppt	83	83	83	77	77	70	70	70	70

Table 9.A.

Circumference of nipa seedlings (in cm) monitored twice a month for 9 months.

	Weeks								
Salinity	0	2	4	6	8	10	12	14	16
0 ppt									
Average	20.04	19.80	19.72	19.92	20.03	20.00	19.85	19.84	19.85
S.D.	2.44	2.42	2.50	2.57	2.67	2.63	2.63	2.63	2.71
15 ppt									
Average	20.77	20.56	20.54	20.64	20.84	20.06	20.47	20.58	20.67
S.D.	2.53	2.55	2.45	2.10	2.13	4.10	2.00	2.12	2.17
30 ppt									
Average	21.82	21.80	21.81	21.92	21.95	22.00	21.75	21.79	22.20
S.D.	1.43	1.42	1.33	1.41	1.49	1.58	1.48	1.53	1.40

Table 9.B.

Circumference of nipa seedlings (in cm) monitored twice a month for 9 months

	Weeks								
Salinity	18	20	22	24	26	28	30	32	34
0 ppt									
Average	19.85	19.81	19.80	19.90	19.77	19.77	19.76	19.76	19.64
S.D.	2.71	2.76	2.81	2.79	2.84	2.84	2.82	2.82	2.83
15 ppt									
Average	20.58	20.58	20.59	20.52	20.52	20.52	20.52	20.52	20.51
S.D.	2.20	2.23	2.24	2.21	2.21	2.21	2.21	2.21	2.21
30 ppt									
Average	22.21	22.22	22.22	22.27	22.28	22.26	22.26	22.26	22.26
S.D.	1.42	1.42	1.42	1.43	1.43	1.50	1.50	1.50	1.50

When the petiole length growth performance of seedlings among the different salinity levels are compared, results showed that increase in length of petioles at 0 and 15 ppt salinities was faster than that at 30 ppt (Tables 11A & B). Results of the ANOVA showed no significant differences in the length of petioles.

The only significant finding was the fastest increase in the number of petioles in 0 ppt salinity followed by those at 15 ppt salinity and those at 30 ppt salinities. Statistical analysis (Kruskal-Wallis Test) comparing the initial and final number of petioles in the seedlings revealed a significant increase in the 0 and 15 ppt only. It seems that freshwater and brackish water favor the growth of petioles of seedlings. This finding is consistent with the observation that seedlings in the wild were found only in areas with salinities lower than 30 ppt.

Table 10.A.

Weight of Nipa Seedlings (in grams)

	Weeks								
Salinity	0	2	4	6	8	10	12	14	16
0 ppt									
Average	111.52	107.91	109.43	111.02	112.60	121.08	123.20	125.42	124.97
S.D.	36.88	35.11	36.01	36.01	36.94	39.48	41.69	41.06	41.17
15 ppt									
Average	116.31	112.18	112.61	116.07	116.28	125.74	128.53	126.72	132.15
S.D.	32.39	28.31	27.14	29.69	30.32	33.71	34.75	41.61	36.36
30 ppt									
Average	147.31	139.74	140.46	141.84	140.19	150.62	154.78	157.91	159.22
S.D.	26.01	26.05	27.33	27.33	27.98	33.29	34.25	33.92	34.86

Table 10.B.

Weight of Seedlings (in grams)

	Weeks								
Salinity	18	20	22	24	26	28	30	32	34
0 ppt									
Average	126.47	128.17	129.10	132.01	131.66	131.75	132.97	134.87	135.18
S.D.	42.64	42.90	44.05	46.33	46.25	46.31	47.01	48.36	49.32
15 ppt									
Average	131.66	133.23	134.06	133.60	134.25	135.18	135.59	137.00	136.94
S.D.	36.77	37.71	37.75	37.31	37.26	37.06	37.23	37.27	37.11
30 ppt									
Average	160.76	162.48	162.28	162.17	162.06	161.95	161.82	162.46	162.46
S.D.	34.59	34.94	35.10	34.26	34.33	34.85	34.98	35.45	35.72

Table 11.A.

Length of petioles (in cm) collected from the experimental seedlings for 9 months

Salinity	Week								
	0	2	4	6	8	10	12	14	16
0 ppt									
Average	0.70	0.97	1.19	2.20	2.63	3.36	3.62	4.43	6.50
S.D.	0.63	0.81	0.98	1.10	1.18	1.42	1.55	1.46	1.72
15 ppt									
Average	0.55	0.88	1.07	1.63	2.07	2.57	2.93	3.55	5.04
S.D.	0.36	0.52	0.67	0.64	0.73	0.93	1.03	1.16	2.07
30 ppt									
Average	0.48	0.63	0.89	1.54	1.80	2.14	2.56	3.17	4.55
S.D.	0.39	0.55	0.73	0.79	0.79	0.83	1.35	0.99	1.73

Table 11.B.

Length of petioles (in cm) collected from the experimental seedlings for 9 months

Salinity	Week								
	18	20	22	24	26	28	30	32	34
0 ppt									
Average	7.44	8.52	9.71	10.70	10.74	12.29	12.37	12.80	14.68
S.D.	1.92	2.01	1.37	1.54	1.62	1.73	1.71	1.97	2.47
15 ppt									
Average	6.12	7.48	7.59	7.78	7.95	10.69	11.51	11.55	14.49
S.D.	2.09	2.28	2.26	2.49	2.44	1.57	1.81	1.81	3.21
30 ppt									
Average	5.47	6.71	7.32	8.53	8.62	9.48	10.04	7.91	8.30
S.D.	2.09	2.50	2.55	2.34	2.27	2.24	2.48	2.00	2.05

DISCUSSION

The field and laboratory findings indicate that seeds of the nipa palm germinate and that seedlings appear to grow better under conditions of lower salinities. As previously discussed, the reports of Bamroongrugsa (1991) and Kaewsinuan (1996) seem to indicate that higher salinity did not favor growth of nipa. Macnae (1968) had implied in his review of mangrove forest that the microhabitats of this palm are areas where both fresh and seawater meet. However, the physico-chemical requirements other than salinity as well as the types of soil and nutrients required by nipa are unknown. Much remains to be done to determine the most favorable total microenvironment for nipa palms. We can only point out the general observation that these palm species apparently need nutrients coming from terrestrial and marine sources to maintain luxuriant growth.

One question remains unanswered: If seedlings are highly dependent on low salinities, how were the mature nipa palms able to establish themselves in Plots 5 and 6, where salinities were generally high and more variable? The present study unfortunately is unable to provide a satisfactory answer.

Nipa appears to require salinities much lower than 30-36 ppt in order to survive and grow normally. However, more experiments to define exactly the physiological and ecological roles of salinity need to be conducted.

Based on data from this study, it is recommended that farming of nipa should be done in mangrove forests and swamps with silty to sandy loam soils at salinities ranging from 0 ppt to much lower than 30 ppt.

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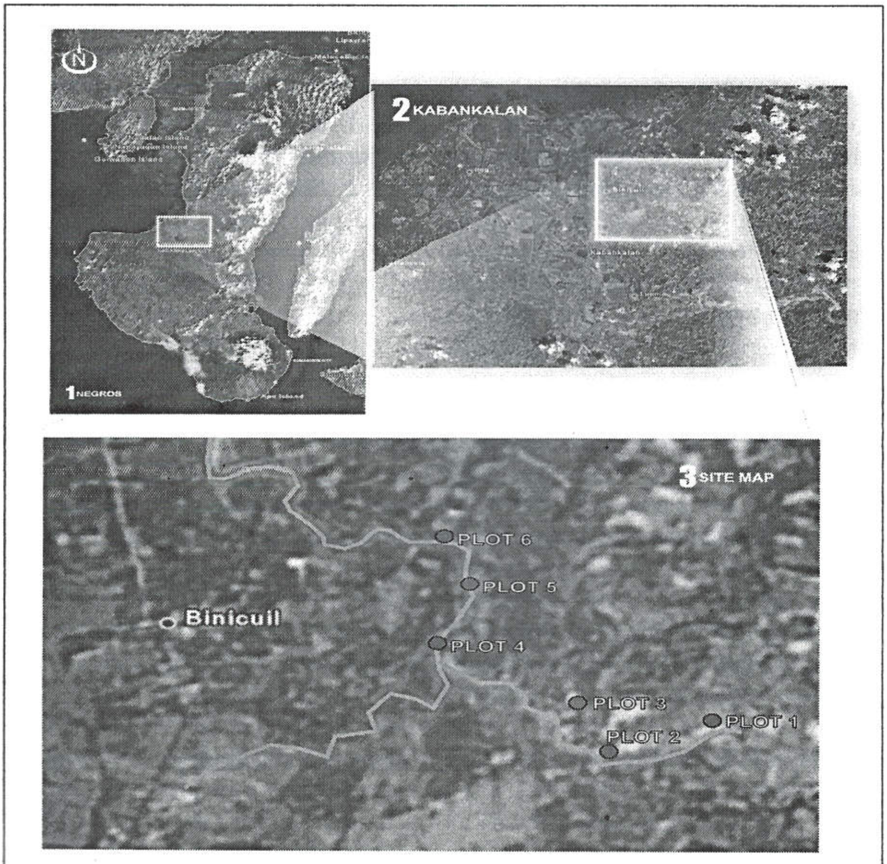


Figure 1. Map Showing the study site in Binicuil, Kabankalan City.

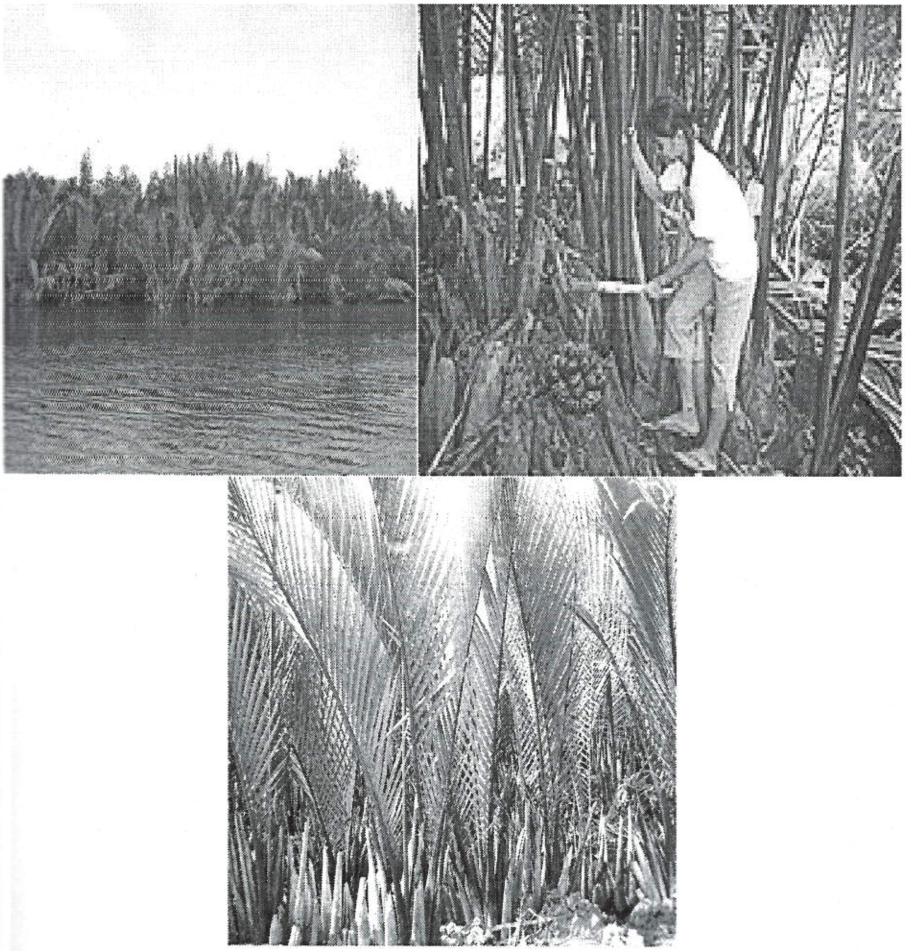
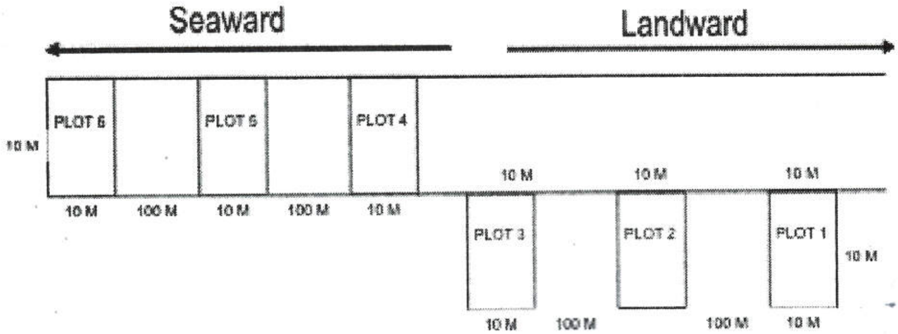


Figure 2. The Nipa groves in the study site. Nipa palms are distinguished by their large, compound, evergreen leaves arranged at the top of an unbranched stem. These palms inhabit coastal and estuarine areas.



The six plots have the following coordinates.
Plot 1 - 10 ° 01.957' N and 122° 49.944' E
Plot 2 - 10° 01.075' N and 122° 49.942' E
Plot 3 - 10° 01.100' N and 122° 49.968' E
Plot 4 - 10° 01.070' N and 122° 49.987 'E
Plot 5 - 10° 01.486' N and 122° 49962' E
Plot 6 - 10° 01.499' N and 122° 49.878 E

Figure 3. The design for the field survey on morphology of *Nypa fruticans*. Plots 1-6 are along the river bank.

Figure 4. The *Nypa fruticans* seedlings used in the experimental study arranged in a Completely Randomized Design (CRD).