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Growth and yield of *Sonneratia apetala* (keora) plantations raised from different seed sources in the central coastal belt of Bangladesh

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ABSTRACT

Growth trials of Sonneratia apetala (keora) raised from three different seed sources were conducted in the newly accreted lands at Rangabali under Patuakhali and Char Kukri-Mukri under Bhola district to assess the variation of growth and wood production of the species planted in 2007 and 2009. Data on survival, tree height and diameter at breast height (dbh) were recorded from 7 and 5 years old two trial plantations. Significantly greater height of 12.54m and 12.09m and greater dbh of 15.58cm and 14.56cm were recorded for best trees seed source at Char Kukri-Mukri and Rangabali sites respectively at the age of 7 years. Similarly, significantly greater height of 11.88m and 11.57m and greater dbh of 14.55cm and 13.44cm were recorded for best trees seed source at the age of 5 years in Char Kukri-Mukri and Rangabali sites respectively. Significantly greater wood volumes of 38.09 m^3/ha/year and 37.50 m^3/ha/year were produced by plantations of best trees seed source in both Char Kukri-Mukri and Rangabali sites respectively at the age of 7 years. The lowest growth and wood production were shown in the plantations raised from seeds of mass collection in both the years. Therefore, large scale plantations of S. apetala can be raised by using seedlings of best trees seeds for obtaining maximum growth and yield of coastal mangrove forest.

Key words: *Sonneratia apetala, growth, yield, seed sources and coastal belt*

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I. Introduction

Bangladesh is one of the leading countries of coastal afforestation programme with different mangrove species. Afforestation programme along the coastal belt was initiated in 1966 with the primary objective to protect the lives and properties of coastal communities from cyclone and tidal surges by creating mangrove forest cover in the exposed 710 km coastal belt (Das and Siddiqi, 1985). Initially almost all the commercially important mangrove species were planted but mostly failed due to lack of knowledge on plantation techniques (Siddiqi, 2001). Among the planted species *Sonneratia apetala* (keora) was the most successful species in all along the coastal belt and *Avicennia officinalis* (baen) was the second most successful species in the eastern coastal belt. Afterwards, massive afforestation mainly with *S. apetala* was carried out throughout the coastal belt under more than 16 development projects (Islam and Rahman, 2015). A total of 0.192 million hectares of accreted lands were afforested

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with mangrove species in the coastal areas till 2013 (Hasan, 2013). *S. apetala* has a priority over *A. officinalis* and other mangrove species because the species shows the best survival and growth performance in the newly accreted lands throughout the coastal belt. Therefore, *S. apetala* is the principal planting species in the coastal afforestation programmes.

S. apetala is the largest and tallest tree in the natural Sundarbans mangrove forest attaining a height up to 20m with a diameter of 80 cm (Siddiqi, 2001). Wood is used for making boxes, paneling, hardboard and other purposes. It produces good quality fuel wood but it has not yet been popularized (Siddiqi, 1993). The growth and yield of planted mangrove species in Bangladesh are lower as compared to those in other South Asian countries such as Thailands, Indonesia, Malaysia and Philippines (Hawlader, 1999). The main reasons were the use of poor quality seeds and planting stocks. More than one-third of the total wood volume per hectare can be achieved by using seeds from superior stands than non-selected trees (Nandy et al., 2004). The use of improved seed source will always remain as an important factor for achieving maximum yield. Intensive forest management activities will never maximize yields unless supplemented with the use of genetically superior trees and their improved seed sources (Zobel and Talbert, 1983). Therefore, the present study was undertaken to assess the growth and yield of *S. apetala* plantations of different seed sources including high quality seeds from phenotypically superior trees.

II. Materials and Methods

The Plantation Trial Unit Division of Bangladesh Forest Research Institute (BFRI) established two experiments in the newly accreted (char) lands in 2007 and 2009 along the central coastline at two offshore islands, Rangabali under Patuakhali district and Char Kukri-Mukri under Bhola district. Rangabali is located at latitude 21^{0}92´ N and longitude 90^{0}45´ E. Char Kukri-Mukri is located at latitude 21^{0}85´ N and longitude 90^{0}72´ E. Both islands are offshore of Bangladesh. The site condition of these two islands was more or less similar. The area forms the lowest landmass and is part of the delta of the extended Himalayan drainage ecosystem. The landscape has been formed by the combined actions of rivers Meghna, Brahmaputra and Ganges. The landscape is low-lying land, estuaries and inlands along the seacoast. Soil of the sites is silt-clay-loam. In monsoon, water salinity ranges from 3-27 ppt while in the dry season it ranges from 10-33 ppt (Siddiqi and Khan, 1990). Soil salinity varies remarkably between the monsoon and dry seasons. Soil salinity ranges from 0.3-4.2 dS/m in December and reaches its peak from April-May when average salinity is as high as 9 dS/m (Hasan, 1987). Soil pH is slightly alkaline and varying between 7.5-8.0 (Siddiqi and Khan, 2000). The climate is humid. Temperatures range between 18°C and 32°C. Annual rainfall varies from 2500-3000 mm (Siddiqi, 2002).

The BFRI established 4.0 ha seed production area (SPA) at Char Taposhi of Rangabali island for selecting two different types of good quality seed sources (best trees and selected trees) in the pure stand of *S. apetala* plantations. The area was established in the middle of the plantation with 10 m buffer zone surrounding the stand. 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. The score was ranged from 53-70 (mean 63) for selected trees and 55-86 (mean 70) for best trees (Nandy et al., 2004). The trees which scored less than 53 were removed from the seed stand. Seeds of *S. apetala* were collected from three different seed sources such as the best trees, the selected trees and the mass collection (non-selected trees) during August-September. Seedlings were raised in polybags of size 25cm × 15cm filled with powdered soil and cowdung mixture at a ratio of 3:1. Seedlings were maintained in the nursery for about 10 months. Eight to ten months old polybag seedlings were planted at 1.2m × 1.2m spacing. In each plot, 100 (10 × 10) seedlings were planted. The experiment was laid out in Randomized Complete Block Design (RCBD) with 3 replications. Data on tree survival, height, diameter at breast height (dbh) were collected in June 2014 when two stands age were 7 and 5 years respectively. The **w**ood volume of standing trees was calculated following *S. apetala* volume table (Islam et al., 1992). All these data were analyzed using Excel spreadsheet and Minitab statistical package. Analysis of variance (ANOVA)

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was used to determine the effect of plantations with different seed sources on tree height, diameter and wood volume.

III. Results and Discussion

Growth performance of *S. apetala* plantations planted in 2007 (7 years old) and 2009 (5 years old) in the central coastal belt of Bangladesh are shown in table 01 and 02. In the plantations raised in 2007, the significantly highest survival was 48% and 54% for best trees seed source and the lowest was 32% and 41% for mass collection seed source at Char Kukri-Mukri and Rangabali sites respectively. Significantly greater height was 12.54m for best trees followed by 9.42m for selected trees and 7.71m for mass collection seed source at Char Kukri-Mukri and it was 12.09m for best trees followed by 9.83m for selected trees and 8.51m for mass collection seed source at Rangabali site. Significantly highest diameter at breast height (dbh) was found 15.58cm at Char Kukri-Mukri and 14.56cm at Rangabali for best trees seed source. Significantly greater wood volumes were found 38.09 m^3/ha/year and 37.50 m^3/ha/year for best trees seed source and the lowest was 9.52 m^3/ha/year and 8.13 m^3/ha/year for mass collection seed source in Char Kukri-Mukri and Rangabali sites respectively (Table 01).

Table 01. Growth performance of *S. apetala* planted in 2007 (7 years old) at Char Kukri-Mukri and Rangabali islands

Seed source	Char Kukri-Mukri				Rangabali			
	Survival %	Height (m)	DBH (cm)	Wood volume (m^3/ha/yr)	Survival %	Height (m)	DBH (cm)	Wood volume (m^3/ha/yr)
Best trees	48c	12.54c	15.58c	38.09c	54c	12.09c	14.56c	37.50c
Selected trees	38b	9.42b	11.75b	15.07b	46b	9.83b	10.98b	18.25b
Mass collection	32a	7.71a	9.76a	9.52a	41a	8.51a	9.75a	8.13a

Figures followed by different letters (like a, b and c) differ significantly at 5% level

In the plantation raised in 2009, significantly highest survival was 53% and 51% for best trees seed source and the lowest was 33% and 40% for mass collection seed source at Char Kukri-Mukri and Rangabali sites respectively. Significantly greater height was 11.88m for best tree followed by 9.00m for selected trees and 7.69m for mass collection seed source at Char Kukri-Mukri and it was 11.57m for best trees followed by 9.83m for selected trees and 8.58m for mass collection seed source at Rangabali site. Significantly greater dbh was 14.55cm and 13.44cm for best trees seed source in Char Kukri-Mukri and Rangabali sites respectively. Similarly, significantly greater wood volumes 51.52 m^3/ha/year and 42.49 m^3/ha/year were also recorded for best trees seed source and it was only 11.45 m^3/ha/year and 13.89 m^3/ha/year for mass collection seed source in Char Kukri-Mukri and Rangabali sites respectively (Table 02).

Table 02. Growth performance of *S. apetala* planted in 2009 (5 years old) at Char Kukri-Mukri and Rangabali islands

Seed source	Char Kukri-Mukri				Rangabali			
	Survival %	Height (m)	DBH (cm)	Wood volume (m^3/ha/yr)	Survival %	Height (m)	DBH (cm)	Wood volume (m^3/ha/yr)
Best trees	53c	11.88c	14.55c	51.52c	51c	11.57c	13.44c	42.49c
Selected trees	45b	9.00b	11.15b	21.87b	46b	9.83b	10.43b	19.14b
Mass collection	33a	7.69a	9.44a	11.45a	40a	8.58a	9.15a	13.89a

Figures followed by different letters (like a, b and c) differ significantly at 5% level

Siddiqi (1988) carried out an experiment on growth and wood production of *S. apetala* at Char Kukri-Mukri and he found average heights of trees were 5.57m after five years and 10.25m after ten years of plantations. He also found wood volume 7.68 m^3/ha/year after five years and 11.48 m^3/ha/year after ten years plantations raised at closer spacings (1.2m × 1.2m). After 10 years, he recorded only 31%

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survival of the trees. In another experiment, Siddiqi (1990) reported that the *S. apetala* trees attained an average height of 8.5m, dbh 10.41cm and survival 40% at the age of five years. Siddiqi and Khan (1990) reported that the height and dbh growth of *S. apetala* trees were 10.50m and 11.88cm after ten years at Rangabali and 12.71m and 12.74cm after eleven years at Char Kukri-Mukri. From these studies, authors found height and dbh growth increment of 1.05m and 1.19cm respectively at Rangabali, and it was 1.16m and 1.16cm at Char Kukri-Mukri. Islam et al. (2015) carried out a study to assess the growth performance of mature *S. apetala* plantations. The authors reported that the height growth of a 17 years old stand was 16.0m and dbh was 33.12cm at Madarbunia of Rangabali island which showed 0.94m height increment and 1.94cm dbh increment. In another stand, they found height growth 20.66m and dbh 26.59cm in a 34 years old stand at Char Patila of Char Kukri-Mukri island which showed 0.60m height increment and 0.78cm dbh increment.

In the present study, the height, dbh and wood volume for best trees seed source were found significantly greater followed by selected trees and then mass collection seed source. For the best trees seed source, the heights growth increment were found 1.79m and 1.73m, dbhs increment were 2.23cm and 2.08cm at Char Kukri-Mukri and Rangabali sites respectively at the age of 7 years. Wood production was also significantly much higher for best trees followed by selected trees and then mass collection seed source in both study sites in both years of plantations. About 3-4.6 times wood volume per ha area were achieved by using seeds of best trees stands than those from non-selected stands. So, the growth increment and yield were much higher for best trees seed source than all other previous records. The result clearly revealed that the seed sources are the important factor for tree growth and their yield. So, the use of improved seed sources from an established SPA provide significant growth and yield and has additional ability to withstand extreme weather conditions in the coastal belt.

IV. Conclusion

S. apetala is the most widely planting species on newly accreted lands in the coastal belt of Bangladesh and generally has shown satisfactory growth performance. Every year new accreted lands are forming in the offshore areas. The lands are suitable for planting *S. apetala*. These new lands can be planted with *S. apetala* species using by SPA seeds for getting maximum growth and timber production. The improved seed sources can enhance the growth performance of the species and their adaptability to vulnerable coastal areas. Therefore, large scale plantation with *S. apetala* can be raised in the newly accreted lands using these types of superior seed sources for achieving significant gain (wood production) from coastal mangrove ecosystem.

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