Pertanika 11(3), 365-374 (1988)

Progress of Crop in Some Rhizophora Stands before First Thinning in Matang Mangrove Reserve of Peninsular Malaysia

*P.B.L. SRIVASTAVA, **SAW LENG GUAN and ASHARI MUKTAR
Faculty of Forestry
Universiti Pertanian Malaysia
43400 Serdang, Selangor, Malaysia

Key words: Mangrove; stocking density; diameter; height

ABSTRAK

Kajian ini melaporkan tentang komposisi dan pola pertumbuhan tanaman yang didominasikan oleh spesis Rhizophora berasaskan kepada stok pertumbuhan, diameter dan ketinggian pada dirian bakau yang terurus di Hutan Simpan Paya Laut Matang, Semenanjung Malaysia. Sejumlah 10 dirian telah dikaji terdiri dari umur 6 tahun (4), 9 tahun (3) dan 12 tahun (3). Secara purata terdapat 8371, 4661 dan 4181 batang sehektar tumbuhan Rhizophora untuk umur 6, 9 dan 12 tahun. Min diameter aras dada (DPD) dan ketinggian ialah 3.26 cm dan 6.34 m bagi umur 6 tahun, 5.50 cm dan 10.96 m bagi umur 9 tahun, dan 6.91 cm dan 12.62 m bagi peringkat umur 12 tahun. Kadar kematian yang tinggi berlaku pada umur di antara 6 hingga 9 tahun dan diperingkat umur ini juga terdapat pertumbuhan yang terbaik dari segi diameter dan ketinggian. Pepanjat Derris trifoliata *mungkin memberi kesan kepada tumbuhan dan kemandirian dibeberapa kawasan.*

ABSTRACT

The study reports the composition and growth pattern of the crops dominated by Rhizophora *species in terms of stocking density, diameter and height growth in some well-managed stands in Matang Mangrove Reserve of Peninsular Malaysia. In all, 10 stands representing 6 years (4), 9 years (3) and 12 years (3) were studied. On an average there were 8371, 4661 and 4181 stems/ha of* Rhizophora *in 6, 9 and 12 year–old crops respectively. Mean DBH and height for the respective age crops were 3.26 cm and 6.34 m, 5.50 cm and 10.96 m and 6.91 cm and 12.62 m. Highest mortality occurred in 6–9 year–old crop. This period also showed best growth both in diameter and height. These studies indicate the need for silvicultural thinning in 6–9 year–old crop. The climber* Derris trifoliata *may seriously affect growth and survival in some areas.*

INTRODUCTION

In an earlier communication (Tay and Srivastava, 1982), some silvicultural aspects of the Mangrove Forest in Matang Reserve, such as, crop composition, stocking density before thinning I, II, III and final felling, DBH and height at these successive stages, were reported and their implications on the current management practices were discussed. The studies had indicated that there was a possibility of large scale mortality between year 2 and 15 when the crop is ready for first thinning. The present study reports observations on the progress of the crop in the early period of rotation i.e. after the final felling till the crop is ready for thinning I. As in the earlier studies it aimed at determining, (i) the species composition, (ii) stocking

Present address : * Department of Forests, Papua New Guinea
** Forest Research Institute, Kepong, Malaysia

density of different aged crops, and (iii) dynamics of size class distribution. On the basis of this information, it was hoped that comments can be made on, (i) rate of growth and survival/mortality, and (ii) realistic stocking and its effect on present thinning schedule, especially the first thinning.

MATERIALS AND METHODS

Study Area

The study was undertaken in Kuala Sepetang and Kuala Trong ranges of Matang Mangrove Reserve in Perak. These are amongst the best and the oldest managed mangrove forests in the world. Numerous publications (e.g. Watson 1928, Noakes 1952, Dixion 1959, Mohd. Darus 1969, Srivastava 1977, Srivastava and Abdullah Sani 1979, Srivastava and Daud 1978, Srivastava and Singh 1980, Tang *et al.*, 1980) have discussed various aspects of this Reserve. Haron (1981) has written the current working plan.

Six stands representing the three age classes of 6–year, 9–year and 12–year old *Rhizophora* dominated stands were located in Kuala Trong Range. In Kuala Sepetang Range, four stands were choosen to represent the three different age classes (Table 1). All sites included in the present study belong to Watson‘s inundation class I and II which are inundated 45 to 62 times in a month by normal tides. The prevailing conditions are suitable for the growth of *Rhizophora* spp., *R. mucronata* on soft mud along the streams and channels and *R. apiculata* showing optimum development in almost pure stands away from the streams.

Sampling Procedures

Systematics strip sampling, as followed by Tay and Srivastava (1982) was used in this study. Systematic sampling was choosen because of the simplicity of design, low cost, convenience on difficult sites and greater control over field work. Besides, in a systematic sample, the relative position in the population of different units included in the sample is fixed. In fact, the method gives a more precise estimate of the population than a random sampling (Sakhatame and Sukhatame, 1970).

In selecting the representative coupes, a preliminary study of the whole Reserve was carried out with the help of maps and files provided by the District Forest Department, Larut Matang. Suitable compartments were made on the basis of the following criteria :

TABLE 1
Locality Features

Range	Site No.	Age (Yrs)	Compt. No.	Total Area (ha)	Area Surveyed (ha)	Actual Area Sampled (ha)
1	2	3	4	5	6	7
KT	1		69	27.1	20.0	1.00
KT	2		72	27.1	20.0	1.00
		6				
KS	3		7	16.2	10.8	0.54
				20.2		
KS	4		21	44.5	10.8	0.54
K.T	5		55	40.5	16.0	0.80
K.T	6	9	72	41.3	20.0	1.00
K.S	7		23	31.0	10.0	0.54
K.T	8		60	38.0	20.0	1.00
K.T	9	12	51	37.2	20.0	1.00
K.S	10		17	16.2	10.8	0.54

Source : Larut Matang District Forest Office Taiping, Perak

Note : KS – Kuala Sepetang
KT – Kuala Terong

(i) coupe selected must be a *Rhizophora* dominated stand,

(ii) the coupe must be of a pre–determined age,

(iii) the coupe must be within Watson's (1928) inundation classes I and II,

(iv) only coupes designated for charcoal were selected; those earmarked for firewood have shorter rotation.

The sampling plots were selected based upon the following methods. A base line was established along a convenient boundary. Sampling lines, spaced 200 m apart were drawn straight and at right angles to the base line. Sample plots of 20m x 10m were marked contiguously along the sampling line, thus making a continuous strip of 10m width. This yielded a sampling intensity of 5 per cent.

All the trees encountered in the plots were counted by species and their diameter at breast height (DBH) recorded. In each plot, height of one tree was recorded with the help of clinometer. Trees occurring on forward and right side boundaries of the plot were included in the enumeration while those on the left and rear end boundaries were excluded.

Other details of the plot, like presence of fern weed *(Acrostichum aureum)* and climbers which could affect the survival and growth of the trees were also recorded. While the presence of fern was estimated ocularly, the occurrence of *Derris trifoliata* was recorded in terms of the trees infested by this climber. Their presence was approximated in the following grades.

Grades	Value	% infestation (trees/plot)
0	Nil	0
1	Rare	1–25
2	Moderate	26–50
3	Abundant	51–75
4	Infested	75–100

Statistical Method

A single classification ANOVA, in the form of a nested ANOVA design was used in this study. When there was significant variance between the means, Student – Neuman – Keul's test was used to determine location of the significant difference. Nintyfive percent confidence level was used in both the nested analyses of variance and the significance test.

RESULTS

Species Composition

Table 2 presents the composition of tree species recorded on different sites. With the exception of Site 7, all sites had *Rhizophora apiculata* as the most dominant species (89.5 to 99.4%). Site 7, however, had only 46.0 of the total stems of this species. *R. mucronata* occurred in generally quite low densities (i.e. less than 4%). Site 7, however, had the highest percentage of this species (50.5%).

TABLE 2

Species composition expressed as percentage of total number of stems

Age Class	Sites	Rhizophora apiculata	Rhizophora mucronata	Bruguiera parviflora	Others	Total
6 Years	1	92.4	3.8	3.8	0	100
	2	97.7	0.1	2.2	0	100
	3	94.2	3.5	2.2	0.1	100
	4	99.4	0.4	0	0.2	100
9 Years	5	91.0	1.0	7.9	0.1	100
	6	96.9	0.8	2.3	0	100
	7	46.9	50.5	0.4	2.2	100
12 Years	8	93.0	3.9	2.8	0.3	100
	9	95.9	2.8	1.2	0	100
	10	89.5	3.0	4.5	3.0	100

On all the sites, *Bruguiera parviflora* comprised of less than 8% of the total stems: The other species recorded rarely were trees of *Bruguiera gymnorrhiza, B. cylindrica, Xylocarpus* sp:, *Avicennia* sp. and *Sonneratia* sp.

Stocking, DBH and Height

The summary of the results of this study is shown in Table 3. In general, the plots in the age class 6 years showed highly variable results. Statistical tests on this results revealed the following.

a. Stocking (Table 4)

There was no significant difference in stocking between the age classes of 9 and 12 years. However, when tested against the 6 years class there were significant differences.

b. DBH (Table 5)

The DBH showed significant differences in all sites and ages.

c. Height (Table 6)

The were significant differences in height between all the age classes. In general there was also a certain amount of uniformity in heights within the age classes as reflected in no significant differences between some of the plots of the same age classes.

Weeds Infestation – Acrostichum aureum *(fern) and* Derris trifoliata *Lour. (climber)*

Sites 6 and 7 were free from fern infestation; Sites 5 and 9 were found to have heavier fern infestation than other sites (Table 7). On the whole fern infestation was low.

Six out of ten sites showed no infestation by climber. Of the remaining four sites, Site 9 showed heaviest infestation. Site 5 also showed heavy infestation. However, sites 2 and 6 had relatively light infestation by the climber.

DISCUSSION

Species Composition

On all the sites, *Rhizophora* spp. formed more than 90% of total standing trees. The most common associate of *Rhizophora* spp. was *Bruguiera parviflora.* This species is not preferred mainly because it is inferior as a fuel wood. In the present study, however, it never exceeded 8 per cent in any stand.

It has been reported by many workers that there is an increase in the frequency of *B. parviflora* after clear felling (Dixon 1959, Mohd. Darus 1969). It appears that the present management system has ample control over the distribution of other inferior species. Among *Rhizophora* spp., *R. apiculata* was dominant on all the sites except site 7 where *R. mucronata* was more abundant.

Stocking

Srivastava and Abdullah Sani (1979) projected that after Thinning I, there should be 6726 stems per ha. If it is assumed that this is the minimum

TABLE 3

Summary of results

3A. Age classes

Age	6 Years	9 Years	12 Years
Stocking (Stems/ha)	8371	4661	4181
DBH	3.26	5.50	6.91
Height (m)	6.34	10.96	12.62

3B. Sites

Age	6 years				9 years			12 years		
Sites	1	2	3	4	5	6	7	8	9	10
Stocking (Stems/ha)	8734	5739	11989	8954	4347	5437	3648	4258	4170	4059
DBH (cm)	3.35	3.69	2.81	3.19	5.52	5.39	5.80	7.23	6.63	6.80
Height (m)	6.28	5.81	6.16	7.10	10.30	10.43	12.15	12.73	12.37	12.77

TABLE 4

Test of significance – Stocking

4A. Age classes (stems per plot)

Rank	1	2	3
Age (years)	12	9	6
Mean stocking ($\bar{x}$)	83.62	93.21	167.42
Replicates (n)	127	117	154
Significant Test	———	———	

4B. Sites (stems per plot)

Rank	1	2	3	4	5	6	7	8	9	10
Site No.	7	10	9	8	5	6	2	1	4	3
Replicates	27	27	50	50	40	50	50	50	27	27
Mean Stocking ($\bar{x}$)	72.96	81.19	83.40	85.16	87.48	108.74	114.78	174.68	179.07	239.78
Significant Test	———	———	———	———	———	———	———	———	———	

Note 1 : Means that have no significant difference with each other are indicated with a common line.

TABLE 5

Test of significance – Diameter at Breast Height (DBH)

5A. Age classes (cm)

Rank	1	2	3
Age (years)	6	9	12
Replicates (n)	25782	10906	10617
Mean DBH ($\bar{x}$)	3.26	5.50	6.91
Significant Test			

5B. Sites (cm)

Rank	1	2	3	4	5	6	7	8	9	10
Site No.	3	4	1	2	6	5	7	9	10	8
Replicates (n)	6474	4835	8734	5739	5437	3499	1970	4170	2189	4258
Mean DBH ($\bar{x}$)	2.81	3.19	3.35	3.69	5.39	5.52	5.80	6.63	6.80	7.23
Significant Test										

Note 1 : Means that have no significant difference with each other are indicated with a common line.

TABLE 6

Test of significance – Height

6A. Age classes (m)

Rank	1	2	3
Age (years)	6	9	12
Replicates (n)	154	117	127
Mean Height ($\bar{x}$)	6.34	10.96	12.62
Significant Test			

6B. Sites (m)

Rank	1	2	3	4	5	6	7	8	9	10
Site No.	2	3	1	4	5	6	7	9	8	10
Replicates	50	27	50	27	40	50	27	50	50	27
Mean Height ($\bar{x}$)	5.81	6.16	6.28	7.10	10.30	10.43	12.15	12.37	12.73	12.77
Significant Test	________	________	________		________	________	________	________	________	________

Footnote 1 : Means that have no significant difference with each other are indicated with a common line.

TABLE 7

Weed infestation (expressed in percentage of plots affected)

7A, *Acrostichum aureum*

Site No.	Infestation – Grades 0	1	2	3	4	
1	42	36	18	2	2	100
2	96	4	–	–	–	100
3	78	19	3	–	–	100
4	96	4	–	–	–	100
5	53	7	15	5	20	100
6	100	–	–	–	–	100
7	100	–	–	–	–	100
8	78	16	6	–	–	100
9	12	44	28	14	2	100
10	78	8	7	7	–	100

7B. *Derris trifoloata* Lour.

Site No.	Infestation – Grades 0	1	2	3	4	
1	100	–	–	–	–	100
2	88	6	–	4	2	100
3	100	–	–	–	–	100
4	100	–	–	–	–	100
5	40	3	12	10	35	100
6	84	8	2	4	2	100
7	100	–	–	–	–	100
8	100	–	–	–	–	100
9	6	22	10	16	46	100
10	100	–	–	–		100

density for adequate stocking before Thinning I then all the sites of six–year–old crop with an average of 8371 stems per ha, with the exception of Site 2 were adequately stocked. The stocking of 6–year crop, in the present study, appears to agree closely with studies conducted by the earlier workers on the younger age crops (Liew etal, 1977, Srivastava & Daud Khamis 1978, Srivastava & Abdullah Sani 1979). They obtained densities ranging from 8,300 to 9,100 stems per ha within 24 months after final felling. From this comparison, it appears that there was little net recruitment or mortality during 24 months to 6 years after felling. A possible reason for low recruitment could be the dense crop near the streams preventing water-borne seedlings from reaching the interior blank areas. Net mortality is also presumably low because the crop has yet to reach a size where competition becomes a major factor. At the same time, 24 month-old plants are strong enough to withstand environmental stresses.

However, the average density by itself can be misleading. During the course of the survey, it was observed that there were large patches of blank areas. The sites at 6 years age could definitely support a density higher than the average number of 8371 stems per ha. This was evident on site 3, where the stocking was as high as 11,989 stems per ha. To get an index of the distribution pattern of the trees, the following exercise can be done.

Using 6726 stems as the minimum stocking per ha, the minimum stocking per plot can be calculated in the following manner:

Area of each plot	: $10 \times 20 m^2 = 200 m^2$
Minimum density per ha	: 6726 stems per ha
Therefore, the minimum stems per plot	$= \frac{6727 \times 200}{10\ 000}$
	= 134.54 stems per plot.

Using this figure, the distribution pattern of stem density per plot was calculated (Table 8). The table shows the cumulative percentage distribution of stems per plot expressed at intervals of approximately one quarter, half, three quarters, one, one and one quarter and one and a half. All the plots stocking less than 134 stems are considered inadequately stocked.

As is evident from this table, between 37% and 64% of the plots in the 6–year old crop were inadequately stocked though the average density was more than the minimum stocking. Apparently a large number of plots were poorly stocked. Thus if a area has high average stocking but has irregular and patchy distribution with large blanks, it would still be considered poorly regenerated and may require planting. However, another equally important consideration is whether 6726 stems per ha is too high a value for adequate stocking. This will be discussed later in this section.

TABLE 8

Cumulative stocking of stem density per plot (percent)

Age (years)	Site No.	Cumulative stocking (stems/plot) less than 32	less than 66	less than 100	less than 134	less than 168	less than 202
	1	2	10	32	46	56	60
	2	10	32	54	64	76	84
6	3	0	7	22	48	55	59
	4	11	26	30	37	52	59
	5	15	38	60	83	95	100
9	6	0	12	40	76	94	100
	7	7	37	85	100	100	100
	8	0	28	72	90	100	100
12	9	0	26	72	92	98	100
	10	11	33	66	100	100	100

The density in the 9–year old stands was, on an average, 4661 stems per ha which compared well with Noakes' (1952) Tentative Yield Table. Noakes estimated a density of 3954 stems per ha at 8 years of age and 3188 stems per ha at 9 years. During this present study with an average stocking of 4661 stems per ha, the 9-year old crop appears to be inadequately stocked compared to the standard of 6726 stems per hectare. Based on this criteria, Table 8 indicates that between 76 to 100% of the plots fall below the adequately stocking standard.

Although the results showed no significant difference at 95% confidence level between the sites, site 7 of the 9–year old crop had the lowest density. This was probably due to the higher composition of *R. mucronata* in the stand. Site 7 had 50.50% of *R. mucronata,* whereas, the other sites had more than 89% of *R. apiculata. R. mucronata* is planted at 1.83m x 1.83m espacement to yield a density of 2990 stems per ha. Therefore, with such a planting distance, higher composition of this species results in a lower density. Moreover, *R. mucronata* is a larger tree than *R. apiculata* and requires more growing space.

Comparing the density of 9–year old crop with that of 6–year old crop, there is an observed drop of about 44%. This is a high rate of loss considering that the net mortality between 24 months and 6 years was negligible. It appears that during this period i.e. between 6 and 9 years, the factors affecting survival are different from those that prevailed during the earlier period. Competition probably is the most important factor as the space between stems is much reduced and the ability of the site to support a large number of stems per unit area becomes limiting. Watson (1932) had observed that the *Rhizophora* spp. are extremely susceptible to competition.

The density of the crop at 12 years of age was 4181 stems per ha. There was no significant difference with the 9–year old crops at 95% confidence level. It can, therefore be infered that mortality between the ages 9 and 12 years is negligible or has slowed down to a level that is statistically not significant. It appears that after the high rate of mortality between the 6 and 9 years, the stands begin to stablise.

At 12 years age, Noakes predicted the density of crop at 2743 stems per ha. This value is lower than the average density observed presently. The present study compares well with Tay and Srivastava's (1982) figures of 15–year old crop in Kuala Trong (3922 stems per ha). It also indicates that the mortality between 12 and 15 years (Tay's observation compared with the present findings) is low compared to the period between 9 and 12 years.

On the basis of the projected figure of 6726 stems per ha, the 12–year crop appeared to be inadequately stocked. Table 8 indicates that more than 90% of the plots have stocking rate of below 134 stems per plot.

Based on the present finding, the apporximation made by Srivastava and Abdullah Sani (1979) appears to be too high. This study, as indicated above, agrees well with Tay and Srivastava's findings. The stocking of the crop at Thinning I should be within a range of 2500 to 4000 stems per ha. Srivastava and Abdullah Sani (1979) did not take into consideration the high rate of mortality between 6 and 9-year old crop and based their projections on 1.22 x 1.22 m initial planting space. Tay and Srivastava (1982) estimated that 3363 stems per ha would be a realistic figure after Thinning I.

If we consider this to be the minimum stocking, then the new stocking per plot for the purpose of the present study would be 67 stems per plot $\frac{336 \times 200}{10\,000}$.

On re-examination of Table 8, it may be seen that only 7 to 38% of the plot were inadequately stocked.

On the basis of the above discussion, the following points can be summarised;

(1) low mortality between 24 months and 6 years,
(2) highest mortality in 6 and 9–year old crop,
(3) crops stabalise after 9 years, mortality being low between 9 and 15 years,
(4) stands with higher percentage of *R. mucronata* have lower density; and,
(5) a better approximation of density of crop at Thinning I would be about 3363 stems per ha.

The implications of the above observations would be that Thinning I would be of greatest value to the stand when competition between stems is most intense, i.e. between 6 and 9 year period. It is the author's contention that the 1.22m (4ft) stick thinning would benefit the crop most during this period. At 6 years, the density of the crop is generally greater than 6726 stems per ha. Hence, stem release would be more appropriate at this stage. However, due to the non-commercial aspect of such a thinning, this practice is not being currently followed in Matang.

The above discussion indicates that systematic studies must be carried out on the effect of thinning when the crop is 6 and 9 years old to determine its effect on the final crop.

The above discussion indicates that systematic studies must be carried out on the effect of thinning when the crop is 6 and 9 years old to determine its effect on the final crop.

The benefits of such a thinning on the subsequent crop might make it worthwhile in spite of little revenue at this age. If the end product are chips when even the small diameter stems can be chipped, as in Sabah and Sarawak, this should become a worthwhile consideration.

Diameter Growth

The results show that there is significant difference at 95% confidence level between the three age classes and between all the sites. This is due to the large sample size used in the computation of the average diameter. The sample size of the sites was generally above 2000 replicates. This probably resulted in the individualistic nature of each site. Nevertheless, an examination of the values in Table 4 will reveal that the average diameters of the same age class identifies better with each other than with different age classes.

The present study showed a much lower average diameter than predicted by Noakes (1952); at ages 8 and 10 years, 6.5 and 8.1 cm respectively or an average of 7.2 cm for a 9–year old stand and 9.5 cm for a 12 year old crop as against 5.5 cm and 6.9 cm in the present study. However, these results compare well with Tay and Srivastava (1982).They recorded the diameter of *Rhizophora* dominated stands to range from 6.6 cm to 9.9 cm with an average of 9.25 cm. The annual growth between 9 and 12 years and between 12 and 15 years is more or less the same, 0.47 cm per year and 0.45 cm per year respectively.

In this study, the growth pattern of diameter between 6 and 12 years is shown in *Figure 1.* The curve is sigmoidal. Highest growth increment occurred during the period between 6 and 9 years. In absolute values, the growth between 6 and 9 years was determined to be 0.75 cm per year as compared to 0.47 cm per year between 9 and 12 years. Both in terms of diameter and height, growth appear to be the highest during the period of 6 and 9 years.

This factor could probably explain the reason for highest mortality during this period. When crop is most vigorous, competition between stems will also be intense resulting in high mortality of the suppressed plants.

Height Growth

Height, being an independent character, generally is a good indicator of the age and site quality of the crop. The results of this study showed a good uniformity of height among the sites of the same age crops but with two exceptions, i.e. Sites 4 and 7. Except for sites 4 and 7 all the sites, showed no significant difference at 95% confidence level with each other within the same age crop.

The reason site 7 had a higher value than the other sites in the 9–year old crops, could be due to the higher proportion of *R. mucronota.* As for site 4, the higher value could be due to two possible reasons, viz: being a better site or it could be a slightly older crop. If planting had occured one year earlier than the other sites, that would make a significant difference in height growth. However, records on planting were not available.

Figure 2 shows the trend of height growth of the three age classes. It shows a typical sigmoidal curve. It is apparent that highest rate of growth occurs between 6 and 9 years. The height difference between 6 and 9 years was 4.63 m, as against 1.66 m between 9 and 12 years. In other words, the rate of growth was 1.54 m and 0.55 m per year during the respective periods. The growth during the period of 6 and 9 years is about 2.8 times faster than between 9 and 12 years. If it is related to the density and DBH, more or less some trends are obtained i.e. higher mortality and greater DBH in the 6–9 years old crop compared to 9–12 year crop.

Weeds

Two species of weeds that might affect the growth of *Rhizophora* spp. found in the present study were Acrostichum and Derris trifoliata. The former is a fern and latter a climber. The climber was seen to have girdled a large number of trees in the affected areas. However, further investigation should be conducted to determine exactly its role in suppressing tree growth. The present study revealed only 4 out of 10 sites affected by this climber.

A. aureum (piai) is generally observed in the drier areas and frequently seen to be associated with peaty soils. On the whole in the present study, only three sites were found to be infested to any significant level (sites 1, 5 and 9). On site 5, piai was found in the large *lasa* form. This was recorded in the last sampling line. Stocking was found to be very low here. On the whole, however piai did not appear to be a major problem on most of the sites surveyed in the present study.

CONCLUSIONS AND SUGGESTIONS

On the basis of this study, the following conclusions can be drawn:–

(i) Based on the present findings, the optimum stocking of *Rhizophora* spp. at Thinning I is more realistic at 3363 stems per hectare.

(ii) The studies further indicate that the period between 6 and 9 years shows intense activity in terms of growth and mortality.

(iii) It is suggested that the Forest Department looks into the possibility of a silvicultural thinning between 6 and 9 years old crop which might improve the rate of growth and reduce mortality.

ACKNOWLEDGEMENT

The authors take this opportunity to thank the Dean, Faculty of Forestry, Universiti Pertanian Malaysia and Forestry staff of Larut - Matang Forest District for facilities. One of us (SLG) is specially thankful to Shu Chow for her support and patience during the study period.

REFERENCES

DIXON, R.G. (1959): A working plan for the Matang Mangrove Forest Reserve, Perak. Forest Dept. Pub.

HARON HJ. ABU HASSAN (1981): A working plan for Matang Mangrove Forest Reserve, Perak. Forest Dept. Pub.

LIEW, T.C., MOHD. NOR. DIAH and W.Y. CHUN. (1975): Mangrove Exploitation and Regeneration in Sabah. *Mal. For.* 38: 260-270.

MOHD. DARUS HAJI MAHMUD. (1969): Rancangan Kerja Bagi Hutan Simpan Paya Laut, Matang, Perak. Forest Dept. Pub.

NOAKES, D.S.P. (1952): A working plan for the Matang Mangrove Forest Reserve, Perak. Forest Dept. Pub.

SRIVASTAVA, P.B.L. and DAUD KHAMIS. (1978): Progress of natural regeneration after the final felling under the current silvicultural practise in the Matang Mangrove Reserve. *Pertanika*, 2: 126-135.

SRIVASTAVA, P.B.L. and ABDULLAH SANI SHAFIE. (1979): Effects logging on natural regeneration of mangrove species in Matang Reserve. *Pertanika*, 2(1): 34-42.

SRIVASTAVA, P.B.L. and H. SINGH. (1980): Composition and distribution pattern of natural regeneration after second thinning in Matang Mangrove Reserve, Perak. *Proc. Asian Symp. on Mangrove Environment: Res. & Management.* Kuala Lumpur.

SAKHATAME and SUKHATAME. (1970): Sampling Theory of Surveys with Applications. Asia Publishing House, Bombay.

TANG H.T., HARON HJ. ABU HASSAN and E.K. CHEAH (1980): Mangrove forest in Peninsular Malaysia: A review of management and research objectives and priorities. *Asian Symposium on Mangrove Environment: Research and Management.* Kuala Lumpur 25-29th August 1980.

TAY, S.P. and P.B.L. SRIVASTAVA (1982): Crop composition and density after thinnings and before final felling in Matang Mangrove Reserve, Perak. *Pertanika* 5(1): 95-104.

WATSON, J.G. (1982). Mangrove Forests of the Malay Peninsular, *Malay. For.* Rec. No. 6. Fraser and Neave, Singapore.

(Received 4 September 1987)