CHAPTER V

DISCUSSIONS

<u>Mangrove seedlings</u>

After 12 months old plantation, average percent survival rate of *R. apiculata* was 66.67 while the average percent survival rate of *B. gymnorrhiza* was 41.33. The average percent survival rate of *C. tagal* was nil after ten months period. The trend of survival of both *R. apiculata* and *B. gymnorrhiza* were similar. But the survival trend of *C. tagal* was different. It was observed that there were at least one study period that percent survival rate of this species greatly decreased. The two reasons that may be the causes of decreased survival rate in mangrove seedlings were due to high temperature and waterlogged condition due to tide. Bamroongrugsa(1991) studied on the mangrove plantation carried out on the new mud flat area caused by the sedimentation from rivers around Pattani Bay. He found that the mortality of mangrove seedlings was very high. The main cause of seedlings mortality were drought and high temperature in the ground during dry season. In this study, the shrimp pond area were bare ground without tree cover due to clear cutting, thus the seedlings faced the direct sun light all day. During the neap tide period, there was approximately one-inch of standing water. The water temperature was also high. The seedlings must adapt themselves to the new environments in the time of establishment especially to temperature and tide (Clarke and Hannon,1969; Chapman,1976). These two factors related to other environmental factors such as salinity, light, and soil conditions. The high water level period during February to June, 1993, caused the seedlings to submerge underwater. There has not been any research on the effect of submergence on these three mangrove seedlings. Clarke and Hannon (1970) studied in *Avicennia* sp. and found that *Avicennia* sp. germinated in waterlog area were with high mortality. He also found that this condition would not affect them if they can split 2-4 leaves. For this study, *R. apiculata* had high survival rate than the rest in the first four months because *R. apiculata* can germinate the leaves after one month old plantation. While *B. gymnorrhiza* and *C. tagal* germinate the leaves after two months old plantation. The survival rate of *C. tagal* was stable only in August and rapidly decreased from October, 1993 to February, 1994. The reason for the decreased survival rate came from waterlogged condition due to high tide from December, 1993 to February, 1994. Besides this, the leakage of the pond in the last two months also caused the high standing water. The electrical pump failed to pump all water out causing the seedlings to submerge underwater everyday. During this period, the shoot apex of *B. gymnorrhiza* and *R. apiculata* were high above the water level so they could survive. All of the seedlings of *C. tagal* could not survive because they were totally submerged under the water. In nature, *C. tagal* was generally found on the drier area landward in contrasted to the

R. apiculata and *B. gymnorrhiza* that were found in the zonation near the sea. Therefore, the frequency of the inundation occurred in the *C. tagal* zone was less than in the *R. apiculata* and *B. gymnorrhiza* zones. Thus the resistance of the *C. tagal* to high standing water was lower than *R. apiculata* and *B. gymnorrhiza*.

The height growth of all three mangrove species showed similar trends. In June, 1993, the average height growth of three mangrove seedlings sharply increased. Firstly, the seedlings that had passed through the time of establishment can easily adapt themselves and thrived in the new environments. They used the storage food from the propagules to increase their height. Secondly, after two months plantation the seedling were with some leaves so that they could synthesized food by photosynthesis. They could grow rapidly due to photosynthetic production. Soonhuae(1978) studied on the distribution, growth, and survival of mangrove seedlings at Amphoe Klung, Changwat Chantaburi. He planted three mangrove species: *R. apiculata*, *R. mucronata* and *B. gymnorrhiza* in September, 1976, and he found that both Rhizophora species sharply increased in height after one month plantation. He also explained that the increased height was because the seedlings used the storage food from hypocotyl. After the sharp increased in height within four months period, the average height growth slowly increased. This may be due to the seedlings invested their energy to enhance the leaves and branches than to increase shoot elongation as in the finding of Soonhuae(1978). Another reason may be due to the decreased storage food in their propagules.

R. apiculata showed higher growth than *B. gymnorrhiza* during the last two months because of the established root system. They can effectively use the nutrients from soil for growth and development (Soonhaue, 1978). Besides this, the inner structure of the *R. apiculata* root can trap air and lenticel in the root also aid in the exchange of gas(Komkris,1993).

The size of the propogules may influence the height growth among species. The propagules of *R. apiculata* were long, while the propagules of *B. gymnorrhiza* were short and chubby. The propagules of *C. tagal* were thinner and shorter than *R. apiculata*. Therefore, the propagules of *R. apiculata* and *B. gymnorrhiza* had more storage food than *C. tagal*. In this study, *R. apiculata* had the highest average height growth, *B. gymnorrhiza* with the median height growth, and *C. tagal* had the lowest average height growth. Aksornkoae(1975) and Kongsangchai(1980) found that *R. apiculata* used storage food from their propagules in the first six-month-old for growth and establishment. Teratanatorn(1980) studied on growth and survival of mangrove species planted on the area after mining at Amphoe Takua Pa, Changwat Phangnga. He also confirmed that the difference of height of each species in the early months may come from the size of propagules because *Rhizophora* spp. in his study were higher than *C. tagal* too. The height growth of *B. gymnorrhiza* in June to December, 1993 were observed higher than *R. apiculata*. This may be due to the canopy structure of *B. gymnorrhiza*(Komgris, 1993). The arrangemant of their branches expand like a circle, so their photosynthesis were very effective (Figure V-1). This

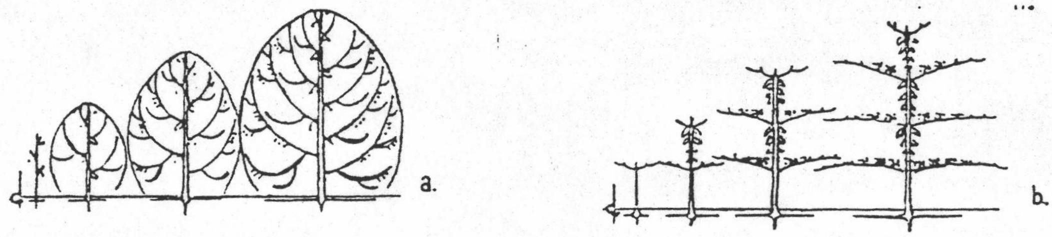

Figure V-1 Architectural model of plant in Family Rhizophoraceae

a) Attim's model found in *R. apiculata*

b) Aubreville model found in *B. gymnorrhiza*

From Tomlinson(1988) quoted by Komkris(1993)

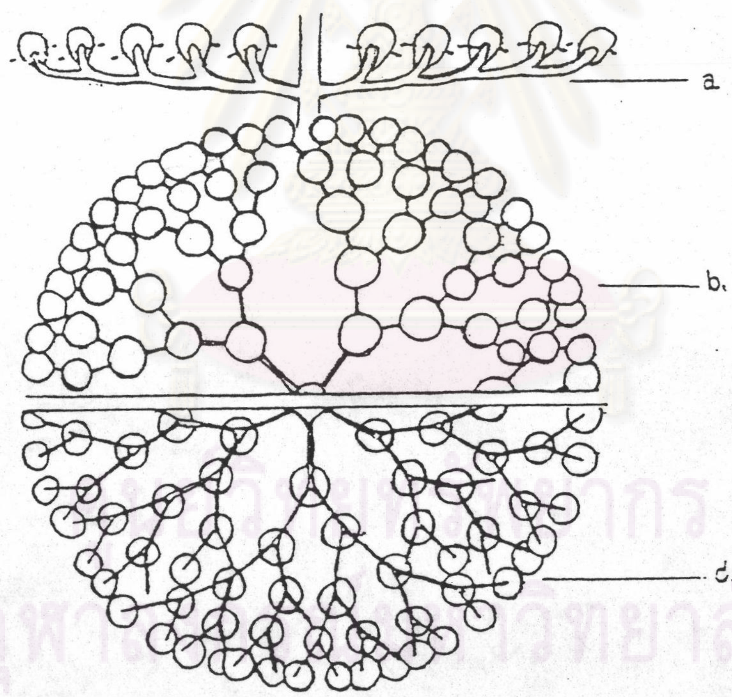

Figure V-2 Branches Formation of Aubreville model

a) side view b) top view c) bottom-up view

From Tomlinson(1988) quoted by Komkris(1993) characteristic only found in *B. gymnorrhiza* and *B. sexangula*. While the arrangement of *R. apiculata* branches were in verticle line with loosen branched (Figure V-2).

Soil parameters. (Table V-1)

Most of the soil properties in this shrimp pond prior to the plantation were different from the natural mangrove soil except for the percentage of moisture content and the sodium concentration. The concentrations of inorganic nitrogen, potassium and magnesium were lower than that of the natural mangrove soil. While the soil pH, the concentrations of phosphate and calcium were high in the shrimp pond soil. The low concentration of inorganic nitrogen affected the growth and survival of seedlings because nitrate was the major element for plant. Moreover, ammonia was very important for early stage of plant(Board of Soil Science, 1987). These concentrations increased after one year old plantation but still lower than the concentrations in natural mangrove. Therefore, nitrogen fertilizer added in soil was necessary. Although potassium and magnesium concentrations before plantation were lower than as compared to the natural forest, their concentratations increased during one year plantation. These levels of potassium and magnesium concentrations were comparable to the concentrations occurred in the natural mangrove. The phosphate and calcium concentrations were also high during one year plantation. The high phosphate concentrations should support high survival rate and growth of seedlings. However, the high

Table V-1 Comparison on soil parameters between this study and natural mangrove forest.

soil parameters	this study before plantation	this study after one year plantation	natural mangrove
texture	silty clay loam	clay loam	clay(Narongrit,1992)
moisture content(%)	54.77-56.21	59.41-63.51	50.7-58.5(Wattayakorn et.al.,1993)
pH	7.4-7.5	7.2-7.3	5.8-6.3(Narongrit,1992)
			6.0-6.5(Wattayakorn et.al.,1993)
NH_3(ppm.)	1.677-1.869	1.755-2.392	8.36-27.11(Wattayakorn et.al.,1993)
NO_2^- (ppm.)	0.004-0.005	0.034-0.044	0.07-0.13(Wattayakorn et.al.,1993)
NO_3^- (ppm.)	0.039-0.056	0.157-0.297	0.94-1.34(Wattayakorn et.al.,1993)
PO_4^{3-}(ppm.)	1.539-2.539	3.501-3.988	0.16-0.26(Wattayakorn et.al.,1993)
K(ppm.)	710.72-837.44	1522.99-1599.02	1670-2050(Narongrit,1992)
			435-643.6(Wattayakorn et.al.,1993)
Ca(ppm.)	6813.60-8216.40	3607.20-4184.35	771.0-843.0(Narongrit,1992)
			510.4-1033.1(Wattayakorn et.al.,1993)
Mg(ppm.)	1337.05-1742.22	6738.73-8786.60	1870.0-2015(Narongrit,1992)
			2090-2775.4(Wattayakorn et.al.,1993)
Na(ppm.)	9398.06-9996.12	7000.00-8493.16	9587.0-10025.0(Narongrit,1992)
			4125.0-10890.0(Wattayakorn et.al.,1993)

calcium concentration hindered the uptake of potassium by plant (Board of Soil Science, 1987). Soil pH in this abandoned shrimp pond were neutral both before and after one year old plantation. This soil pH was in the suitable range for plant.(Figure V-3)

This investigation revealed that this shrimp pond soil was not at all a waste land. Most of the soil parameters especially the pH were in the suitable range that plant could uptake nutrients for growth. Therefore, the rehabilitation of mangrove seedlings on the area such as this should be successful. However, soil analysis was very important before any plantation.

The inorganic nitrogen in the shrimp pond were similar to the concentrations in the abandoned tin mining area but were lower than the concentrations in the natural mangrove of Wattayakorn et.al.(1993). While the phosphate concentrations contrasted to the inorganic nitrogen with were very high concentration when compared with the study of Wattayakorn et.al.(1993) both in natural mangrove and abandoned tin-mining. This was also true for the both calcium and magnesium concentrations were found higher than those reported in the study of Narongrit(1993) in shrimp farming soil and the study of Wattayakorn et. al.(1993) in natural mangrove soil and in abandoned tin mining soil. The extractable potassium concentrations were similar to the concentrations in the natural mangrove and shrimp pond of Narongrit(1993) but lower than the finding of Wattayakorn et.al.(1993) in the natural mangrove and abandoned tin-mining. The sodium concentrations were similar to the study of Narongrit(1993) and Wattayakorn

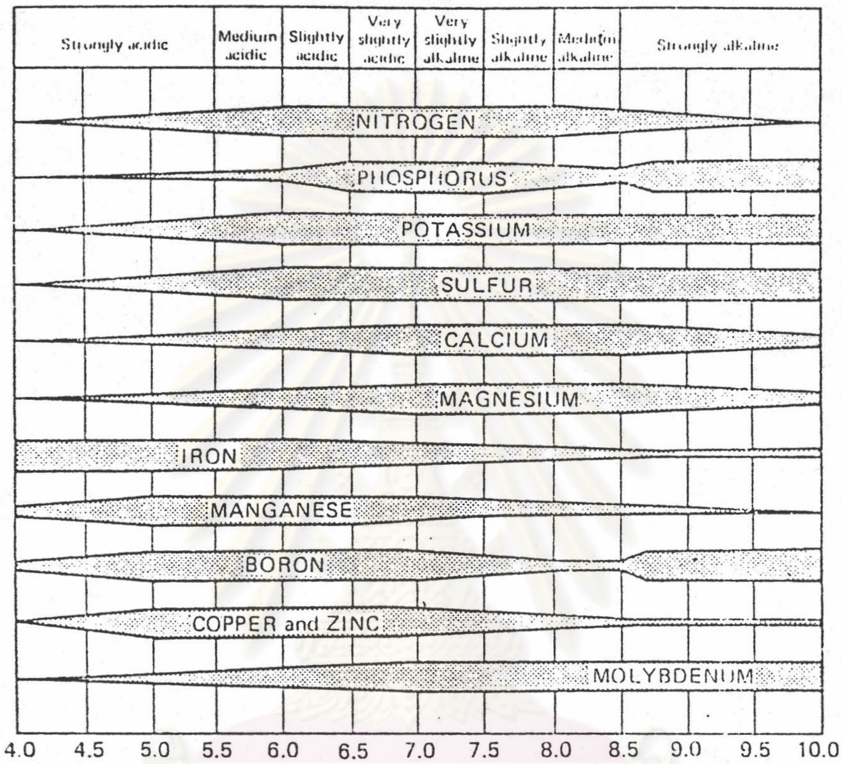

Figure V-3 **General relationship between soil pH and availability of plant nutrients, the wider bar, the more availability. (Foth, 1984)**

et.al.(1993). Soil pH range lined between 6.8-7.5, and it meant this soil had neutral condition. In general, soil reaction of natural mangrove was slight to strong acid(Aksornkoae,1982; Higaki and Takagi,1985; Kongsangchai,1985; Panichsuko, 1985; Aksornkoae,1986; Narongrit,1993; Wattayakorn et.al.,1993) as same as the area after shrimp farming (Chantadisai and Apinan,1985; Bhodipak,1988).and abandoned tin-mining area (Wattayakorn et.al., 1993) But this soil was not acidity may be due to this soil submerged under seawater before plantation so the sulfuric acid from oxidation reaction did not occurred(Bhodipak,1988). This finding corresponded to Narongrit(1993) that the shrimp pond soil submerged under seawater(the bottom area) at laest 4 months will show the neutral to slight base. Percent moisture content of all three mangrove seedlings soil were higher than 50 percent. These were similar to the study in natural mangrove soil but higher than in abandoned tin mining soil(Wattayakorn et.al.,1993). The soil texture were silty clay loam and clay loam that were classified in the group of moderately fine-textured soil as same the group as the shrimp pond soil in the work of Narongrit(1993). This group of soil caused poor soil drainage.

From this study, *R. apiculata* had the highest survival rate and growth. The environmental factors of this abandoned shrimp pond as shown in Table V-2 - Table V-4 were suitable for *R. apiculata* than both of *B. gymnorrhiza* and *C. tagal*. Tide, water salinity, and soil texture of all three mangrove species were similar to other researches, while the soil nutrients

Table V-2 Comparison on some parameters affected on survival and growth of *R. apiculata* between this study and other researches

Parameters	in this study	other researches			
		natural mangrove area	private plantation area	after mining area	mud flat area
tide	spring tide	normal high tide (Banijabatana,1957;			
		Ding Hou,1958; Steenis,1958;			
		Chapman,1970; Berry,1972; Sasekumar,1973;			
		Klankamsorn and Jarruppat,1982)			
water salinity	10-20 ppt.	tolerate below 15 ppt. (Watson,1928)			
		tolerate 1-30 ppt. (de Hann,1931)			
soil texture	silty clay loam	soft clay (Ding Hou,1958; Steenis,1958;	silty clay loam (Sukseleung,1981)	silt loam (Aksornkoae,1986)	silty clay (Panichsuko, 1984)
	clay loam	Walsh,1974)	clay (Wechakit,1987)	sandy clay loam (Teratanatorn,1988)	
		damp sticky soil (Kalk,1962)			
		new sedimental silt (Jordan,1964)			
		black soil with sand and humus(Macnae,1968)			
		silty clay (Panichsuko,1984)			

Table V-2 Comparison on some parameters effected on survival and growth of *R. apiculata* between this study and other researches(cont.)

Parameters	in this study	other researches			
		natural mangrove	private plantation	after mining area	mudflat area
soil pH	6.8-7.5	low pH (Thomlinson,1957)	5.7-6.4 (Sukseleung,1981)	6.1 (Aksornkoae et.al.,1986)	7.5-7.7 (Srisawasdi,1983)
		5.6 (Hesse,1961)	3.6-6.2 (Wechakit,1987)	6.4 (Teratanatorn,1988)	3.3-6.2 (Panichsuko,1984)
		6.6 (Giglioli and Thornton,1965)			
		2.68-4.95 (Kongsangchai,1974)			
		7.5 (Pornpattima,1979)			
NH_3(ppm.)	0.488-1.961	1 (Hesse, 1961)			
NO_3^-(ppm.)	0.039-0.355	1 (Hesse, 1961)			
P (ppm.)	1.539-7.89*	5.25-5.75 (Kongsangchai,1974)	51 (Wechakit,1987)	8-16 (Aksornkoae et. al.,1986)	37-58 (Srisawasdi,1991)
				11.7 (Teratanatorn,1988)	8-11 (Panichsuko,1984)
K (ppm.)	710.72-1746.07	67.3-902 (Kongsangchai,1974)	484-703 (Sukseleung,1981)	902 (Aksornkoae et. al.,1986)	768-800 (Srisawasdi,1991)
			765 (Wechakit,1987)	67.3 (Teratanatorn,1988)	136-137 (Panichsuko,1984)
Ca(ppm.)	3607.2-8216.4		987-1480 (Sukseleung,1981)	131 (Teratanatorn,1988)	110-196 (Panichsuko,1984)
			1520 (Wechakit,1987)		
Mg(ppm.)	1337.05-8786.6		2115-3105 (Sukseleung,1981)	1237 (Teratanatorn,1988)	248-1110 (Panichsuko,1984))
			2340 (Wechakit,1987)		

* PO_4^{3-} concentration

Table V-3 Comparison on some parameters affected on survival and growth of *B. gymnorrhiza* between this study and other researches

Parameters	in this study	other researches
		nature mangrove area
tide	spring tide	spring tide (Watson,1928)
water salinity	10-20 ppt.	10-30 ppt. (de Hann,1931; Macnae,1968)
soil texture	silty clay loam	soft, muddy soil (de Hann,1931)
	clay loam	sand (Hatheway,1953; Moul,1957; Gledhill,1963)
		dry soil with underground water near soil surface (Macnae and Kalk,1962)
		sand (Hatheway,1953; Moul,1957; Gledhill,1963)
soil pH	6.8-7.5	3.9-3.95 (Kongsangchai,1974)
P(ppm.)	1.539-7.89*	5.7-5.88 (Kongsangchai,1974)
K (ppm.)	710.72-1746.07	139.75-159 (Kongsangchai,1974)

* PO_4^{3-} concentration

Table V-4 Comparison on some parameters affected on survival and growth of *C tagal* between this study and other researches

Parameters	in this study	other researches: natural mangrove	other researches: mud flat area	other researches: after mining area
tide	spring tide	spring tide (Banijabatana,1957; Chapman,1970; Berry,1972; Sasekumar,1973; Klankamsorn and Jarruppat,1982)		
water salinity	10-20 ppt.	more than 30 ppt. (Macnae,1968) not more than 60 ppt. (Chapman,1976)		
soil texture	silty clay loam clay loam	dry soil (Macnae and Kalk,1962) silty clay (Srisawasdi,1985)	silty loam (Srisawasdi,1991)	clay (Teratanatorn,1988)
soil pH	6.8-7.5	4.2 (Srisawasdi,1985)		2.2 (Teratanatorn,1988)
P(ppm.)	1.539-7.89‡	15.6 (Srisawasdi,1985)	37-58 (Srisawasdi,1991)	13.7 (Teratanatorn,1988)
K(ppm.)	710.72-1746.07	902 (Srisawasdi,1985)	768-800 (Srisawasdi,1991)	13.3 (Teratanatorn,1988)
Ca(ppm.)	3607.2-8216.4			121 (Teratanatorn,1988)
Mg(ppm.)	1337.05-8786.6			1237 (Teratanatorn,1988)
Na (ppm.)	5376.07-10594.17			5867 (Teratanatorn,1988)

‡ PO_4^{3-} concentration

were different. The factors that favored for *R. apiculata*, *B. gymnorrhiza* and *C. tagal* were tide, water salinity, soil texture. Besides these three factors, soil pH, phosphate, potassium and magnesium concentrations in the shrimp pond were also in the suitable range for *R. apiculata*. While the phosphate and sodium concentration were also favored for *B. gymnorrhiza* and *C. tagal* respectively. However, the survival rate and height growth of both *R. apiculata* and *B. gymnorrhiza* were as high as other researches at different areas while both survival rate and height growth of *C. tagal* were lower than other investigations (Figure V-4 - Figure V-9). Therefore, the suitable mangrove species that could survive and thrive on this shrimp pond area were *R. apiculata* and *B. gymnorrhiza*. In order to increase the percent survival and heightgrowthofallthree mangrove seedlings in the same soil condition such as in this case, attentions should be paid to the certain soil(Table V-5). The percent silt is the prime important factor influencing the survival of *R. apiculata*. The percent silt, potassium, calcium and sodium concentrations greatly on the other hand influenced the growth. The soil with more silt caused the good soil drainage, so the survival rate increased. In the same time, the soil with more silt caused low growth because of low fertility. The high magnesium and potassium concentrations elevated height growth because both of them were the essential nutrient for plants. The calcium concentration in this study pond washigh. Thus there is no need to add calcium in the shrimp pond prior to plantation. As for *B. gymnorrhiza*, the magnesium and ammonia concentrations were the major factors on the survival while magnesium and phosphate concentrations on the growth. The ammonia concentration in this study was low, so the increase of ammonia concentration in the form of fertilizer would ensure the high survival rate of this species. While magnesium and phosphate concentrations also important for the height growth of *B. gymnorrhiza*. However high concentrations of both magnesium potassium would hinder the survival rate of this species. This is also true for *C. tagal*. It is evidenced that in this study pond, not only soil parameters but also the high standing water due to the dike obstruction were important for the survival rate and growth of seedlings. Therefore, the enhancement of normal flooding tide such as the removal of the dike should be carried out in order to increase the percent survival and height growth. This operation may not be feasibled because it is costly. The limit of the standing water level in the pond to approximately 10-20 centimeters should be another choice. The latter method is more feasible in term of cost and operation.

<u>Changes in Soil parameters during plantation period</u>.

The soil texture for all three mangrove seedlings was silty clay loam. Throughout the plantation period, the soil texture remained the same except for the last four months that the texture was clay loam. The percentage of sand increased during this period may be due to high water level and the road

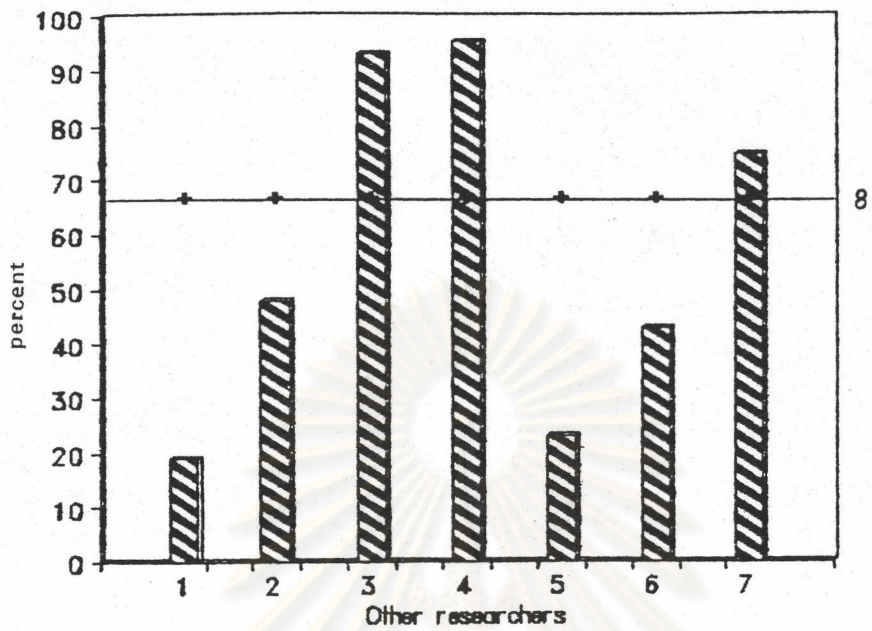

Figure V-4 Comparison on survival of *R. apiculata* after one year plantation.

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1 - Soonhaue(1978) study on bared area at Chantaburi Province.

2 - Soonhaue(1978) study in natural mangrove at Chantaburi Province.

3 - Srisawasdi(1982) study on abandoned mining area at Phang-nga.

* data ended at six-month-old seedlings *

4 - Wechakit(1987) study on private plantation at Samutsongkram.

5 - Teratanatorn(1988) study on area after mining at Phang-nga.

6 - Bamroongrugsa(1991) study on new mud flat at Pattani Bay.

7 - Srisawasdi(1993) study on mud flat at Nakorn Si Thammarat.

8 - —+—+— Data from this study.

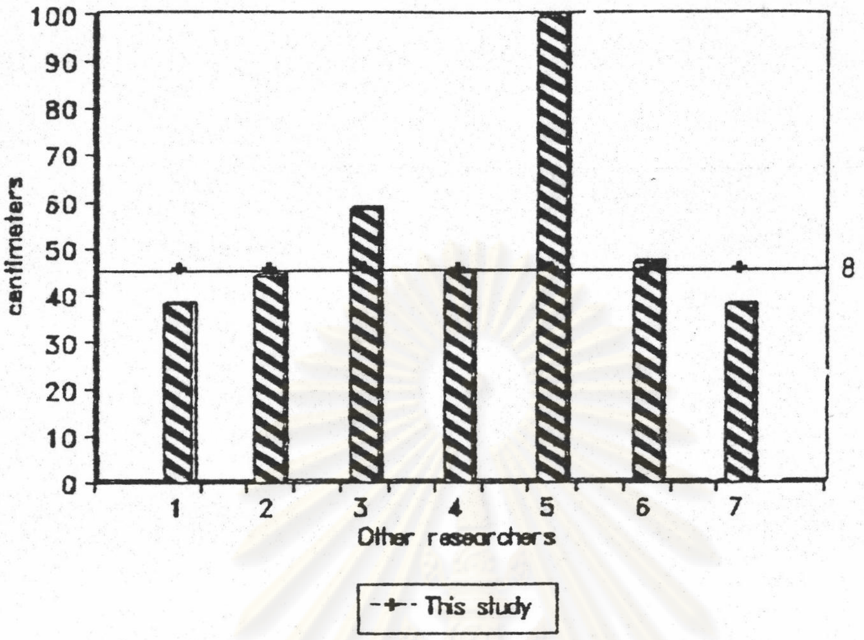

Figure V-5 Comparison on height growth of *R. apiculata* after one year plantation.

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1 - Soonhaue(1978) study on bared area at Chantaburi Province.

2 - Soonhaue(1978) study in natural mangrove at Chantaburi Province.

3 - Srisawasdi(1982) study on abandoned mining area at Phang-nga.

* data ended at six-month-old seedlings *

4 - Wechakit(1987) study on private plantation at Samutsongkram.

5 - Teratanatorn(1988) study on area after mining at Phang-nga.

6 - Bamroongrugsa(1991) study on new mud flat at Pattani Bay.

7 - Srisawasdi(1993) study on mud flat at Nakorn Si Thammarat.

8 - — + — + — Data from this study.

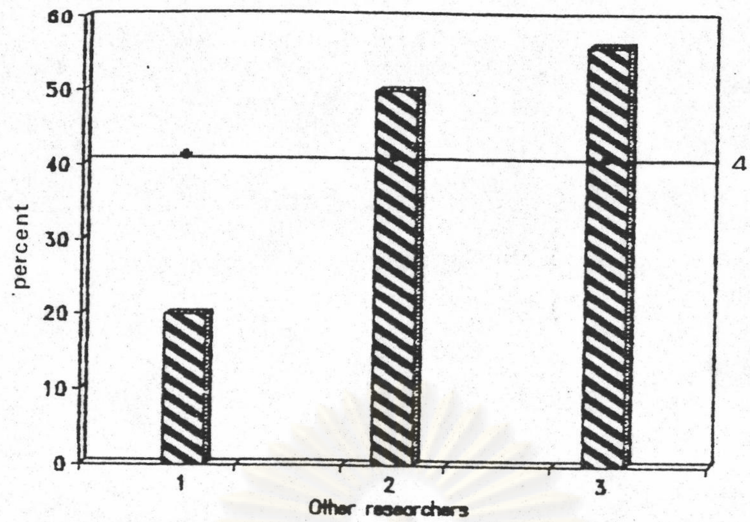

Figure V-6 Comparison on survival of *B. gymnorrhiza* after one year plantation.

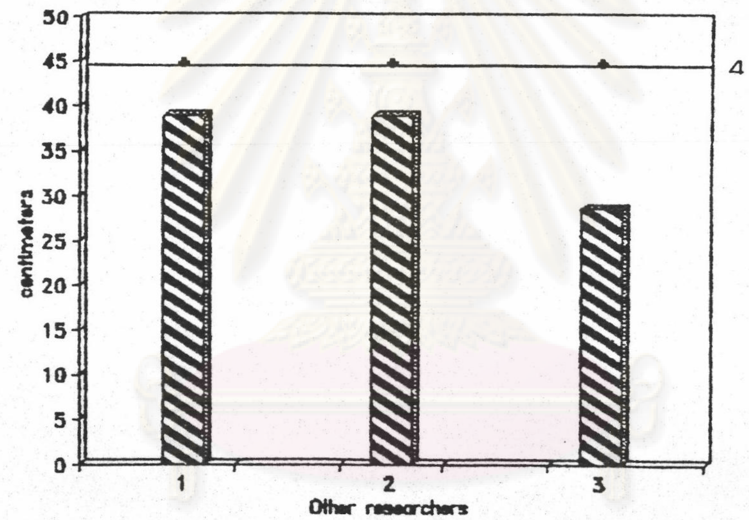

Figure V-7 Comparison on height growth of *B. gymnorrhiza* after one year plantation.

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1 - Soonhaue(1978) study on bared area at Chantaburi Province.

2 - Soonhaue(1978) study in natural mangrove at Chantaburi Province.

3 - Srisawasdi(1982) study on abandoned mining area at Phang-nga.

* data ended at six-month-old seedlings *

4 - — + — + — Data from this study.

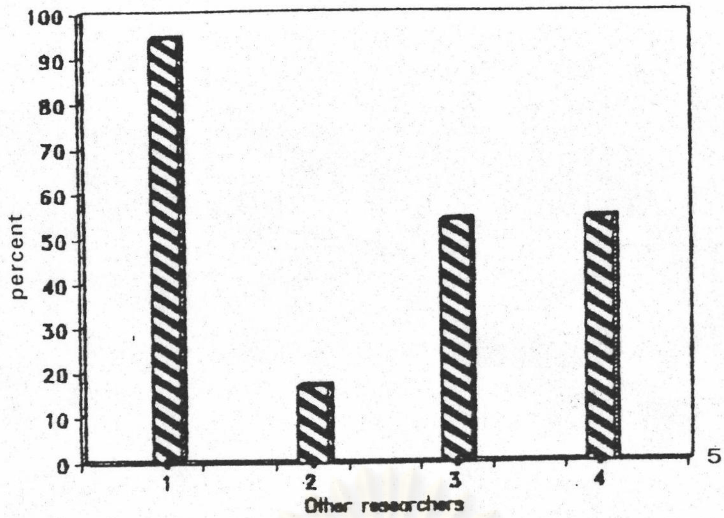

Figure V-8 Comparison on survival of *C. tagal* after one year plantation.

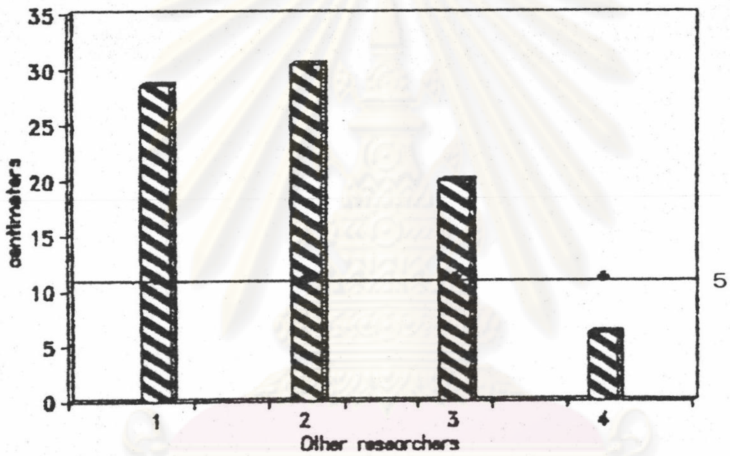

Figure V-9 Comparison on height growth of *C. tagal* after one year plantation.

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1 - Srisawasdi(1982) study on abandoned mining area at Phang-nga.

* data ended at six-month-old seedlings *

2 - Teratanatorn(1988) study on area after mining at Phang-nga.

3 - Bamroongrugsa(1991) study on new mud flat at Pattani Bay.

4 - Srisawasdi(1993) study on mud flat at Nakorn Si Thammarat.

5 - — + — + — Data from this study.

Table V-5 The multiple regression equation from stepwise method for survival and height growth of three mangrove seedlings.

mangrove species	multiple regression equations	multiple r	standard error
R. apiculata	SURVIVAL = $-51.9376 + 3.2187SILT - 32.1263NO_3^-$	0.90687	6.32522
	HEIGHT = $60.3367 - 1.8339SILT + 0.0289K - 0.0147Ca + 0.00201Na$	0.99188	2.78195
B. gymnorrhiza	SURVIVAL = $86.9529 - 0.0105Mg + 14.1465NH_3$	0.93602	9.69434
	HEIGHT = $-14.5782 + 0.0056Mg + 5.6599PO_4^{3-}$	0.93345	6.99683
C. tagal	SURVIVAL = $152.0629 - 0.0102Mg - 0.0465K$	0.93695	1.97124
	HEIGHT = $-11.1134 + 0.0143K$	0.96403	11.24853

construction around the shrimp pond in December, 1993.

The soil pH in the shrimp pond ranged between 6.8-7.5 with neutral condition in contrast to slight to strong acid soil condition as reported for the natural mangrove forest (Aksornkoae, 1982; Higaki and Takagi,1985; Kongsangchai,1985; Panichsuko, 1985; Aksornkoae,1986; Narongrit,1993; Wattayakorn et. al.,1993) and the area after shrimp farm (Chantadisai and Apinan,1985; Bhodipak, 1988). But this soil was not acidity due to this soil totally submerged underwater before the plantation, so that the sulfuric acid from oxidation reaction did not occurred(Bhodipak,1988). Narongrit(1993) found that the shrimp pond soil that submerged under seawater (the bottom area) at least 4 months will show the neutral to slight base. After plantation, the pH decreased due to the oxidation reaction and in the last four months the pH increased again when soil submerged under seawater.

The percentage of moisture content of all three mangrove seedlings were high comparable to the natural mangrove forest. The high moisture content remained stable through out the plantation period.

The changes in the inorganic nitrogen group showed that the ammonia and nitrite concentrations decreased during the first four months and increased steadily in the last eight months. While the nitrate concentration increased sharply during the first four months and gradually declined in the last eight months. The decreases in ammonia and nitrite concentrations were due to the anaerobic condition because the soil submerged under seawater more than one year before plantation. As for ammonia, the decrease in ammonia concentration also due to the uptake of the seedlings (Board of Soil Science Department,1987). The increase in nitrate concentration not only due to ammonia and nitrite with aerobic condition but also due to the rain(Hungspreugs, 1989). Becaues of anaerobic condition due to high tide in the last four months, the ammonia and nitrite concentrations increased that corresponded to the decrease in nitrate concentration.

The Phosphate concentrations as well as the extractable potassium concentrations increased during the first eight months and declined during the last four months. In contrast, the decrease in phosphate concentrations were due to anaerobic condition. Mortimer(1971) stated that the reducing condition gained the exodus of phosphate from sediment. Besides this, phosphate that was fixed by ferric and aluminum oxide was substituted by the organic anion, so there were more phosphate in soil solution (Board of Soil Science Department,1987). The increase in extractable potassium concentrations was due to the cation exchange capacity of clay mineral. In general, potassium concentrations in seawater is approximately 399 milligram per litre; of this 99 percent is free ion, and the rest is in sulphate form (Hungspreugs,1989). When the seawater was drained into the pond, the clay minerals can adsorbe these free ions on their surface thus the extractable potassium concentration increased. Walsh(1967) confirmed that clay can adsorb high potassium concentration from seawater that causes high potassium concentration in soil. Narongrit(1993) also found that mangrove soil that submerged under seawater for a long time would have high potassium concentration than in shrimp farm soil. From Board of Soil Science(1987), soil pH increased, the extractable potassium concentration that losses by leaching will decrease as follow:

Soil pH	Base saturation(%)	Exchangeable K loss by leaching (% of total)
4.83	28	70
5.30	40	49
5.63	50	26
7.03	72	16

The changes in extractable calcium concentrations were in contrasted to the extractable magnesium concentrations during the plantation period. The calcium concentration decreased during the first four months while the magnesium concentration was in the reverse trend. It was due to the effect of cation exchange. Calcium has the replacing power more than magnesium, so it is adsorbed by clay better than magnesium. While the concentration of magnesium in seawater is higher than calcium, so the magnesium out competed the calcium ion on clay surface.

The exchangeable sodium concentrations of all three mangrove seedlings was very high during the study period due to high sodium concentration in seawater (Hungspreugs, 1989). The sodium concentrations in October, 1993 was low due to heavy rain.