ESTABLISHMENT OF MANGROVE SEED PRODUCTION AREA FOR *SONNERATIA APETALA*

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There is constant appearance of newly accreted habitats along the 710 km coast of Bangladesh. To stabilise and consolidate these new accretions, the Government of Bangladesh initiated a coastal afforestation scheme in 1966 and this is being carried out in one of the most rapidly changing natural environments in the world. Only a small number of specialised species are able to withstand such rapidly changing environments especially regular inundation with saline water.

The species *Sonneratia apetala* and *Avicennia officinalis* appear promising for accelerating the process of siltation and soil stabilisation. *Sonneratia apetala* was reported to have priority over *A. officinalis* because of its survival and growth (Siddiqi & Islam 1988). To date, 138 000 ha of accreted land in Bangladesh have been brought under coastal plantation mainly with *S. apetala*. However, the growth and yield are lower when compared with those of Southeat Asian countries such as Thailand, Indonesia, Malaysia and Philippines (Howlader 1999). Main reasons were the use of poor quality seeds and planting stocks. Whatever standard of maintenance is provided, the use of improved seed source will always remain as an important factor for achieving maximum yield. Intensive forest management activities will never maximise yields unless supplemented with the use of genetically superior trees and their improved seed sources (Zobel & Talbert 1983).

Sonneratia apetala has not received due attention for increasing its ability to withstand stressed conditions. The present study was undertaken with a view to provide improved seed sources by selecting superior phenotypes from nature-made stressed conditions. Depending on geo-morphological conditions and hydrological features, the coast of Bangladesh has been divided into three distinct regions, namely Eastern, Central and Western regions (ESCAP 1987). The Bangladesh Forest Research Institute (BFRI) has been establishing a series of seed production area (SPA) suitable for each region. Selection of seed trees was done in mini plots due to the uneven creation of nature-made environments for growing mangrove trees throughout the new accretions. This paper attempts to provide scientific basis for the establishment of site-suitable SPA for mangrove species and aims to select two different types of seed sources having different degrees of ability to withstand extreme conditions.

The study was conducted at the Sitakunda Research Station of the BFRI, Chittagong. A reconnaissance survey in the existing *S. apetala* plantations of Eastern Coastal Belt of Bangladesh was undertaken to look for a suitable site for the establishment of SPA. Massive mangrove afforestation in Bangladesh resulted in the creation of a pure stand for *S. apetala* (Spalding *et al.* 1997). The reconnaissance survey found that the Mogadia Forest Belt of Mirsharai Range was the best site having a large number of good phenotypic individuals. The forest floors in most of these accreted habitats were found to be of convex type with several mini basins in the centre of the delta causing high variability of tree growth. The

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selected plantation was raised by the Forest Department in 1986 and it is now mature for seed production. The site is easily accessible and not exposed to major natural disaster or logging.

In general, an area of 4 ha for most of forest tree species is suggested for practical and scientific management of SPA (Schmidt 1993). Through conventional method, the area is divided into four equal blocks and two sample plots of dimensions 25 × 25 m are established in each block. Seed trees are selected by choosing five healthy trees from each plot. Such procedure does not allow comparison and selection of best performing trees from the minimum conditional variation of existing base populations of the stand. To overcome these shortcomings, the demarcated 4-ha area was divided into 10 blocks and sub-divided into 100 plots, each measuring 20 × 20 m. An area of 4 ha was demarcated in the middle of the plantation with 10 m buffer zone surrounding the stand. In this study, laying out of plot size as well as evaluating and selecting seed trees from the respective plots was modified. This was to allow maximum possibility for comparison and selection of better genotypes from the variable phenotypes growing under the same soil and environmental conditions in smaller plot sizes. An extensive selection was introduced and a total of 100 best trees (BT) were selected by scoring one BT in each plot. The selected BT was used for comparison and selection of other seed trees in the respective plot.

Thorough assessment was also made in each alternate plot by using the point grading method (Zabala 1988), where seed trees were evaluated by providing highest score 10 for diameter at breast height (DBH), 15 for individual tree height, 20 for bole form, 5 for natural pruning, 10 for branch angle, 5 for branch size, 10 for crown development and fruit production, 10 for apical dominance, 5 for forking and 10 for individual tree health. Measurements of height (H) and DBH of all trees from all plots were taken. A survey was also conducted to find out the extent of damage caused by bee-hole borer attack in each plot. Tree volume over bark was calculated using the following formula (Rahman *et al.* 1994):

$$V = 0.0073 + 0.00003324\, D^2H$$

where the average height (H) and DBH (D) collected for all trees, selected trees and best trees have been used separately.

Mapping of the stand was done by charting all trees, whether dead or alive, in individual plots. In the final assessment, trees to be retained, trees to be removed and best trees in each plot were indicated in the map.

The point grading method used in this study showed that trees with a score of 63 were considered selected seed trees (Table 1). Mean score received by the best tree in each block was 70. The score ranged from 53 to 70 for selected seed trees and 55 to 86 for best trees. Other trees which scored less than 53 were not considered in the analysis and recommended for removal from the seed stand. Special attention was given to the presence of an insect or pest attack in any tree because *S. apetala* is known to be susceptible to stem borer attack (Baksha 1983, Islam *et al.* 1989). Possible measures (Baksha 1996) as well as option for integrated management (Palis 1998) have been recommended.

A total of 21.1% of trees were affected by bee-hole borer in the seed stand which ranged from 5.5% in block 9 to 31.2% in block 1 (Table 2). Maximum damage was recorded especially in blocks 1 and 2. It is apparent that site selection and introduction of extensive tree selection method in these specific sites appeared to be highly suitable because resistant genotypes could only be captured and selected from those areas where severe attack had

Table 1 Scoring and evaluation of seed trees

Block	Evaluation of trees			
	Selected seed tree		Best tree	
	Score achieved	Range	Score achieved	Range
1	68	65–70	80	78–86
2	66	65–68	71	67–76
3	64	63–65	70	65–74
4	63	61–65	69	67–72
5	63	60–66	69	65–76
6	58	53–64	62	55–70
7	58	53–63	64	59–72
8	63	61–65	69	66–73
9	63	62–65	75	71–77
10	63	61–63	71	68–74
Mean	62.9	–	70.0	–
SE	± 0.97	–	± 1.59	–

taken place.

A total of 1159 seed trees were selected out of 3213 trees existing in the demarcated area. The selection intensity was 36.1%, varying from 31.6 to 41.1% (Table 3). The selection intensity was maximum in blocks where minimum infestation occurred. As discussed earlier, maximum trees were affected in blocks 1 and 2. Consequently, the selection intensities were 32.2 and 31.6% respectively. The overall selection intensity of the SPA could be higher if there was no infestation (Figure 1). However, it is noteworthy to mention that the eventual seed stand after roguing and thinning will usually be 100 to 200 trees ha^{-1} (Zabala 1988). This means that the 4 ha SPA should contain 400 to 800 trees. In this regard, as indicated earlier that there will be 1159 seed trees in the presently established 4-ha SPA. These seed trees would be available in the stand after thinning and removing undesirable trees from the stand.

Measurements of height and DBH of all trees were also taken in order to identify the growth variation between selected and non-selected trees. Height ranged from 9.4 to 13.3 m for all trees, 9.8 to 14.4 m for selected trees and 10.8 to 15.6 m for best trees. Similarly, the DBH ranged from 10.7 to 13.7 cm for all trees, 11.5 to 14.7 cm for selected trees and 12.1

Table 2 Extent of damage caused by bee-hole borer attack in the selected plots

Block	Total tree	Tree attacked by borer		
		No.	%	Range
1	173	54	31.2	18.2–40.4
2	131	37	28.2	15.6–35.1
3	98	16	16.3	13.3–19.5
4	108	10	9.2	5.0–12.9
5	62	11	17.7	17.0–20.0
6	37	9	24.3	21.0–30.0
7	67	18	26.9	16.7–36.8
8	69	13	18.8	16.7–20.5
9	105	10	5.5	6.7–13.5
10	74	17	23.0	5.9–37.5
SE	–	–	± 2.61	–

Table 3 Intensity of seed tree selection for the establishment of SPA

Block	Number of trees		
	Existing tree	Selected seed tree	Selection intensity (%)
1	484	156	32.2
2	380	120	31.6
3	341	118	34.6
4	369	132	35.8
5	316	109	34.5
6	184	75	40.8
7	160	54	33.7
8	323	127	39.3
9	325	132	40.6
10	331	136	41.1
SE	-	-	±1.11

to 15.8 cm for best trees (Table 4).

The mean height variation was 7.2% better for selected trees and 24.3% for best trees. The mean DBH variation was 8.9% higher for selected trees and 18.7% for best trees. Such phenotypic variations recorded from each of the vulnerable sites of Bangladesh may have great importance because they may serve as basic materials for species evolution in future.

The type of benefit or gain that can be achieved from using the seeds of SPA has also been identified by calculating the wood volume of trees presently available in the explored area. Although the genetic worth of selected trees of the explored area has not yet been verified, it may be assumed that their progenies will inherit their superior properties. This is because a major part of forest tree breeding in the world has been based on the selection of superior phenotypes with such assumption of expressing their superior properties of selected phenotypes in their progenies (Nandy 1989). Phenotypic selection has been proven effective in capturing most of the genetic variations existing in natural populations (El-Kassaby 2000).

It was found that the demarcated area contained a total of 3213 trees in 4 ha or 803 trees per hectare with an average wood volume of 50.7 $m^3 ha^{-1}$ (Table 5). The plantations to be raised by using seeds of selected trees would yield 62.9 m^3 with an expected gain of 24.1% which may rise up to 66.5% ha^{-1} from the plantations to be raised by collecting seeds of only best trees of the SPA. On current estimates, there are some 96 000 ha of suitable coastal lands presently available for further plantations in Bangladesh (Saenger & Siddiqi 1993). It may be assumed that at least 50% of these estimated coastal areas will be

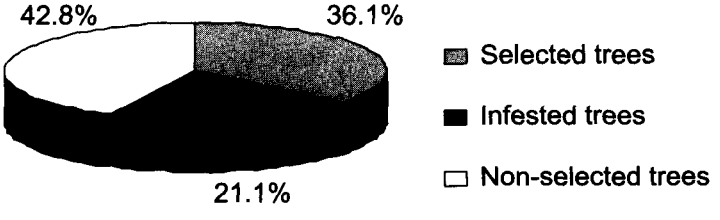

Figure 1 Selection intensity of the SPA

Table 4 Growth variation between selected and non-selected trees

Block	All trees		Selected seed tree		Best tree	
	Height (m)	DBH (cm)	Height (m)	DBH (cm)	Height (m)	DBH (cm)
1	13.3	11.6	14.4	13.3	15.6	14.8
2	12.2	12.2	13.0	13.8	14.3	15.4
3	12.5	12.4	13.3	13.7	14.8	14.7
4	12.6	12.2	13.2	12.6	14.7	15.4
5	10.9	11.3	11.9	12.8	13.2	13.5
6	9.4	10.7	9.8	11.5	10.8	12.1
7	9.7	13.6	10.5	14.7	12.7	15.7
8	9.8	13.7	10.1	14.4	13.8	14.6
9	10.6	13.1	11.3	14.4	13.5	15.8
10	10.4	12.3	11.1	13.3	14.3	14.2
Mean	11.1	12.3	11.9	13.4	13.8	14.6
SE	± 0.44	± 0.30	± 0.49	± 0.31	± 0.42	± 0.36

Table 5 Expected gain to be achieved by using the seeds of SPA

Seed type	Wood volume			Expected gain/ha	
	Volume for individual tree	Existing trees /ha		Volume (m^3)	%
		No.	Volume (m^3)		
Before Selection					
Non-selected tree	0.06312	803	50.68	–	–
After Selection					
Selected tree	0.07833	803	62.90	12.22	24.1
Best tree	0.10508	803	84.38	33.70	66.5

planted by involving *S. apetala* because this species had already been recognised as a priority planting species and it covered more than 80% of the planted area (Palis 1998). Considering the involvement of *S. apetala* in raising 50% or 48 000 ha of estimated area for further plantation in the coastal areas of Bangladesh, the yield in terms of wood volume at the time of harvesting would be 2.4 million m^3. It can achieve up to 3.0 million m^3 and even 4.1 million m^3 from the plantations to be raised by using seeds of selected trees and best trees of the SPA respectively. In conclusion, a most reliable and significant gain can be achieved from using these types of superior seed sources in man-made afforestation programmes.

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