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RESEARCH ARTICLE

ASSESSMENT OF BIOMASS CARBON STOCK OF MACROPROLIFERATED SEEDLINGS OF SELECTED BAMBOO SPECIES IN HILLY REGION OF ASSAM

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ABSTRACT

Bamboo plays an important role in global carbon cycle. It is a long lived woody giant evergreen grass belonging to Poaceae family. Bamboo is extensively distributed in tropics, sub tropics and temperate region of the world. India is the second largest bamboo producing country in the world and two third of growing stock is available in North East India. Bamboo plant can able to clean environment by carbon sequestration, lower light intensity and protect earth from UV rays. Due to fast growing canopy cover, it releases more oxygen as compare to similar stands of tree. The study assessed the growth performance, biomass production and quantifies carbon stock of three economically important bamboo species such as, *Bambusa balcooa, Bambusa nutans* and *Bambusa tulda* cultivated through macroproliferated seedling in jhum affected area of Karbi Anglong district Assam. Each bamboo seedling was planted at 6.6 x 6.6 m spacing. Number of newly emerged culm, growth performance, above ground biomass (AGB) and carbon stock from one year interval up to four year of growth was recorded. Maximum height and DBH was recorded in *B. balcooa* (5.85m & 4.80 cm), *B. tulda* (5.67m. & 3.59 cm.) followed by *B. nutans* (4.39 m & 3.38 cm.). *B. tulda* has higher biomass accumulation potential than *B. balcooa* and *B. nutans*. Study revealed that stem, twigs and leaves of *B. tulda* accumulate 43.34%, 34.42% and 22.26% carbon content respectively in 4th year old seedling. Amount of above ground biomass carbon stock evaluated from stem (382.60 t C ha^{-1}) twigs (21.47 t C ha^{-1}) and leaves (10.02 t C ha^{-1}) of *B. tulda* plantation indicate as potential species for protect environment. Study concluded that bamboo seedlings established through macro proliferation technique will help to mitigate climate change.

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INTRODUCTION

Bamboo is a fast growing, renewable, widespread and eco friendly resource, which has great potential for poverty alleviation and environmental conservation. Bamboo is naturally grown in hilly terrain of North-east India and plays a major role in the livelihood of rural people through cottage industry. Due to its fast growth and development it is considered as an ideal plant to sequester carbon and expect to play active role in mitigating impact of climate change. Degradation of forest due to slash and burning operation is one of the major problems of hilly area. Bamboo is a pioneering plant can be grown in early forest succession in shifting cultivation areas. Besides these, bamboo has recognized as more advanced over tree in terms of carbon fixing capacity and they can store more than 40 tonnes of CO_2 per hectare and release very little amount of carbon during harvesting period.

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Scurlock *et al.*, (2000) stated that biomass and carbon production capability of bamboo (7-30%) has much higher compared to the fast growing woody species. Due to fast growth and productivity of bamboo can be identified as a notable sink of atmosphere carbon (Nath *et al.,* 2008). Bamboo has known as renewable natural resources as a substitute of woody species in the last 15-20 years (Kumar and Kumari, 2010). Carbon sequestration capacity may be varies according to the nature of species, plantation sites and management practices (Ramakrishnan *et al.* 1998). Cultivation of suitable bamboo species in degraded land would give assured economic returns as it is becoming increasingly important in the rural economy due to diverse value added products and protect environment, mitigate deforestation, illegal felling and restore soil erosion. A field experiment carried out macro proliferated seedlings of *Bambusa balcooa, B. tulda.* and *B. nutans* were planted in degraded shifting cultivation area of Karbi Angling district, Assam. For large scale plantation, such as abandoned land in shifting cultivation area, seedling raised from bamboo was more feasible because of the large stock of planting material.

On the other hand nutrient and light demand was also less in seedling raised bamboo. The present study was conducted to estimate the biomass production potential and carbon stock of *B. balcooa, B. tulda* and *B. nutans* seedling grown in shifting cultivation area.

MATERIALS AND METHODS

The experiment was carried out at Johnar Sinar village under Nilip Block of Karbi Anglong district and lying on 26^0 13' 29.18"N and $93^0$48' 39.24" E with elevation of 132m of hilly terrain. Approximate 4922.019 sq. km area was covered by forest including 14 numbers of State Reserve Forest and 17 numbers of District Council Reserve Forest. Shifting cultivation or slash and burning operation is traditional agriculture plays major role among tribal people. The climate of this area may varied on temperature ranges from 23°C - 32°C in summer and 6°C -12°C during winter season. Winter season are foggy, cold and dry. Moderate to heavy rainfall have found during monsoon season. The average rainfall is 2416 mm approximately (Anonymous 2013). Highest amount of relative humidity was recorded in the month of August (90%). For the experiment one year fallow land was selected. The experiment was laid out in Randomized Block Design (RBD) of 15m x15m plot with 6.6 m x6.6 m spacing. Total 12 Nos. of plot was prepared for each bamboo species with three replications. About 6 months old healthy, macro proliferated seedlings with 4-6 shoots are suitable for macro proliferation were grown in RFRI nursery, Three different bamboo species *viz., Bambusa balcooa (*Bholuka*), B.tulda* (Jati) and *B. nutans* (Mokal) seedlings were planted in the onset of monsoon.

Newly emerged shoot was recorded at the end of the month of June in every year. Fresh biomass was collected by destructive sampling and estimated following the method of Yadav (2010). For estimation of plant carbon leaf, twig and bole of each bamboo species were collected randomly from the experimental sites. Samples were dried in air, then oven dried and pass through 2mm sieve for further analysis. Plant carbon was analyzed by following Walkley and Black's wet oxidation method as described by Jha (2005. The total biomass carbon, tones carbon per hectare (t C ha^{-1}) was calculated by using the following formula: Above Ground Biomass (AGB) carbon (t C ha^{-1}) = Components of above ground biomass (t ha^{-1}) x Carbon content (%).

RESULTS AND DISCUSSION

Culm emergence and Growth parameter: Results represent the culm emergence and growth parameter of bamboo seedling at different age group from one year to 4^{th} year old. Table-1 showed number of newly emerged culm per 10 square meters *in B. balcooa*, *B. tulda* and *B. nutans* during four consecutive years. Highest number of culm was recorded in *B. tulda* (929 no./ha) at four year of plantation. Growth parameter is mainly influenced by spacing and prevailing environmental condition of particular sites. Perusal results table -2 revealed that maximum culm length was noticed in *B. balcooa* (5.85 m), *B. tulda* (5.67m) followed by *B. nutans* (4.39 m) at four year old seedling. Similar trend was also observed in DBH also.

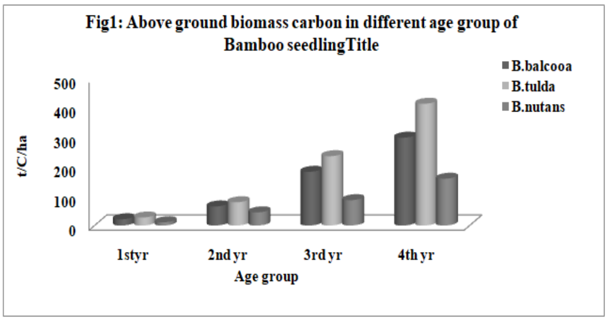
Table 1. Number of newly emerged shoots from Bamboo seedling

Name of species	No. of culm 10^2 m			
	1^{st} year	2^{nd} year	3^{rd} year	4^{th} year
Bambusa balcooa	3.25±0.06	4.32±0.04	6.28±0.02	9.05±0.5
Bambusa tulda	3.88±0.12	4.5±0.8	6.74±0.15	9.29±0.2
Bambusa nutans	2.02±0.09	3.18±0.17	5.84±0.06	8.62±0.14

Biomass allocation in different components of Bamboo: Bamboo components were the most significant source of variation of above ground biomass (Table-3). It consists of different parts of above ground viz, bole, twigs and leaves. Maximum amount of biomass component was found in four year old seedlings. Biomass allocation of the culm component was varied in order of *B. tulda* (89.15%) > *B. nutans* (88.86%) > *B. balcooa* (72.66%) at four year plantation. Similar trend was also observed in twigs and leaves of all three bamboo species. Remarkably highest amount of biomass production observed in stem followed by twigs and leaves irrespective of species. Highest amount of total dry biomass production recorded at fourth year old *B. tulda* (9.902 t ha^{-1}) plantation.

Estimation of Plant Biomass Carbon and Above Ground Biomass Carbon: Highest concentration of carbon content was found in bamboo (Table 4) species. Maximum concentration of carbon was recorded in stem followed by twigs and leaves. Stem of *B. tulda* (43.34%) has shown considerably more carbon content as followed by *B. balcooa* (38.79%) and *B. nutans* (36.76%). Significant increment of carbon percentage was observed with age of plantation irrespective to components. Many workers have (Negi *et al*., 2003 and Swami and Puri, 2005) have also reported similar trend in different components of some tree species.

Above ground biomass carbon may be varied according to the age group and nature of components. The results revealed that highest amount of carbon stock was recorded in *B. tulda* stem (382.60 t C/ha) as compared to *B. balcooa* (237.78 t C/ha) and *B. nutans* (146.45 t C/ha). The variation of age and types of bamboo species directly related with above ground carbon storage (Fig. 1).



The progressive increment of biomass production and above ground biomass (AGB) in carbon was recorded upto four years old bamboo plantation (Table 5). Least amount of biomass production found in the initial year in *B. tulda* (1.286 t ha^{-1}) and gradually increase with the age of the plantation (9.902 t ha^{-1}) due to its prolific emergence of culms. Similar trend of increment of total above ground biomass (AGB) carbon found in *B. tulda* (414.09 t C ha^{-1}) after four year of plantation.

Table 2. Progressive growth data in different age groups of Bamboo plantation

Name of species	One yr old		Two yr old		Three yr old		Four yr old	
	L (m)	G(cm)	L(m)	G(cm)	L(m)	G(cm)	L(m)	G(cm)
B.balcooa	3.39 ±0.2	3.40 ±0.05	3.85 ±0.12	3.56 ±0.04	4.56 ±0.5	4.4 ±0.01	5.85 ±0.4	4.80 ±0.05
B. tulda	3.18 ±0.6	3.05 ±0.15	3.42 ±0.02	3.14 ±0.05	4.61 ±0.2	3.22 ±0.06	5.67 ±0.08	3.59 ±0.16
B. nutans	2.86 ±0.05	2.96 ±0.8	3.15 ±0.24	3.02 ±0.02	3.37 ±0.15	3.26 ±0.15	4.39 ±0.15	3.38 ±0.15

L- Length, G-Girth

Table 3. Biomass production (t ha^{-1}) in different age groups of Bamboo

Species	Dr wt. (t ha^{-1})				
		One yr old	Two yr old	Three yr old	Four yr old
B.balcooa	B	0.926	2.383	4.428	6.130
	T	-	0.146	0.291	2.04
	L	0.032	0.087	0.174	0.266
	Total	0.958	2.616	4.893	8.436
B.tulda	B	1.243	2.274	5.743	8.828
	T	-	0.155	0.378	0.624
	L	0.0438	0.117	0.215	0.450
	Total	1.286	2.546	6.336	9.902
B. nutans	B	0.579	1.575	2.707	3.984
	T	-	0.091	0.192	0.332
	L	0.0177	0.062	0.121	0.167
	Total	0.596	1.728	3.020	4.483

B- Bole, T- Twigs, L-Leaves

Table 4. Percentage of plant carbon in various components of Bamboo species

Species	Categories	One yr old	Two yr old	Three old	Four yr old
B.balcooa	Stem	22.72±0.27	25.76±0.08	32.09±0.1	38.79±0.4
	Twigs	-	17.22±0.02	24.88±0.05	27.25±0.06
	Leaves	11.88±0.04	12.98±0.4	17.68±0.2	23.28±0.02
	Total	34.6	55.96	74.65	88.32
B. tulda	Stem	21.54±0.6	32.48±0.4	38.5±0.21	43.34±0.18
	Twigs	-	16.65±0.08	28.42±0.16	34.42±0.02
	Leaves	12.75±0.18	16.72±0. 15	19.82±0.09	22.26±0.3
	Total	34.29	71.74	86.74	100.02
B. nutans	Stem	18.84±0.05	26.59±0.18	29.41±0.02	36.76±0.26
	Twigs	-	14.48±0.21	22.38±0.18	27.82±0.05
	Leaves	10.66±0.06	16.55±0.04	19.45±0.04	21.78±0.04
	Total	29.50	63.62	71.24	86.36

Table 5. Progressive increment of Biomass production (t ha^{-1}) and Above Ground Biomass carbon (t C ha^{-1}) in different bamboo plantation

Species		One year	Two year	Three year	Four year
B. balcooa	Biomass	0.958	2.616	4.893	8.436
	AGB	21.383	65.023	182.78	298.76
B. tulda	Biomass	1.286	2.546	6.336	9.902
	AGB	27.332	79.278	235.99	414.09
B. nutans	Biomass	0.596	1.728	3.020	4.483
	AGB	11.098	44.780	86.28	159.32

Therefore, it can be expect that *B tulda* is more potential in terms of carbon sequestration and could help in rehabilitating degraded jhum fallow**.** A little work has been done on carbon sequestration potentiality of bamboos in North East India. Borah and Chandra (2010) assess the carbon storage potential of naturally occurring bamboo strand of this region by grouping different diameter classes and conclude that *B. balcooa* has high potential to store carbon. Arunachalam and Arunachalam (2002) specified that *B. nutans* could help in rehabilitating jhum fallows with special reference to soil nutrient enrichment. *B. tulda* planted through macroproliferated seedlings have shown high potentiality towards carbon storage within short period of time and exhibit significant relationship with growth performance.

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