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GROWTH AND DEVELOPMENT OF *BAMBUSA VULGARIS* SCHRAD. *EX* WENDL. PLANTED IN THE COASTAL HOMESTEADS OF BANGLADESH

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Abstract

The study was conducted in the coastal homesteads of Bangladesh to assess the growth and development of *Bambusa vulgaris* Schrad. *ex* Wendl. planted in 2010 and 2011 using branch cutting seedlings. Trials were established at 5 different sites of the coastal belt. Data on seedling survival, culm height, culm diameter, culms production etc. were recorded from 4.0 years old and 3.0 years old two trial plantations. The result revealed that significantly greater culm height was 16.30 m, culm diameter was 5.29 cm from Rangabali site but greater number of culms/clump was 21.20 at Char Kukri-Mukri site at the age of 4.0 years raised in 2010. In the plantations of 2011, the significantly greater height was 13.21, greater diameter was 4.55 cm and greater number of culms/clump was 15.44 from Rangabali site at the age of 3.0 years. The promising culm height was recorded from Rangabali and Char Kukri-Mukri sites and it was grown up to 20.53 m and 17.94 m respectively of 4 years old plantations. Therefore, large scale plantations with *B. vulgaris* in the coastal homesteads can be established for the development of bamboo vegetation in the remote coastal areas of Bangladesh. Thus, homesteads bamboo plantations can provide income-generating opportunities for poor farmers and can protect habitation and properties of the coastal population from natural disaster as safeguard.

Key words: Growth, *Bambusa vulgaris*, Homesteads, Coastal belt, Culm production

Introduction

Bamboo is one of the most important fast growing and high yielding renewable non-timber resources in the world. It has 75 genera and 1250 species around the globe (Sharma 1980) belonging to the subfamily Bambusoideae of the family Poaceae. In the Indian subcontinent, it is known as the "poor men's timber", in China as "friend of people" and in Vietnam as "brother of people" (Banik 2000). About 2.5 billion people depend on it economically, with a trade value of more than 2.5 billion US dollars per year (Lobovikov *et al.* 2007). It is also one of the most important forest resources because of its rapid growth rate, unique strength, and its capacity to easily adapt. In Bangladesh, 33 species of bamboo have so far been found, of these 7 occur in the forests naturally and

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the rest are cultivated in the home garden throughout the country to fulfill day to day needs of village people (Banik 1980). Bamboos in Bangladesh can be divided into two groups, forest bamboos (thin walled) and village bamboos (thick walled). The most available thick walled bamboos are *Bambusa vulgaris* Schrad. *ex* Wendl. and *Bambusa balcooa* Roxb. Bamboo plays a significant role in the rural economy of the country. At present, 80% of supplies of bamboos come from village lands and the rest from natural forests.

Bambusa vulgaris is a widely grown village bamboo in rural area of the country and it has multiple uses. This bamboo species is 10-35 m tall, thick walled with glossy green culm, 3-10 cm in diameter at the base and branching from mid-culm to top of the stem (Alam 1982 and Hossain *et al.* 2005). It grows mostly on river bank, roadsides, wastelands and open ground, generally in low altitude and can thrive under a wide range of moisture and soil condition (Ohrnberger 1999). It controls soil erosion and stabilizes river bank and provides a number of ecosystem services. Bamboo has important roles to play in sequestering carbon in forest ecosystem (INBAR 2014). The demand for bamboo is increasing at much higher rate than their availability (supply) due to the rapid growth in human population. In recent years, there has been growing concern over the rapidly declining production of bamboo both in villages and natural forests of Bangladesh. One of the options of increasing bamboo resource is through its massive cultivation on village farms. Farmers however need information to assist them to grow and manage bamboo. This species could be propagated only vegetatively (Banik 2000 and Koshy and Pushpangadan 1997). The branch cutting technique is inexpensive without seasonality, produces a lot of propagation materials with high survival rate and reduces damages of bamboo clumps (Banik 2000).

The coastal belt of Bangladesh is 710 km long along the Bay of Bengal and is comprised of various forms of accreted (char) lands and off-shore islands (Siddiqi 2001). There are 6.85 million households in the coastal belt mostly inhabited by agricultural labourers, small farmers and fishermen (Ahmad 2004). Homesteads plantation plays a vital role in providing timber, fuelwood, fodder, bamboos and fruits. The diversity and occurrence of bamboos in the home gardens of coastal belt are limited in comparison to other areas of the country (Banik 1997). The people of the country have cultivated more than 15 bamboo species in their homesteads for many years. But village farmers have knowledge of bamboo cultivation on a limited scale, based mostly on personal experiences and not on systematic scientific studies. The situation calls for immediate attention to more scientific cultivation and mass reproduction of bamboo to meet increasing demands for planting materials. Bangladesh Forest Research Institute (BFRI) has been conducting research on bamboo and has developed several technologies on various vegetative propagations and raising of plantations (Banik 1980, Banik 2000 and Sirajuddoula *et al.* 2001). A little study on growth performance of bamboo was carried out in the coastal areas of Bangladesh. Therefore, the present study was undertaken to assess the success of branch cutting seedlings in the field condition and to assess the growth and productivity of *B. vulgaris* in the coastal homesteads of Bangladesh. This will enhance the capacity of coastal farmers to cultivate large scale plantation of *B. vulgaris* using new propagation technology.

Materials and Methods

Plantation Trial Unit Division of Bangladesh Forest Research Institute (BFRI) carried out experiments on growth and development of *B. vulgaris* in the coastal homesteads of Bangladesh since 2010. Experimental plots were laid out at Char Kukri-Mukri under Bhola, Rangabali under Patuakhali, Char Osman under Noakhali and Kolatoli under Cox's Bazar district, Bangladesh in 2010. In 2011, experimental plots are established at Rangabali, Char Kukri-Mukri, Char Osman and Sitakundu (under Chittagang district). The coastal zone of Bangladesh covering an area of 47,201 km^2 includes 19 coastal districts out of 64 districts of the country. It lies between latitude $21^0 26'$-$22^0 39'$N and longitude $90^0 39'$-$91^0 58'$ E. The coastal zone constitutes 30% of the country's area and 28% of the population of Bangladesh (Islam 2004). Every year newly accreted lands are added in the coastal belt. The area forms the lowest landmass and is part of the delta of the extended Himalayan drainage ecosystem. The landscapes have been formed by the combined actions of rivers Meghna, Brahmaputra and Ganges. These landscapes are low-lying land, estuaries and inland along the seacoast. Coastal saline soils occur in the river deltas along the sea coast. Tidal and estuarine floodplains cover almost 98% of the coastal area (Hassan 1999). Tidal floodplains occur in Patuakhali, Chittagong and Cox's Bazar district and estuarine floodplains occur in Noakhali, Bhola and Patuakhali districts. Salinity of the soil and water at this region decreases toward north and increases towards east and west taking Bhola district in the centre. In monsoon, water salinity ranges from 0.3-2.7‰ while in the dry season from 1.0-3.3‰ (Siddiqi and Khan 1990). Soil pH is slightly or moderately alkaline (7.5–8.0). Soil salinity ranges from 0.3-37.8 $dS \cdot m^{-1}$ at different study sites (Table 1) (FAO 1988 and SRDI 2010). Soil of the site is non-calcareous, grey floodplain and silt-clay-loam. The climate is humid. Temperatures range between 18 and 32^0C. The amount of rainfall varies from 3000 mm in the west, 2300 mm in the centre, and as high as 4000 mm in the east coastal belt (Siddiqi 2002).

Seedlings of *B. vulgaris* were raised in the nursery at Char Kukri-Mukri, Rangabali, Char Osman, Sitakukdu and Kolatoli Forest Research Stations using branch cutting technology. Propagation technology of bamboo branch cutting is well developed. Branches were selected from 1-2 year old culms and cut carefully from the culm using a

Table 1. Soil and climatic characteristics in the study areas of Bangladesh.

District	Latitude	Longitude	Annual rainfall (mm)	Agro-ecological Zone	Land type	Soil type	Soil salinity dS/m
Bhola	$22^0 39'$	$90^0 39'$	3000	Saline and non saline, Meghna eastern char land	Medium high land	Calcareous Alluvium + Grey floodplain soil	-
Patuakhali	$22^0 24'$	$90^0 19'$	2500-3000	Non saline and non-calcareous saline	Medium high land	Non-calcareous grey floodplain soil	0.5-9.9
Noakhali	$22^0 51'$	$91^0 07'$	3000	Saline Meghna eastern char land	Medium High land	Calcareous alluvium seasonally saline	0.3-31.5
Chittagong	$22^0 20'$	$91^0 51'$	2500-3000	Young tidal flood plain, river flood and piedmont plains	Medium high land and + High land	Non-calcareous alluvium	4.7-26.5
Cox's Bazar	$21^0 26'$	$91^0 58'$	3000	Mangrove tidal flood plain, low hills and piedmont plains	Medium high land and low land	Acid sulphate soil and brown hill soil	1.3-37.8

Source: FAO 1988 and SRDI 2010

saw during June-July. Cuttings were produced by trimming leaves, small branches and the branch tip with 2-6 nodes, may be 50-80 cm long with healthy buds. The collected branch cuttings were placed on the bed of sand rooting media of 7-10 cm deep. Water was sprayed regularly over the cuttings for one month. Within 30-45 days, each of the cuttings produced profuse active roots and leaves. At this stage, cuttings were uprooted carefully from the bed and then transplanted to the polybags of size 25 cm x 15 cm filled with mixed powdered loamy soils and cow dung at 3:1 ratio. Seedlings were then kept under shed for one week. After that seedlings were placed on normal nursery beds and maintained for another 10-12 months. Seedlings of this bamboo species were distributed to the selected farmers for planting on the farmer's home garden during 2010 and 2011. In each year, 40 farmers were selected in each study sites and 5-10 seedlings were distributed and planted scatteredly in each homestead. Data on seedlings survival, height and DBH (diameter at breast height) of dominant culms, number of new culms (3^{rd} and 4^{th} year), total number of culms/clump, etc. were collected from experimental bamboo plantations in September, 2014. Data were computed and analyzed using Excel and MINITAB-11 statistical package.

Results and Discussion

The growth performance of *B. vulgaris* planted in 2010 (4.0 years old) and 2011 (3.0 years old) at different sites of the coastal belt are presented in Tables 2 and 3. In the plantations raised in 2010, the mean highest survival was 51% at Char Osman and the lowest was found only 30% at Rangabali site. The significantly greater culm mean height was 16.30 m at Rangabali and the lowest was 5.61 m at Char Osman site. The maximum culm height 20.53 m was recorded at Rangabali followed by 17.94 m at Char Kukri-Mukri, 16.34 m at Cox's Bazar and 10.11 m at Char Osman site. Significantly greater diameter was 5.29 cm at Rangabali and the lowest was 4.16 cm at Char Kukri-Mukri site. The new shoots (culms) emergence in 4th year of plantations was recorded and significantly higher number of culms/clump was found 10.50 at Cox's Bazar followed by 7.60 at Char Kukri-Mukri and 6.15 at Rangabali site. The highest number of total culms/clump was 21.20 at Char Kukri-Mukri and the lowest was 5.92 at Char Osman site. The average growth parameter of this species at 4 sites was calculated. The average survival of *B. vulgaris* in the coastal area of Bangladesh was 40.50%, height was 11.31 m, diameter was 4.67 cm and number of culm production/clump was 14.68 at the age of 4.0 years after planting (Table 2).

Table 2. Growth performance of *Bambusa vulgaris* planted in 2010 (4.0 years old) at different locations of the coastal belt of Bangladesh.

Location	Mean survival %	Mean height of dominant culm (m)	Maximum height (m)	Mean diameter of dominant culm(cm)	Maximum diameter (cm)	Mean no. of new culms/ clump	Total no. of culms/ clump
Rangabali	30a	16.30d	20.53	5.29b	6.84	6.15b	15.50b
Char Kukri	47b	13.41c	17.94	4.16a	5.73	7.60b	21.20b
Char Osman	51b	5.61a	10.11	4.27a	6.39	2.26a	5.92a
Kolatoli	34a	9.91b	16.34	4.98b	7.05	10.50c	16.10b
Average	40.50	11.31	-	4.67	-	6.63	14.68

Notes: Means with the different letters (like a,b...) in a column are significantly different at 5% level.

In the plantation raised in 2011, the maximum mean survival 41% was recorded from Char Osman site and the lowest 30% was from Char Kukri-Mukri site. The significantly greater height 13.21 m was recorded from Rangabali and the lowest 3.74 m was from Char Osman site. The maximum culm height 16.16 m was from Rangabali followed by 14.62 m at Char Kukri-Mukri, 8.40 m at Sitakundu and 7.66 m at Char Osman site. The mean greatest culm diameter (4.55 cm) was recorded from Rangabali and lowest 2.02 cm was at Sitakundu site. The maximum culm diameter (6.13 cm) was also recorded from

Rangabali site. The significantly higher number of total culms/clump was found 15.44 at Rangabali but it was only 5.07 at Char Osman site. The average survival for all sites was 34.25%, height was 8.00 m, diameter was 3.16 cm and total number of culms/clump was 11.50 at the age of 3.0 years after planting (Table 3).

Table 3. Growth performance of *Bambusa vulgaris* planted in 2011 (3.0 years old) at different locations of the coastal belt of Bangladesh.

Location	Mean survival %	Mean height of dominant culm (m)	Maximum height (m)	Mean diameter of dominant culm(cm)	Maximum diameter (cm)	Mean no. of new culms/ clump	Total no. of culms/ clump
Rangabali	31a	13.21d	16.16	4.55c	6.13	6.15b	15.44b
Char Kukri	30a	10.15c	14.62	3.70b	5.13	6.16b	14.00b
Char Osman	41b	3.74a	7.66	4.16b	5.91	1.92a	5.07a
Sitakundu	35ab	4.91b	8.40	2.02a	3.47	3.60ab	11.50b
Average	34.25	8.00	-	3.16	-	4.46	11.50

Notes: Means with the different letters (like a,b...) in a column are significantly different at 5% level.

The height and diameter of the emerged culms gradually increased year after year following planting of branch cutting seedlings. Sirajuddoula *et al.* (2001) reported that the average height of *B. vulgaris* was 7.9 m in 3rd year and it was 13.7 m and diameter was 6.41 cm in the 4th year. Bhol and Nayak (2014) conducted an experiment at Orissa University of Agriculture and Technology, Bhubaneswar, India on the effect of planting technique of offsets on growth and development of *B. vulgaris*. The authors found that total number of culm produced was 14.9-20.3, number of new culms recruited per clump was 6.4-8.1, height growth of dominating culm was 8.31-9.15 m and DBH growth of dominating culm was 4.42-5.11 cm under different treatments by the end of 4 year of plantation. Asari and Suratman (2010) stated that average height and diameter growth of *B. vulgaris* were 14.27 m and 6.5 cm respectively and culm production was 4.28 per clump per year in a forest of Pahang National Park, Malaysia. Alemayehu *et al.* (2015) reported that average number of culms, height and DBH for *B. vulgaris* var. green were 66.0, 6.77 m, 1.9 cm respectively of 4 year old clumps in Ethopia.

Significant differences in growth and development parameters were found in different study sites of the coastal belt of Bangladesh. On the basis of survival, height, diameter and culm production, the result of the present study showed promising growth performance of *B. vulgaris* in Rangabali and Char Kukri-Mukri sites in both planting years. But poor growth behavior was recorded in Char Osman and Sitakundu (eastern coastal belt) sites in comparison to other study sites like Rangabali and Char Kukri-Mukri (central coastal belt). However, there was low seedling survival of *B. vulgaris* at all planting sites. The factors that were responsible for low seedling survival in the coastal homesteads were flooding by high tidal inundation during the monsoon, cyclonic wind action, soil salinity, drought in the dry season and grazing by domestic animals like buffalos, cows and goats. The main reason is poor maintenance of planted seedlings by family members due to lack of awareness for bamboo cultivation. As a result, many seedlings were damaged or died at the early stage of plantation.

The coastal belt of Bangladesh and the communities are most vulnerable to the impact of extreme weather events due to climate change. Bamboo is not only an important part of many natural and agricultural ecosystems but also provide a number of environmental services. They can function as carbon sinks, control soil erosion, provide organic matter to the soil, conserve biodiversity, beautify the landscape and provide household food security (Schröder 2012). The bamboo plantations along the coastline can protect human habitat, lives and properties as a strong natural barrier from extreme weather events resulting from climate change. Bamboo forests and plantations make good windbreaks, shelter natural vegetation and crops. Bamboos roots and rhizomes grow in all directions forming a complex network of up to more than 1 m depth belowground that helps to hold soil particles together and prevents erosion as well as allowing water to percolate downward. Bamboo is stronger than steel and its root can reduce soil erosion by up to 75% (Thokchom and Yadava 2015). In the coastal area of Bangladesh, bamboo plantations can play a crucial role in stabilizing riverbank, regulating watersheds, preventing landslides, protecting soil erosion and conserving soils in the newly established coastal homesteads. The plantations of bamboo improve the physical and chemical composition of soil considerably, preserve water in soil by creating a natural water reservoir. It also adds a large amount of organic matter to the soil. Bamboos can capture and sequester significant amount of atmospheric carbon and consequently help in mitigating climate change, in a similar way that forests do. It is a versatile plant that offers carbon sink to the international climate initiatives that will significantly reduce the negative effects of greenhouse gases on the planet (INBAR 2014). Bamboo biomass, bamboo litter and bamboo soil act as a carbon sink in forest ecosystem.

B. vulgaris is an economically important bamboo species in Bangladesh. But the abundance of this bamboo vegetation in the coastal home gardens is poor. So, there is an urgent need to raise bamboo plantations both in homesteads and forest lands in the coastal areas. The major constraints are the lack of an efficient propagation method and suitable bamboo species for raising plantations. The growth and culms production of *B. vulgaris* in the coastal homesteads showed promising performance especially in the western coastal areas. Therefore, large scale plantation programs with this bamboo species can be initiated along the coastal belt to meet the increasing demand for bamboo resources and improving bamboo vegetation. Thus, homesteads bamboo plantations can provide income-generating opportunities for family members and can provide shelter for houses, lives and other properties of the rural coastal people. However, suitability of other bamboo species needs to be investigated to identify other suitable species in the coastal homesteads for sustainable production of bamboo resources.

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