DIAMETER INCREMENTS FOR SIX MANGROVE TREE SPECIES IN THE SUNDARBANS FOREST OF BANGLADESH

M. A. Latif
M. F. Rahman
S. Das
N. A. Siddiqi

ABSTRACT

The analyses of the data collected on six occasions in between 1977 and 1990 from the permanent sample plots in the Sundarbans of Bangladesh are presented in the present paper. The diameter at breast height (dbh) increment for the two important species -- sundri (*Heritiera fomes* Buch. Ham.), and gewa (*Excoecaria agallocha* Linn.) were estimated separately for all the site qualities/height classes and salinity zones. The mean dbh increments per year ranged from 0.062 cm to 0.151 cm for sundri and 0.049 cm to 0.189 cm for gewa. There were only a small number of trees for passur (*Xylocarpus mekongensis* Pierre), keora (*Sonneratia apetala* Buch. -Ham), baen (*Avicennia officinalis* Linn.) and kankra (*Bruguiera* spp.). Therefore, the mean annual dbh increments were estimated for all the site qualities and salinity zones together. The mean dbh increments for passur, keora, baen and kankra were 0.206 cm, 0.192 cm, 0.219 cm and 0.178 cm respectively. The increment rate was higher at higher site qualities and lower salinity zones. But it does not depend on the forest composition. Top dying sundri trees showed lower dbh increment rate.

The rate of ingrowth for sundri was 15 trees per hectare per year, while the natural death and removals were 27 trees per hectare per year. The corresponding data for gewa were 22 and 8.1 respectively. The observation suggests that proportion of gewa is increasing and sundri is decreasing. Keora is being eliminated naturally without natural regeneration in the plots.

সারসংক্ষেপ

আলোচ্য প্রবন্ধে বাংলাদেশের সুন্দরবন এলাকায় স্থাপিত স্থায়ী নমুনা প্লট হইতে ১৯৭৭ সাল হইতে ১৯৯০ সাল পর্যন্ত সময়ে ছয়বার উপাত্ত সংগ্রহ করিয়া তাহা বিশ্লেষণের ফলাফল দেওয়া হইয়াছে। ইহাতে এই বনের প্রধান ছয়টি প্রজাতির গাছ সুন্দরী, গেওয়া, পশুর, কেওড়া, বাইন ও কাঁকরা এর বুক উচ্চতায় ব্যাসের বর্ধনহার

M. A. Latif, Senior Research Officer; M. F. Rahman, Field Investigator; S. Das, Field Investigator and N. A. Siddiqi, Senior Research Officer; Bangladesh Forest Research Institute, P. O. Box 273, Chittagong, Bangladesh.

নির্ণয় করা হইয়াছে। সুন্দরী ও গেওয়া গাছের বাৎসরিক ব্যাসে বর্ধন হার বিভিন্ন লবণাক্ততা ও গাছের উচ্চতা শ্রেণীর জন্য নির্ণয় করা হয় যাহা যথাক্রমে ০·০৬২ সেঃ মিঃ হইতে ০·১৫১ সেঃ মিঃ এবং ০·০৪৯ সেঃ মিঃ হইতে ০·১৮৯ সেঃ মিঃ এর মধ্যে পড়ে। পশুর, কেওড়া, বাইন ও কাঁকরা প্রজাতির গাছের সংখ্যা কম হওয়ায় সকল লবণাক্ততা ও উচ্চতা শ্রেণীর জন্য একত্রে গড় ব্যাস বৃদ্ধি নির্ণয় করা হয় যাহা যথাক্রমে প্রতি বৎসরে ০·২০৬, ০·১৯২, ০·২১৯ ও ০·১৭৮ সেঃ মিঃ। উপাত্ত বিশ্লেষণে দেখা যায় যে, লবণাক্ততা কম এবং গাছের উচ্চতা শ্রেণী বেশী হইলে ব্যাসের বর্ধনহার বেশী হয় তবে প্রজাতি মিশ্রণের উপর ইহা নির্ভর করে না। আগা মরা সুন্দরী গাছের বর্ধনহার কম। ইহাতে আরো দেখা যায় যে এই বন এলাকায় উক্ত সময়ে সুন্দরী গাছের সংখ্যা কমিয়াছে এবং গেওয়া গাছের সংখ্যা বাড়িয়াছে এবং স্থায়ী প্লটে নূতন কোন কেওড়া গাছ জন্মায় নাই।

INTRODUCTION

The Sundarbans mangrove forest covers a land area of 0.4 million hectares in the south-west corner of Bangladesh. It is a saline swamp forest, much dissected by water courses and composed of halophytes. The soil and water salinity of the tract increases from north-east to south-western part of the forest (Hassan and Razzaq 1981; Hassan 1983). The species composition and growth rates of the tree species also vary with the different levels of soil and water salinity (Curtis 1933, Karim 1983 and Chaffey *et al*. 1985).

Reliable growth data for the tree species in this forest are not available, but these are required for the scientific management of the forest. Therefore, permanent sample plots were laid out in 1977 to generate growth data of the important species in the Sundarbans in relation to various levels of Salinity. And the analyses of the data collected on six occasions in between 1977 and 1990 from the plots are presented in the present paper.

MATERIALS AND METHODS

The Sundarbans is not homogenous forest throughout the whole tract in respect of species composition and site quality, canopy closure and growth rates. Four site qualities described as stand heights, were identified in the Sundarbans (Curtis 1933 and Chaffey *et al*. 1985). The largest trees are found in the north and north-east part of the forest (Das and Siddiqi, 1985). A total of 12 permanent sample plots, each of 0.04 ha and distributed throughout the whole of the Sundarbans, were laid out in 1977.

All trees above 5.0 cm diameter at breast height (dbh) were serially numbered, and dbh points were marked and measured by diameter tape corrected to the nearest 0.1 cm. The relative position of each tree on the ground were marked in the plot map. The measurements were taken on six occasions in between 1977 and 1990. On each occasion, the numebr of missing trees, ingrowth and dbh of the surviving trees were recorded. The missing trees were the trees which died naturally or were removed by any means. Ingrowth were the trees growing from lower dbh class to 5.0 cm dbh class and above. Data on the number of missing trees and ingrowth were analysed to study the trend of tree densities and species composition. The ingrowth was estimated as the rate of increase of the number of trees per hectare per year. The data in respect of dbh were summarised individually for the available species growing at each plot at 5.0 cm dbh classes. Plotting of data on graph papers of each dbh class for every species revealed that it was linear. Therefore, linear regression equations were derived plot wise for each dbh class for each species. These were followed by the comparison of the slopes of the regression lines with one another. The plots having statistically same slope values were grouped together for further analyses.

The growth rates for each dbh class or dbh classes with similar slopes for every species were estimated through regression analyses. The dbh values at different measurements were taken as the dependent variables while the times (years) elapsed after the initial measurement were taken as the independent variables. Thus the slopes were the mean dbh increment per year.

The mean dbh increment for the two important sepcies sundri (Heritiera fomes Buch. -Ham.) and gewa (Excoecaria agallocha Linn.) were estimated separetely for all the site qualities and salinity zones. There were only a small number of trees for the species passur (*Xylocarpus mekongensis* Pierre), keora (*Sonneratia apetala* Buch. -Ham), baen (*Avicennia Officinalis* Linn.) and kakra (*Bruguiera* spp.). Therefore, the mean annual dbh increments were estimated for all the site qualities and salinity zones together. Twenty five top-dying trees were marked in seven permanent plots in 1977 and their dbh, basal area and volume increments were compared with those of the healthy trees of the similar dimensions at the same plots.

RESULTS AND DISCUSSIONS

The number of trees recorded at the time of plot establishment in 1977 and surviving till 1990 (excluding natural death and removals) and ingrowth for each species are summarised in table 1 and 2. The natural death and removals are higher and ingrowth is lower for sundri as compared to gewa. The rate of ingrowth for sundri is 15 and natural death and removals are 27 trees per hectare per year. The corresponding data for gewa are 22 and 8.1 respectively. The proportion of gewa is increasing and sundri is decreasing. This indicates the possibility of change of the proportion of species composition in the Sundarbans. Chaffey *et al.* (1985) observed similar trend in species composition. No regeneration of keora was observed in the plots. This indicates that it has been disappearing naturally in the plots.

Table 1. Species composition observed in 1977 and 1990 in the permanent sample plots

Species Composition (Forest type)	Sundri (number)	%	Gewa (number)	%	Others (number)	%
Observations in 1977						
Sundri	235	88.3	13	4.9	18	6.8
Sundri—Gewa	219	61.3	130	36.4	8	2.3
Gewa—Sundri	72	37.9	111	58.4	7	3.7
Keora	0	0	7	17.5	33	82.5
Over all	526	61.7	261	30.6	66	7.7
Observations in 1990						
Sundri	153	74.3	46	20.3	7	5.4
Sundri—Gewa	231	60.8	140	36.8	9	2.4
Gewa—Sundri	60	29.0	133	64.2	14	6.8
Keora	4	7.0	30	52.6	23	40.4
Over all	448	52.7	349	41.1	53	6.2

Table 2. **Removals including natural death and ingrowths observed in the permanent sample plots in between 1977 and 1990.**

Criteria	Sundri		Gewa		Others	
	total	n/ha/yr	total	n/ha/yr	total	n/ha/yr
Removals and natural deaths	173	27.4	51	8.1	25	4.0
Ingrowth	95	15.0	139	22.0	12	1.9

Table 3. **Dbh increments for different species of Sundarbans at different levels of salinity and site qualities**

Site Quality	Salinity Zone	Species	dbh class (cm)	Number of stems	Mean annual dbh increment (cm/yr.)
1 & 2	Fresh water	Sundri	5.0 - 10.0	58	0.136
			10.1 - 15.0	33	0.151
			15.0+	13	0.113
		Gewa	5.0 - 20.0	132	0.189
2	Moderately saline	sundri	5.0 - 20.0	132	0.125
		Gewa	5.0 - 15.0	19	0.092
3	Do	Sundri	5.0 - 20.0	107	0.079
		Gewa	5.0 - 20.0	57	0.077
3	Severely saline	Sundri	All	12	0.062
		Gewa	All	3	0.049
All	All	Baen	All	7	0.219
		Kankra	All	8	0.178
		Keora	All	22	0.192
		Passur	All	9	0.206

Table 4. **Reduction of growth due to sundri top-dying in the permanent sample plots of the Sundarbans during the 13-year period**

Criteria		Dbh (cm)	BA (m^2)	Volume (m^3)
Sound tree				
	Initial	11.71	0.3004	2.1024
	After 13 years	13.54	0.3830	2.8151
	Increment (%)	15.62	27.50	33.87
Top-dying trees				
	Initial	11.20	0.2692	1.88448
	After 13 years	11.95	0.3042	2.2359
	Increment (%)	6.70	13.00	18.65
Reduction due to top-dying (%)		8.92	14.5	15.2

The dbh increments were observed to be different for different species growing at different salinity zones and site qualities. The increments were higher at better site qualities and lower salinity zones. But it did not depend on the species compositions. The mean dbh increments per year were ranging from 0.062 cm to 0.151 cm and 0.049 cm to 0.189 cm for the two important species sundri and gewa respectively depending on salinity and site quality (table 3). The ages of the trees in the natural forests managed under selection system is not known. The dbh increment rates generated from the study may be used to calculate the movement ratios (Davis, 1966) and the movement ratios may be used to project the stand table for estimation of the future yield.

Wellwood (1960) determined the mean annual dbh increment for gewa to be 0.478 cm by counting the annual rings. Curtis (1930) observed the same data following the same procedure to be 0.348 cm. From the remeasurement data of gewa in the permanent sample polts Choudhury (1968) reported that the periodic annual dbh increment for the species was 0.150 cm. A compromise of these three was used to project the stand table for the estimation of future yield (Choudhury 1968 and Chaffey *et al.* 1985). The mean dbh increments observed in the present study in the fresh water and moderately saline water zones are closer to those reported by Choudhury (1968). It is clear from the present study that the dbh increments are lower than those used for the estimation of the yield in the past working plans. The growth rings of the different species in the Sundarbans are not distinct (Pearson and Brown 1932). Therefore, the growth rates estimated by counting the annual rings are not desirable. Under the above circumstances, it is recommended to re-estimate the future yield with the growth rate observed in the permanent sample plots to estimate an annual sustained yield.

The mean reduction of growth rate due to sundri top-dying observed after 13 years are 8.93%, 14.5% and 15.2% for dbh, basal area and volume for twenty five tree respectively (Table 4). It seems that top-dying retarded the growth rate.

REFERENCES

Chaffey, D.R.; Miller, F. R. and Sandom, J. H. 1985. A forest inventory of the Sundarbans, Bangladesh (main report) Overseas Development Administration, Land Resources Development Centre, England. 196 pp

Choudhury, A. M. 1968. Working plan of Sundarbans Forest Division for the period 1960—61 to 1979—80. Government Press. Bangladesh. Volume 1, 32-33 pp

Curtis, S. J. 1933. Working plan for the forests of the Sundarbans Division for the period from April 1931 to 31st March 1951. Calcutta, Bengal Government Press.

Das, S. and Siddiqui, N. A. 1985. The mangroves and mangrove forests of Bangladesh. Mangrove Silviculture Division Bulletin No. 2. Bangladesh Forest Research Institute, Chittagong. 142. pp

Davis, K. P. 1966. Forest management: regulation and valuation. McGraw Hill book company, New York

Hassan, M. M. 1983. Map of different salinity zones of the Sundarbans. Soil Science Division, Bangladesh Forest Research Institute, Chittagong. (Unpublished)

Hassan, M. M. and Razzaq. M. A. 1981. A preliminary evaluation of the clay mineralogy of the Sundarbans soils. *Bano Biggyan Patrika*. 10. (1 & 2): 21-26

Karim, A. 1983. Soil salinity and plant relationship in mangrove areas. Paper presented at UNDP/UNESCO Training Seminar on Geology, Sedimentology,

Erosion and Accretion in mangrove Areas, Dhaka 19 pp

Pearson, R. S. and Brown, H. P. 1932. Commercial Timbers of India. Government of India. Central Publication Branch, Calcutta

Wellwood, 1960. Forestal Forest Inventory, 1958-59 Sundarbans forests. Forestal Forestry and Engineering International Limited, Canada