GROWTH CHARACTERISTICS OF DOMINANTLY PLANTED SPECIES, *RHYZOPHORE APICULATA*, AND MICROCLIMATE IN THE MANGROVE FOREST IN CAN GIO DISTRICT, HO CHI MINH CITY, VIETNAM

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ABSTRACT

Characteristics of natural and reforested mangrove vegetations, microclimate in the mangrove forest, and growth of *Rhizophora apiculata* were investigated in Can Gio, Ho Chi Minh city, Vietnam. The elevation affects the survival and growth of the plants through affecting tidal inundation. Higher elevations with a lower tidal inundation and shorter inundation periods are preferable for *Rhizophora apiculata*

KEYWORDS: mangrove, microclimate, restoration, *Rhizophora apiculata*, Vietnam

INTRODUCTION

The pressures of increasing population, food production and industrial and urban development have recently damaged tropical and sub-tropical coastal zones. Especially in mangrove swamps, the excessive cutting of plants for fuel and construction materials and the conversion of the forests into agricultural land and aquaculture ponds for commercial production have caused environmental problems. Afforestation of mangroves and restoration of coastal zones, therefore, has recently become an urgent issue in many parts of the world. Promotion of plantation would be achieved by increasing survival and growth rates of plants through understanding how their growth characteristics are affected by environmental conditions in the plantation sites.

The objective of this study is to reduce the information gap on species-site-matching for mangrove restoration. We have investigated characteristics of natural and reforested mangrove vegetations, microclimate in the mangrove forest, and growth of dominantly planted species, *Rhizophora apiculata,* in Can Gio district, Ho Chi Minh city, Vietnam.

RESEARCH SITE

The research site (10° 23-30′ N and 106° 52-53′ E) was set inside the national park named "Can Gio Mangrove Biosphere Reserve" in Can Gio district located in 20 km southeast of Ho Chi Minh City, Vietnam (Fig. 1). This area was widely covered by natural mangrove forests before the 19th century. The mangrove forests, however, quickly reduced following growth in other land uses such as agricultural development, shrimp farming, charcoal production and destruction following several wars. Especially during the two Indochina wars, the mangroves in Can Gio district were completely destroyed by herbicide spray. After many years of herbicide spraying, the degraded land still remains degraded and bushy or bare. After the end of the war, great efforts have been made towards the rehabilitation of mangroves and 54 % of the area was recovered by 1998.

VEGETATION AT THE RESEARCH SITE

Actual vegetation and zoning of mangroves at our research site of the reforested area in Can Gio are shown in Table 1. For twenty years or more it has been planted *Rhizophora apiculata* at the research site and surrounding areas in Can Gio district. In most of the researched areas the planted *Rhizophora apiculata* reaches eight meters or more in height, developing a dense forest. However, by making a detailed examination at the mouth of the small river, we noticed the formation of a forest of *Avicennia* and *Sonneratia*, in which no planted *Rhizophora apiculata* could be detected. Even at *Rhizophora apiculata* groves it is possible to find naturally grown mangrove trees and shrubs such as *Lumnizera*, *Ceriops* and *Excoecaria*. This indicates that the process of restoration is going well to close to a natural ecosystem.

An *Avicennia alba*-community of around ten meters height spreads out nearby the mangrove forest front line or at the river mouth where it was detected the presence of accumulations of silt soil and fine sands. As component species, *Sonneratia alba*, which can be encountered in similar habitats, was identified. Inland from the *Avicennia alba*-community there is a single-species area covered with *Rhizophora apiculata* of eight meters or more.

MICROCLIMATE IN THE MANGROVE FOREST

The temporally variations of vertical distributions of air temperature and relative humidity in the mangrove forest are respectively shown in Figs. 2 and 3. The vertical distribution of air temperature was almost uniform in general, although the air temperature tended to rise as the height from the ground level is higher in daytime (Fig. 2). The relative humidity which was about 80% at around 9:00 lowered to 55-65% at 12:00-13:00 (Fig. 3). It rose afterwards and became 90-95% at around 17:00. The relative humidity tended to lower at a height of 5m at daytime. The distribution of the water vapour pressure also showed the similar tendency. It was guessed that the water vapour supplied by transpiration from the tree crown which is located at a height of 8m and evaporation from wet ground surface was being transported to the forest outside by the advection inside the forest. The difference of air temperature and relative humidity by the distance from the coast was not remarkable.

GROWTH PERFORMANCE OF *RHYZOPHORA APICULATA* AS AFFECTED BY ELEVATION

Determining the effect of environmental conditions on survival and growth of mangroves is important for successful plantation of mangroves in intertidal zones. Kitaya et al (2002a) and Komiyama et al. (1996) reported that microtopography affected survival and growth of young seedlings of *Rhizophora apiculata.*

In this research, the tree height of *Rhizophora apiculata* was affected by the distance from the coastal line as shown in Fig. 4. The mean tree height was greater at farer places from the sea. The air temperature and humidity did not show significant differences among different places in the research site. This growth promotion would be due to the lower tidal inundation and shorter inundation periods at higher elevations in the farer places from the sea.

A basic experiment was conducted with seedlings of *Rhizophora apiculata* for three years at the another site. Percentage survival of *Rhizophora apiculata* as affected by the elevations was measured every year after planting seedlings. The result is shown in Fig. 5. Plants showed lower percentage survival in lower elevations. The plants can survive at the relative elevations higher than 0.6 m and most of the plants survived at the relative elevations higher than 1.0 m after two years. However percentage survival values decreased at the relative elevations higher than 1.4 m three years after plantation. Plants showed different stem lengths and diameters in response to topography in the same experiment (Fig. 6). The mean stem elongation rate of plants at the relative elevations of 0-0.6 m was smaller than that at the relative elevations of 0.6-1.8 m. The stem elongation of the plants was almost constant regardless of the relative elevations ranging from 0.6 to 1.8 m. The plants also showed different rates of stem diameter increase in response to topography. *Rhizophora apiculata* had thicker stems at higher elevations. Therefore the growth rate that was indicated with the stem length multiplied by the stem diameter was greater at higher elevations.

There are approximately linear relationships between net photosynthetic rates and leaf conductance and between transpiration rates and leaf conductance, respectively (Kitaya et al., 2002b). We thus measured leaf conductance to assay how elevations affected net photosynthetic and transpiration rates in leaves. Leaf conductance was affected by elevations (Fig. 7). The mean leaf conductance at a relative elevation of 0.8 m was 1.5 times that at a relative elevation of 0.1 m. In the case of the transpiration rates, almost similar tendency was obtained. Therefore lower elevation would suppress the photosynthesis and thus growth of *Rhizophora apiculata*.

The elevation affects tidal inundation and the inundation period. Inundation for prolonged periods resulted in lower stomatal conductance and thus lower photosynthetic rates and lower transpiration rates. Survival and growth of *Rhizophora apiculata* were affected by even a slight elevation difference of 0.2 m.

CONCLUDING REMARKS

We may conclude that higher elevations with a lower tidal inundation and shorter inundation periods are preferable for growth of *Rhizophora apiculata* although the species is generally considered to have a tolerance to a higher tidal inundation and longer inundation periods. We expect that the results will provide a guideline information for selection of appropriate planting places in a mangrove restoration program. The Can Gio district seems to be a suitable site not only to conduct basic studies on ecosystems but also to investigate past and future changes of socio-ecosystems caused by rehabilitation and restoration of mangroves and coastal ecosystems.

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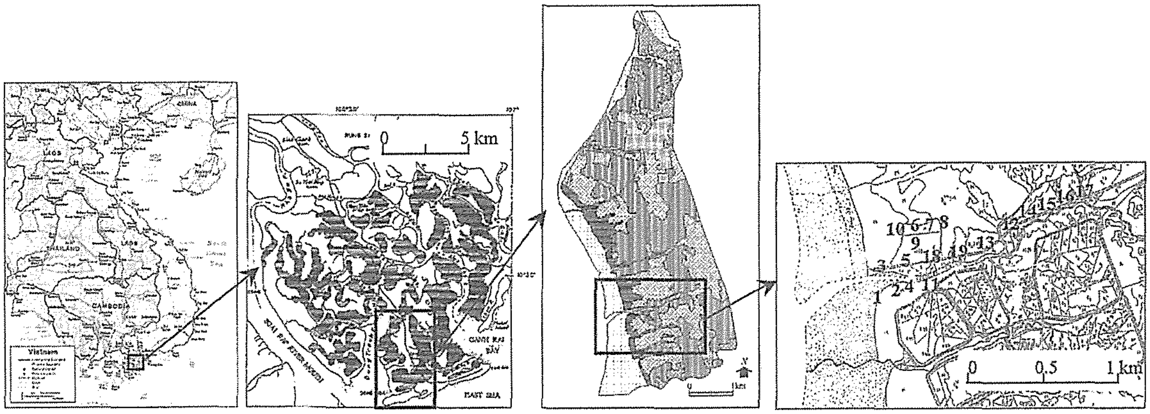

Vietnam　　Can Gio district　　A part of National Park　　Research area

Fig. 1. The research site in Can Gio district, Ho Chi Minh City, Vietnam.
For numbers in the right hand map, refer to Table 1.

Table 1. Phytosociological community at the research site in Can Gio district.

A: *Avicennia alba*-community(A1: Pionia phase, A2: Typical phase, A3: *Ceriops decandra* phase)
B: *Rhizophora mucronata*-community
C: *Sonneratia alba-Rhizophora apiculata* -community
D: *Avicennia alba-Avicennia officinalis* -community
E: *Rhizophora apiculata* -community

		A					B	C		D			E							
		A1	A2			A3														
No.:		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Date(July, 2002):		25th	25th	25th	25th	25th	26th	26th	26th	26th	26th	26th	26th	26th	26th	26th	26th	26th	25th	25th
qm:		25	100	150	100	120	30	30	30	30	30	30	100	100	100	50	100	100	120	150
Height of tree layer(m):			7	13	9	11							8	14	8	8	8.5	8.5	13	17
Cover of tree layer(%):			90	85	70	80							95	95	95	95	95	95	80	90
Height of shrub layer(m):			2	4	6	6	5	5	4	5	5	4	3	3	3		5		3	6
Cover of shrub layer(%):			5	5	30	30	70	70	70	95	80	100	5	3	3		3		5	5
Height of herb layer(m):		1.2		1.2	1.2	1.2	1	1	1	0.5	0.8	0.8	0.8	0.6	0.8	0.6	1	1	1	0.88
Cover of herb layer(%):		5		10	5	5	5	3	5	15	20	3	3	3	5	3	5	3	5	5
Total no. of species:		1	1	2	3	5	4	4	3	6	6	4	4	4	3	2	3	2	3	4
Mangtove tree species																				
Avicennia alba	T	.	5.4	5.4	4.5	3.3	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	S	.	2.1		3.3	1.2	.	.	.	2.2	2.2	.	.	.	.	.	.	.	.	+
	H	1.2		1.2	+.2		+.2	+	+	2.2	.	+	.	.	.	+	.	.	.	+
Rhizophora mucronata	S	.	.	.	.	.	4.4	.	.	.	.	.	.	.	.	.	.	.	.	.
Rhizophora apiculata	T	.	.	+.2	.	2.2	.	.	.	.	.	.	5.5	5.5	5.5	5.5	5.5	5.5	5.4	5.5
	S	.	.	.	1.2	2.2	2.2	4.4	4.4	.	1.2	.	.	+	+		+	.	1.2	+.2
	H	.	.	+	+	+	+	+	+	.	.	.	.	+	+		+	+	+.2	+.2
Sonneratia alba	T,S	.	.	.	(1.)	.	+.2	2.2	1.1	.	.	.	(+)	.	.	.	.	.	.	.
	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Avicennia officinalis	T	.	.	.	.	2.2	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1
	S	.	.	.	.	.	.	.	.	5.5	4.4	5.5	+	+	.	.	.	.	.	+
	H	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	1.2	.
Finlasia obovata	S,H	.	.	.	.	.	.	+		+.2	+	1.2	.	.	.	.	.	.	.	.
Lumnitzera raxcemosa	S	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	1.1	.	.
Ceriops decandra	T	.	.	.	.	2.3	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	S	.	.	.	.	2.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	H	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Excoecaria agallocha	S	.	.	.	.	.	.	.	.	(+)	.	.	.	.	.	.	.	.	.	.
Other species																				
Acanthus ilicifolius	H	.	.	.	.	.	.	.	.	.	2.2	(+)	.	.	.	.	+	.	+	.
Acrosticum aureum	H	.	.	.	.	.	.	.	.	+	.	.	.	+	+	.	.	.	.	.
Clerodendrum inerme	S	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.
	H	.	.	.	.	.	.	.	.	+.2	.	.	.	.	.	.	.	.	.	.
Derris trifolia	S	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
Finlaysonia obovata	S	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.

Italic: Planted mangrove species, Arial: Dominated species

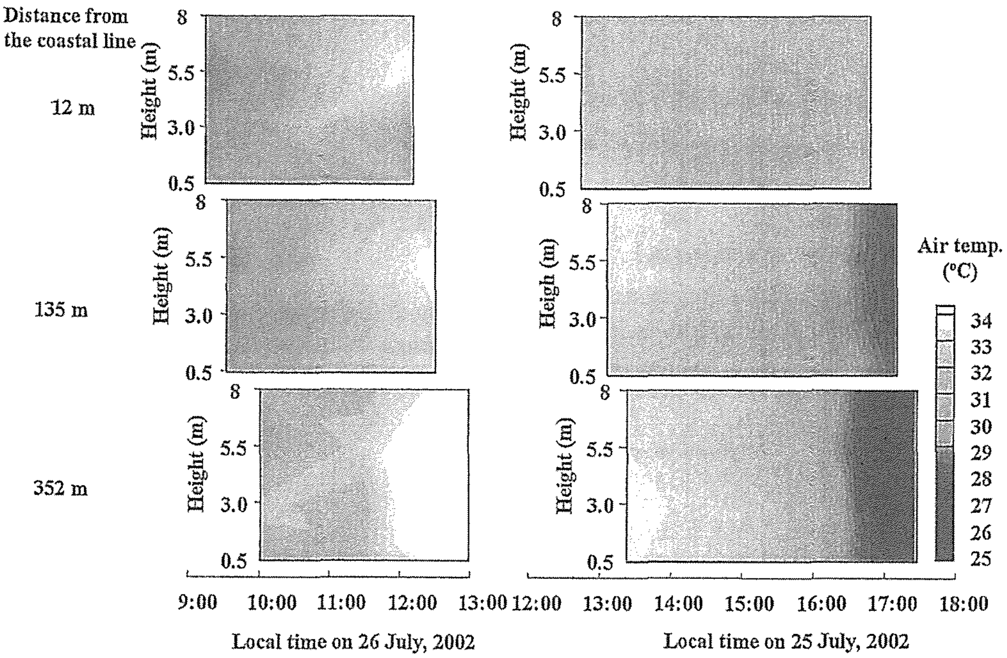

Fig. 2. The temporally variation of vertical distributions of air temperature in the mangrove forest

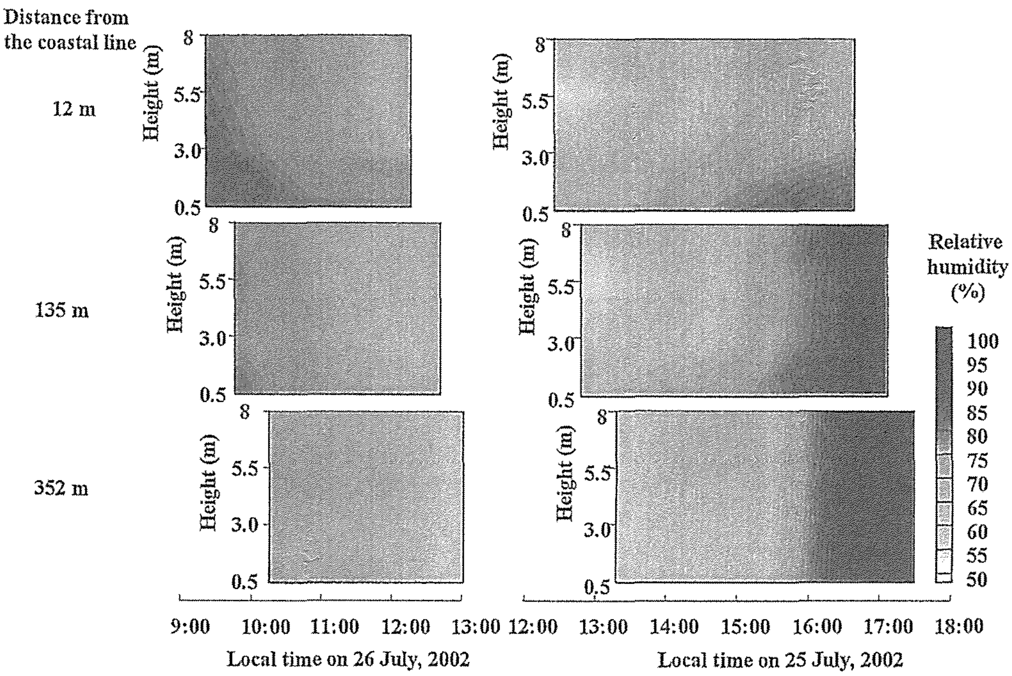

Fig. 3. The temporally variation of vertical distributions of relative humidity in the mangrove forest

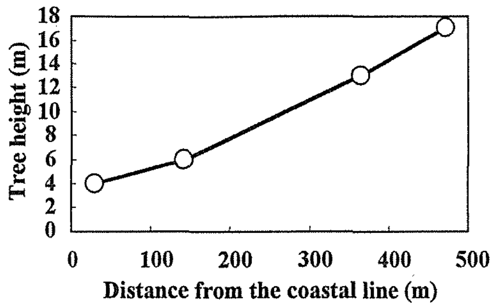

Fig. 4. Effect of distances from the coastal line on tree heights of *Rhizophora apiculata* in the mangrove forest.

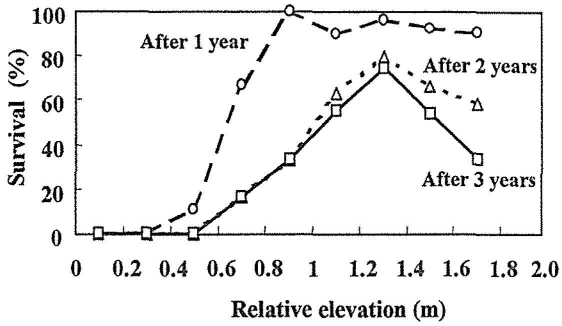

Fig. 5. Effect of elevations on survival of *Rhizophora apiculata* for three years.

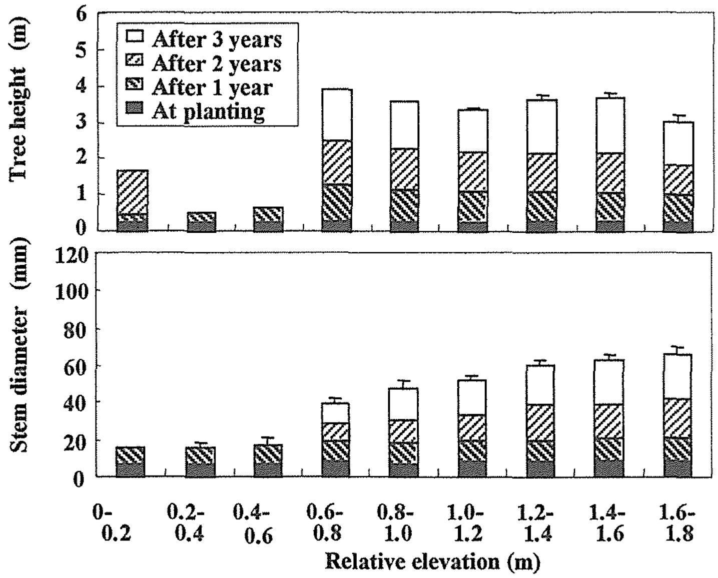

Fig. 6. Effect of elevations on tree heights and stem diameters of *Rhizophora apiculata* for three years. T: Standard deviation

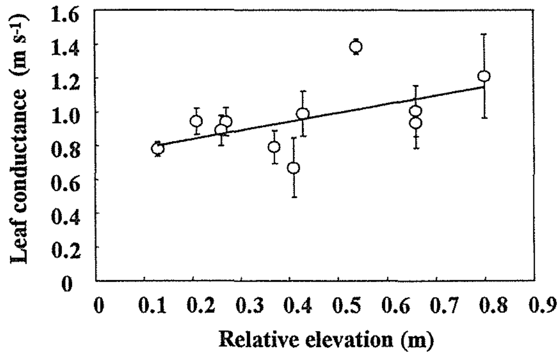

Fig. 7. Effect of elevations on leaf conductance of *Rhizophora apiculata.*
The leaf conductances were measured under photosynthetic photon flux densities ranging 800-2000 μmol m^{-1} s^{-1}. I: Standard error