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Rehabilitation of degraded Jhum land of Assam (India) through plantation of selected bamboo species and explore their potentiality towards carbon sequestration

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Abstract

A study was conducted in selected sites of degraded shifting cultivation land under Nilip and Rongmongwe Block of Karbi Anglong district, Assam. Bamboo plantation was raised from rhizome and seedling in two different spacing regimes i.e. 5mx5m and 6.6mx6.6m. Number of newly emerged shoots raised from both rhizome and seedlings was recorded in every year. Gfjud Culm emergence was found to be considerably more in B. tulda followed by B. nutans and B. balcooa and was recorded comparatively low in seedling origin plantation Progressive growth data showed rapid increase of newly emerged culm upto one year and after that the growth was slow. Significantly low growth was observed in seedling origin plantation. Maximum growth was observed in B. balcooa followed by B. tulda and B. nutans. No significant difference of growth was noticed due to spacing. Progressive increment of biomass production showed significant increase with age of plantation. B. tulda scored highest value of biomass production (254.30tha^{-1}) followed by B. balcooa (174.19tha^{-1}) and B nutans (149.84tha^{-1}) in four year plantation. Percentage of plant carbon as well as total biomass carbon stock (tC/ha) increase with increase in age of the plant. Low value of biomass carbon was recorded in seedling origin plantation. B. tulda recorded highest biomass carbon stock (8894.12tC/ha) followed by B. balcooa (5982.79tC/ha) and B nutans (3587.23tC/ha). In B. tulda biomass carbon stock was comparatively more at 5mx5m spacing (8894.12tC/ha) than 6.6mx6.6m spacing (6984.21tC/ha) but in other two species no significant difference was noticed. Soil organic carbon stock was recorded maximum in B. tulda (1025.7tC ha^{-1}) and least in B. nutans (782.3tC ha^{-1}) in rhizome plantation of 6.6mx6.6m spacing. Same trend was noticed in seedling plantation also. Comparative assessment of total carbon stock reveals that B. tulda plantation showed highest value of carbon stock (9857.52tC ha^{-1}) and (2567.56tC ha^{-1}) raised from rhizome and seedlings respectively. Least value was observed in B. nutans. Therefore, it can be assumed that B. tulda has potential in terms of carbon sequestration and can be suggested for large scale plantation for rehabilitation of jhum land as well as to mitigate global warming.

Keywords: Bamboo plantation, shifting cultivation, rehabilitation, carbon sequestration.

Introduction

Greenhouse gas emission has become a matter of great concern because of the future projection of global warming, the most devastating problems of the new millennium and related effects on biological life. Carbon-di-oxide (CO_2) is one of the major greenhouse gases which is increasing drastically in recent decades. The Intergovernmental Panel of Climate Change[1] has identified creation and strengthening of carbon sinks in the soil as a clear option for removal of CO_2 from the atmosphere and recognized soil organic carbon as major carbon pool. The role of plantations as potential carbon sinks to help mitigate global warming is being increasingly studied. Carbon sequestration varies according to species, plantation site and management practices. Young fast growing trees sequest more carbon per unit time comparison to mature slow growing trees. Soil also plays an important role in carbon sequestration by increasing soil organic carbon (SOC). Assessment of carbon stocks in vegetation and soil is a basic step in evaluating the carbon sequestration potential of an ecosystem.

Forest destruction leads to land degradation that makes significant contributions to emission of carbon in to the ecosystem and have the prospective added emissions in future decades. Hence, restoration of degraded land is a priority in forestry sector. In North Eastern Region of India shifting cultivation is a widely practiced food production system and is main source of livelihood. Traditionally it was productive and sustainable but in recent time due to shortening of jhum cycle it is blamed as the causal factor of most serious challenges including deforestation that makes significant contributions to global emissions of greenhouse gases ultimately leading to global warming, lowering productivity, depletion of soil fertility, erosion and finally deepening impoverishment of jhum dependent communities. Enriching such degraded forests and deforested areas with bamboo species could be an effective means of increasing the carbon sequestration potential of that particular ecosystems[2]. Hence, rehabilitation of degraded shifting cultivation land through bamboo plantation could be a key intervention provided it addresses environmental concern and at the same time develops livelihood of local communities. Bamboo is a pioneering plant and can be grown in soil damaged by overgrazing and poor agricultural techniques. Bamboo plantation have significant advantage over other biomass resources due to the vigorous growth, species diversity, early establishment, short harvesting period, adaptability to diverse soil and climatic conditions, sustainability in yield and its multifarious uses. The fastest growing capacity of bamboo makes it a valuable sink for carbon storage. The ability of bamboo towards carbon sequestration is well documented and recognized internationally. Available studies conclude that in every 5 years it would produce at least 86t/ha biomass and sequester 43 tC/ha, the value reveals almost twice recoded in teak plantation[3]. It was also reported that carbon storage potential of some common bamboo species is much more promising than the of many other tree species considered in the CDM projects[4]. Compared to the fast growing wood species bamboo biomass and carbon production was observed 7-30% higher[5]. It releases negligible amount of carbon into the atmosphere at the time of harvesting and unlike timber it can store in excess of 40 tons CO_2 per hectare depending on planting density. Bamboos are utilized for different livelihood purposes and form an integral part of life especially of rural communities[6]. Moreover, tribal communities have been found to be more concerned about the species like bamboo that have immediate economic benefit than the long term benefit of tree plantation. The present study was conducted to rehabilate abandoned jhum land by planting selected bamboo species *viz Bambusa balcooa* (Bholuka), *B.tulda* (Jati) and *B. nutans* (Mokal) and quantifies their carbon sequestration potential so that it can provide both environmental security and economic profitability.

Materials and methods

Selection of site: Study was conducted in the degraded shifting cultivation sites of Karbi Anglong district, (N 26^{0}13' 29.18" and E 93^{0}48' 39.24") Assam with elevation of 132m. The temperature varied from 23°C to 32°C and 6°C to 12°C during summer and winter respectively. Average rainfall was recorded as 2416mm and relative humidity was highest as 90% in the month of August. Karbi Anglong district is bounded by Golaghat district in the east, Morigaon and Meghalaya in the west, Nagaon and Golaghat district in northern side and Dima Hasao district and Nagaland in the south. Extensive survey was conducted in different villages under Nilip Block, Rongmongwe Block, Bokajan block, Samelangso Block, Howraghat Block, Lumbajong Block, Rongkhang Block and Chinthong Block for selection of willing farmer and degraded land under jhum cultivation for plantation of bamboo. According to farmer's choice three bamboo species such as *B. balcooa*, *B. tulda* and *B. nutans* were selected and plantation sites were chosen in degraded shifting cultivation area under Nilip and Rongmongwe Block of the district.

Preparation of Experimental plot: Slashing and burning of the selected plot was carried out and sub plot was prepared for raising *B.balcooa*, *B.tulda* and *B. nutans* from both rhizome and seedling. The experiment was laid out in Randomized Block Design (RBD) with 5mx5m and 6.6mx6.6m spacing having three replications for each species.

Plantation of Bamboo seedlings: Rhizome plantation: About 18 months old healthy, rhizomes of were collected from three different bamboo species *viz. B.balcooa*, *B. tulda* and *B. nutans*. The rhizome attached to this culm was carefully separated at the rhizome neck, wrapped in gunny bags for transportation. Before transplanting of bamboo rhizomes, it was dipped in Bavistin solution diluted at 1 gram per liter. A pit of 50x50x50cm. was dug and offset planted vertically in the pit during the onset of monsoon.

Seedling plantation: Macroproliferated seedlings was raised in nursery of Rain Forest Research Institute, Jorhat, Assam. Seedlings of 4-6 months age usually produce 4-6 shoots and are suitable for macro proliferation. Individual rhizomes are separated with the help of secateurs from the clump at the rhizome neck region. The cut end of the culm was sealed with wax covering to prevent desiccation. The separated rhizome cutting with root portion was dipped with 0.1% Bavistin solution for 1 minute to prevent the possible attack of soil borne diseases and planted in the polybag. The mother stock of the seedlings can be multiplied upto 4-6 times depending upon the environmental condition. After two months the seedlings were transported to the field. For plantation 30x30x30cm. was dug and seedlings was planted during the onset of monsoon.

Recording of newly emerged shoot and progressive growth of bamboo culm: Number of newly emerged shoots of bamboo raised from both rhizome and seedlings were recorded in the month of August every year maintained in different spacing regime. Progressive growth data of bamboo culm was recorded in every year up to four years of study.

Estimation of dry biomass: Above (stem, twigs, leaves) and below (rhizome) ground biomass was collected from three different species by destructive sampling from the experimental plot every year and dry biomass was estimated following standard method[7].

Estimation of plant carbon: Plant samples of various parts (leaf, twig, bole and rhizome) from selected species raised from both rhizome and seedlings were randomly collected from the study area. Samples were air-dried followed by oven drying, ground and passed through sieve having pore size 2mm. Plant carbon was analysed by following standard method[8,9].

Estimation of soil organic carbon: Composite soil samples were collected from each plot. For collection of sample a pit

30cm deep, 30cm wide and 30cm long was dug out. Soil from 0 to 30cm depth, from three sides of the pit, scraped with the help of khurpi and the soil was mixed thoroughly. This composite sample was air dried, ground and sieved through 100 mesh sieve in the laboratory and analyzed for organic carbon[8].

Analysis of soil bulk density: Soil bulk density in every sub-plot was estimated by standard core method[10,11].

Calculation of soil organic carbon stock: Soil organic carbon stock was computed and expressed in tC ha^{-1} by multiplying the soil organic carbon (g kg^{-1}) with bulk density (g cm^{-3}) and depth (cm) of soil[12].

Estimation of Total biomass carbon: The total biomass carbon, tones carbon per hectare (tC ha^{-1}) was calculated by using the following formula:

Total Biomass carbon (t C ha^{-1}) = Components of above and below ground biomass (tha^{-1}) x Carbon content (%).

Results and discussion

Number of newly emerged shoots/ha raised from rhizome and seedling of selected bamboo species were recorded during post monsoon period in each year upto the fourth year of plantation (Table-1) Data reveals that Culm emergence was considerably more in *B. tulda* followed by *B. nutans* and *B. balcooa* respectively. Significantly low value of culm emergence was noticed in seedling plantation compared to rhizome. No significant difference was noticed due to difference in spacing; however the emergence recorded comparatively high in third and fourth year plantation in 6.6x6.6m spacing. Percentage increase of total no of culm was more in *B. tulda* and the least in *B. nutans* in both Rhizome and seedling plantation.

Progressive height of culm: Progressive height of culm (cm) in different age groups of Bamboo plantation raised from rhizome and seedlings was recorded in each year (Table-2). Growth was recorded significantly less in seedling origin plantation. Because of the less amount of reserve food in seedlings the growth was significantly less in seedling origin plantation compared to rhizome. Maximum growth was recorded in *B. balcooa* followed by *B. tulda* and *B. nutans* in both rhizome and seedling origin plantations. No significant difference in growth was noticed due to spacing.

Progressive increase in biomass production: Figure-1a and 1b represents the progressive increase in biomass production in successive years of plantation upto four years. Due to emergence of more number of culms with increase in the age of plantation biomass production.

In the initial year *B. tulda* produces only 7.599t ha^{-1} of dry biomass which goes upto 254.3t ha^{-1} in the fourth year. Production of biomass was almost four times higher in rhizome origin plantation compared to seedling origin plantation. *B. tulda* scored highest value of biomass production (254.30t ha^{-1}) followed by *B. balcooa* (174.19t ha^{-1}) and *B nutans* (149.84t ha^{-1}) raised through rhizome at the end of the study. Likewise in seedling plantation also significantly high value of biomass production was recorded in *B. tulda* (70.075t ha^{-1}) and least in *B. nutans* (28.967t ha^{-1}). Prolific emergence of culms of *B. tulda* with increasing age of plantation contributed to increment of biomass production.

Table-1: Number of newly emerged shoots in different spacing in Rhizome and seedling plantation.

Sample plot	Spacing	No. of culm/ha								Percentage of increase	
		Year 1		Year 2		Year 3		Year 4			
		R	S	R	S	R	S	R	S	R	S
B. balcooa	5mx5m	400	238	900	467	1750	920	3416	1941	754.0	722.4
	6.6mx6.6m	396	224	996	454	1870	1084	3662	1954	824.7	772.3
B. tulda	5mx5m	860	358	1980	741	3590	1756	7972	3529	826.9	885.7
	6.6mx6.6m	857	351	1978	726	3701	1974	8113	3686	846.6	950.2
B. nutans	5mx5m	700	208	1500	348	2800	736	5228	1651	646.8	693.7
	6.6mx6.6m	718	206	1498	331	2878	727	5678	1778	690.8	763.1

R-Rhizome: S- Seedling.

Table-2: Progressive height of culm (cm) in different age groups of Bamboo plantation raised from rhizome and seedlings.

Name of species		Year 1		Year 2		Year 3		Year 4	
		Rhizome	Seedling	Rhizome	Seedling	Rhizome	Seedling	Rhizome	Seedling
B. balcooa	5mx5m	4.71 ±0.17	3.08 ±0.14	6.32 ±0.11	5.00 ±0.20	6.8 ±0.13	5.80 ±0.09	10.2 ±0.11	8.64 ±0.13
	6.6mx6.6m	4.52 ±0.18	3.64 ±0.04	5.82 ±0.20	3.11 ±0.19	6.43 ±0.20	5.71 ±0.05	7.48 ±0.18	5.82 ±0.11
B. tulda	5mx5m	4.41 ±0.19	2.64 ±0.07	5.22 ±0.17	4.10 ±0.12	6.4 ±0.15	5.37 ±0.02	9.7 ±0.17	8.42 ±0.03
	6.6mx6.6m	4.47 ±0.19	3.54 ±0.08	5.65 ±0.13	4.26 ±0.19	6.01 ±0.16	5.61 ±0.05	6.27 ±0.11	5.18 ±0.15
B. nutans	5mx5m	4.10 ±0.19	2.26 ±0.10	4.83 ±0.06	4.30 ±0.18	5.7 ±0.15	4.47 ±0.08	7.6 ±0.12	6.91 ±0.07
	6.6mx6.6m	4.15 ±0.19	3.12 ±0.17	5.43 ±0.23	2.12 ±0.19	5.81 ±0.10	4.22 ±0.06	5.69 ±0.13	4.35 ±0.11

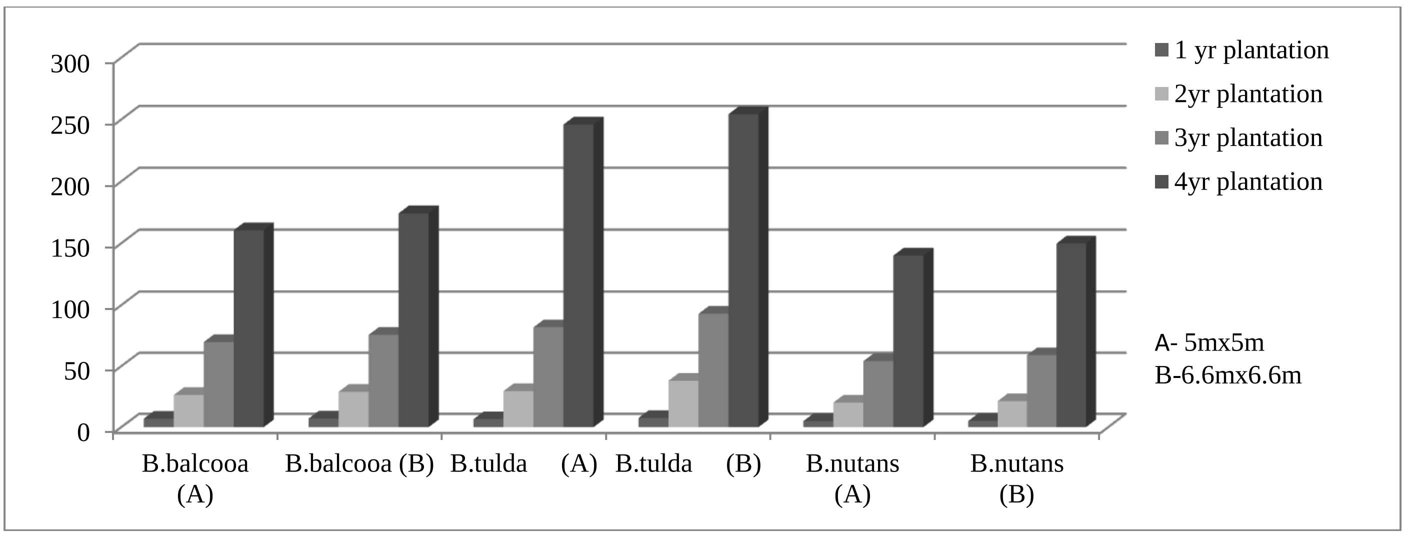

Figure-1a: Progressive increase in biomass production (t/ha) with age of plantation raised from Rhizome in different spacing regimes.

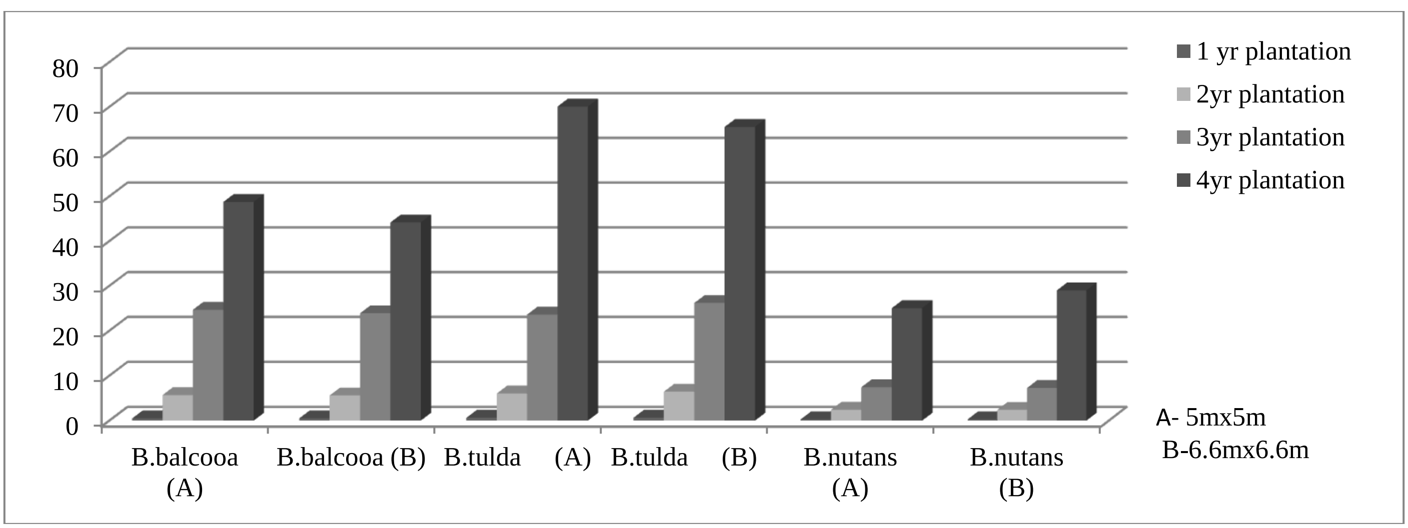

Figure-1b: Progressive increase in biomass production (t/ha) with age of plantation raised from seedlings in different spacing regimes.

Plant carbon: Percentage of plant carbon in different components of bamboo viz. culm, twigs, leaves and rhizome at different age intervals were recorded and pooled data was presented in Table-3. In all the cases increase of carbon percentage was found to be proportional with increase in age of the plant. Bamboo culm constitutes the maximum portion of total biomass hence observations reveal that the culm stored maximum amount of carbon irrespective of species followed by twigs, rhizome and leaves. Study carried out in distribution pattern of organic matter, growth parameters and contribution of various parts towards total biomass carbon of five year old *Eucalyptus camadulensis* also revealed that maximum carbon was stored in stem[13]. Carbon content of 54 plant species under conifer, exotics, dicotyledonous and monocotyledonous was estimated and found that maximum biomass was stored in wood portion[14].

Progressive increment of total biomass carbon stock: Progressive increment of total biomass carbon stock (tC/ha) upto four year old plantation raised from both rhizome and seedlings is presented in Figure-2a and Figure-2b. Highest biomass carbon stock in rhizome plantation was recorded in *B. tulda* (8894.12tC/ha) followed by *B. balcooa* (5982.79tC/ha) and *B nutans* (3587.23tC/ha). Highest culm density of *B.tulda* reflects directly in production of maximum biomass. Seedling plantation also follows a similar trend. However, in seedling plantation biomass carbon stock was recorded low than rhizome plantation. This must be due to long gestation period of seedling raised bamboo compared to rhizome raised bamboo. No significant difference was noticed due to spacing. However in *B. tulda* biomass carbon stock was comparatively more in 5mx5m spacing (8894.12tC/ha) than 6.6mx6.6m spacing (6984.21tC/ha). Comparatively more value was observed in 6.6mx6.6m spacing irrespective of species in plantations raised through seedling.

Soil properties: Bulk Density: Value of bulk density was observed to be inversely proportional with age of bamboo plantation (Table-4). The low value of bulk density may be due to development of soil micropore space which leads reduction of compactness in soil. Clay fraction has a major role on soil bulk density. Increased level of clay fraction has a major contribution upon the development of soil micropore space which reduces the bulk density of soil[15]. Porosity of the soil is found to increase due to decrease of bulk density[16-18]. No significant differences of bulk density was observed among the species.

Table-3: Percentage of plant carbon in bamboo in different age grown from Rhizome and seedling in different spacing regime.

Name of species	Spacing	R or S	Year 1 plantation	Two year plantation		Three year plantation			Four year plantation			
			1 yr. culm	1 yr. culm	2 yr. culm	1 yr. culm	2 yr. culm	3 yr. culm	1 yr. culm	2 yr. culm	3 yr. culm	4 yr. culm
B. balcooa	5mx5m	R	18.20	20.57	23.77	23.41	27.93	39.14	23.44	27.92	33.60	33.77
		S	14.24	16.87	18.80	20.11	23.23	28.99	20.26	23.36	29.16	29.24
	6.6mx 6.6m	R	17.96	20.42	23.82	23.22	27.55	32.32	23.47	30.16	32.29	32.56
		S	14.01	16.84	18.54	20.33	22.88	23.18	20.61	22.34	30.00	30.19
B. tulda	5mx5m	R	18.96	20.27	23.41	24,26	27.13	32.29	24.89	27.28	32.88	33.48
		S	15.42	17.03	19.75	20.96	22.44	26.71	21.15	22.69	27.07	27.28
	6.6mx 6.6m	R	19.19	20.52	22.74	24.46	24,57	27.93	24.74	24.67	28.03	28.07
		S	15.37	16.91	19.53	20.87	20.23	26.70	21.02	23,27	27.08	26.28
B. nutans	5mx5m	R	16.03	19.24	20.39	19.54	23.32	26.47	19.61	22.27	26.58	28.77
		S	12.76	14.00	16.26	15.51	15.57	25.93	15.83	18.71	25.99	26.04
	6.6mx 6.6m	R	15.85	18.96	20.21	19.34	24.14	26.42	19.47	24.33	26.07	24.68
		S	13.26	13.98	16.22	15.39	18.58	26.16	15.47	18.65	26.36	26.43

R- Rhizome, S-Seedling

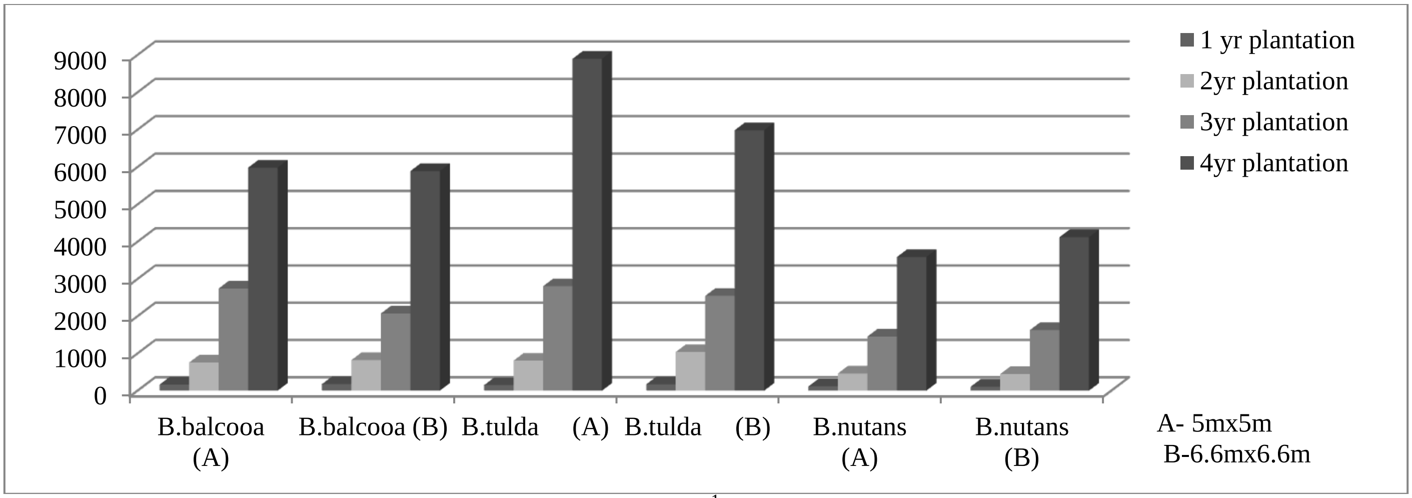

Figure-2a: Progressive increment of biomass carbon stock ($tCha^{-1}$) upto four year old plantation raised from Rhizome in different spacing regime**.**

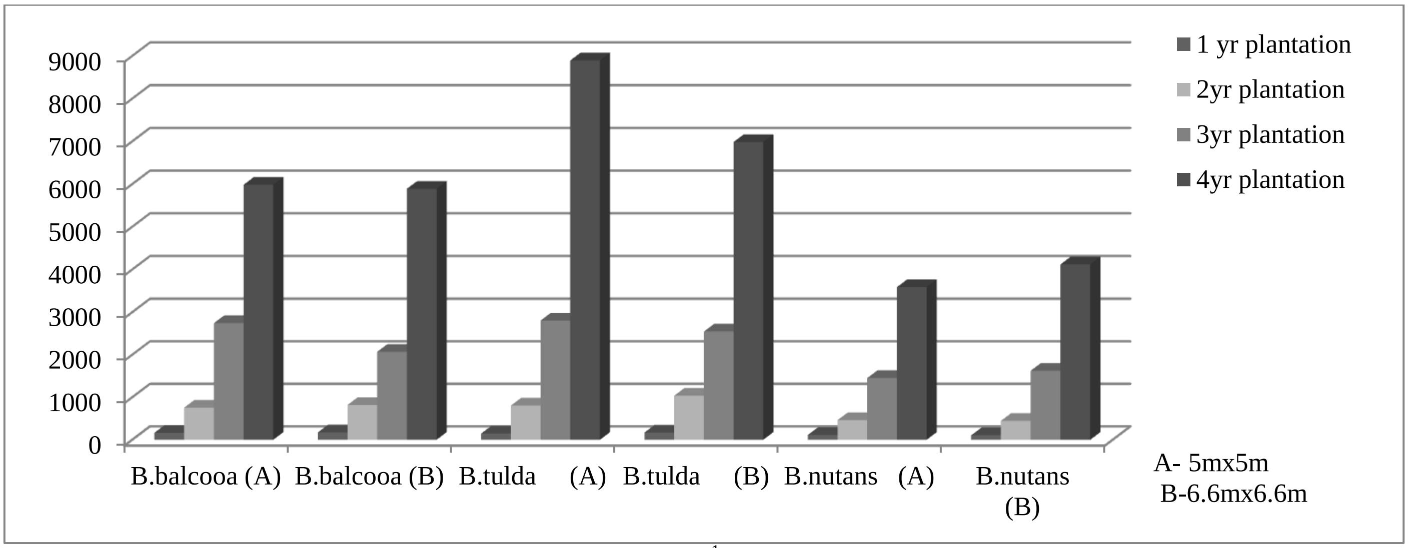

Figure-2b: Progressive increment of biomass carbon stock ($tCha^{-1}$) upto four year old plantation raised from seedlings in different spacing regime

Table-4: Bulk density (gm/cm^3) of soil in Bamboo plantation raised from Rhizome and seedling at different age intervals.

Sample plot	Spacing	Year 1		Year 2		Year 3		Year 4	
		Rhizome	Seedling	Rhizome	Seedling	Rhizome	Seedling	Rhizome	Seedling
B. balcooa	5mx5m	1.32 ±0.063	1.22 ±0.042	1.24 ±0.023	1.18 ±0.047	1.20 ±0.066	1.16 ±0.056	1.21 ±0.026	1.16 ±0.056
	6.6mx6.6m	1.34 ±0.033	1.31 ±0.072	1.28 ±0.024	1.26 ±0.033	1.28 ±0.044	1.20 ±0.044	1.27 ±0.045	1.21 ±0.012
B. tulda	5mx5m	1.29 ±0.076	1.32 ±0.019	1.25 ±0.066	1.28 ±0.011	1.24 ±0.042	1.24 ±0.023	1.24 ±0.057	1.24 ±0.035
	6.6mx6.6m	1.34 ±0.031	1.34 ±0.027	1.32 ±0.0	1.29 ±0.014	1.30 ±0.018	1.27 ±0.029	1.30 ±0.023	1.25 ±0.042
B. nutans	5mx5m	1.23 ±0.045	1.30 ±0.0	1.22 ±0.011	1.25 ±0.018	1.18 ±0.056	1.20 ±0.041	1.18 ±0.045	1.18 ±0.034
	6.6mx6.6m	1.24 ±0.031	1.33 ±0.011	1.20 ±0.056	1.27 ±0.023	1.18 ±0.012	1.23 ±0.059	1.18 ±0.034	1.21 ±0.019

Soil organic carbon: Decrease of carbon percentage was noticed up to second year of plantation in after which the value of carbon percentage was found to be increased. This may be due to the of litter fall from the mature bamboo (Table-5). *B. tulda* growing plot recorded highest percentage of carbon (2.59) followed by *B. balcooa* (2.49) and *B. nutans* (2.42). In plantation raised through seedlings carbon content remains more or less same upto second year of plantation after which a decreasing trend was noticed. The value recorded was comparatively less in *B. balcooa* plot while no difference was noticed between *B. tulda* and *B. nutans* plantation. As the growth of bamboo raised from seedlings was slow probably carbon concentration decreased, due to less accumulation from plants and natural loss from soil. No difference was noticed in carbon content between the two spacing trial.

Soil organic carbon increased gradually with age of the plantation (Table-6). Maximum soil organic carbon was recorded in *B. tulda* (1025.7tC ha^{-1}) and least in *B. nutans* (782.3t ha^{-1}) in rhizome plantation of 6.6mx6.6m spacing (Table-6). Same trend was noticed in seedling plantation also. Carbon stock was found to be significantly less in seedling origin plantations ranging from 700.9tC ha^{-1} to 907.5tC ha^{-1}.

Estimation of total carbon stock (t C ha^{-1}) in four year old plantation: Total carbon stock (plant+soil) depends on factors like Net primary productivity, biomass, carbon addition from plant into the soil through litter decomposition etc. contributes significantly on total carbon stock (plant+soil)[19]. Total carbon stock from biomass and soil in four year old plantation raised from rhizome and seedlings is presented in Figure-3a and Figure-3b. Comparative assessment of total carbon stock reveals that *B. tulda* (9857.52tC ha^{-1}) plantation showed significantly high value of carbon stock. Among the species least value was recorded in *B nutans* (4373.03tC ha^{-}1) raised from rhizome. In seedling origin plantation also the same trend was observed. *B tulda* showed highest value (2567.56tC ha^{-1}) followed by *B. balcooa* (2194.09tC ha^{-1}) and *B. nutans* (1253.22tC ha^{-1}). However, the differences of values were more prominent in rhizome plantation. Among the spacing trials value recorded was more or less same.

Table-5: Soil Organic Carbon (%) of Bamboo plantation raised from seedling at different age intervals.

Sample plot	Spacing	Year 1		Year 2		Year 3		Year 4	
		Rhizome	Seedling	Rhizome	Seedling	Rhizome	Seedling	Rhizome	Seedling
B. balcooa	5mx5m	1.59 ±0.054	1.57 ±0.018	1.72 ±0.032	1.68 ±0.033	2.18 ±0.032	1.88 ±0.035	2.32 ±0.012	2.18 ±0.065
	6.6mx 6.6m	1.61 ±0.015	1.56 ±0.011	1.77 ±0.027	1.72 ±0.076	2.21 ±0.052	1.93 ±0.013	2.38 ±0.045	2.21 ±0.055
B. tulda	5mx5m	1.67 ±0.083	1.61 ±0.025	1.78 ±0.044	1.73 ±0.067	2.46 ±0.046	2.16 ±0.018	2.59 ±0.038	2.40 ±0.078
	6.6mx 6.6m	1.69 ±0.018	1.64 ±0.045	1.80 ±0.032	1.70 ±0.048	2.49 ±0.045	2.22 ±0.055	2.63 ±0.071	2.42 ±0.043
B. nutans	5mx5m	1.56 ±0.015	1.59 ±0.019	1.66 ±0.046	1.64 ±0.063	1.91 ±0.032	1.85 ±0.055	2.22 ±0.0	1.98 ±0.055
	6.6mx 6.6m	1.63 ±0.0	1.61 ±0.014	1.73 ±0.022	1.72 ±0.017	2.01 ±0.012	1.92 ±0.017	2.21 ±0.012	2.05 ±0.068

Table-6: Soil organic carbon (SOC) stock (tC ha^{-1}) in under of Bamboo plantation raised from rhizome and seedling at different age intervals.

Sample plot	Spacing	Year 1		Year 2		Year 3		Year 4	
		Rhizome	Seedling	Rhizome	Seedling	Rhizome	Seedling	Rhizome	Seedling
B. balcooa	5mx5m	629.6	574.6	639.8	594.7	784.8	654.2	842.1	758.6
	6.6mx6.6m	647.2	613.0	679.6	650.1	848.6	694.8	906.7	802.2
B. tulda	5mx5m	646.2	637.5	667.5	664.3	915.1	883.5	963.4	892.8
	6.6mx6.6m	679.3	659.2	712.8	657.9	971.1	845.8	1025.7	907.5
B. nutans	5mx5m	575.4	620.1	607.5	615.0	676.1	666.0	785.8	700.9
	6.6mx6.6m	606.3	642.3	622.8	655.3	711.5	708.4	782.3	744.1

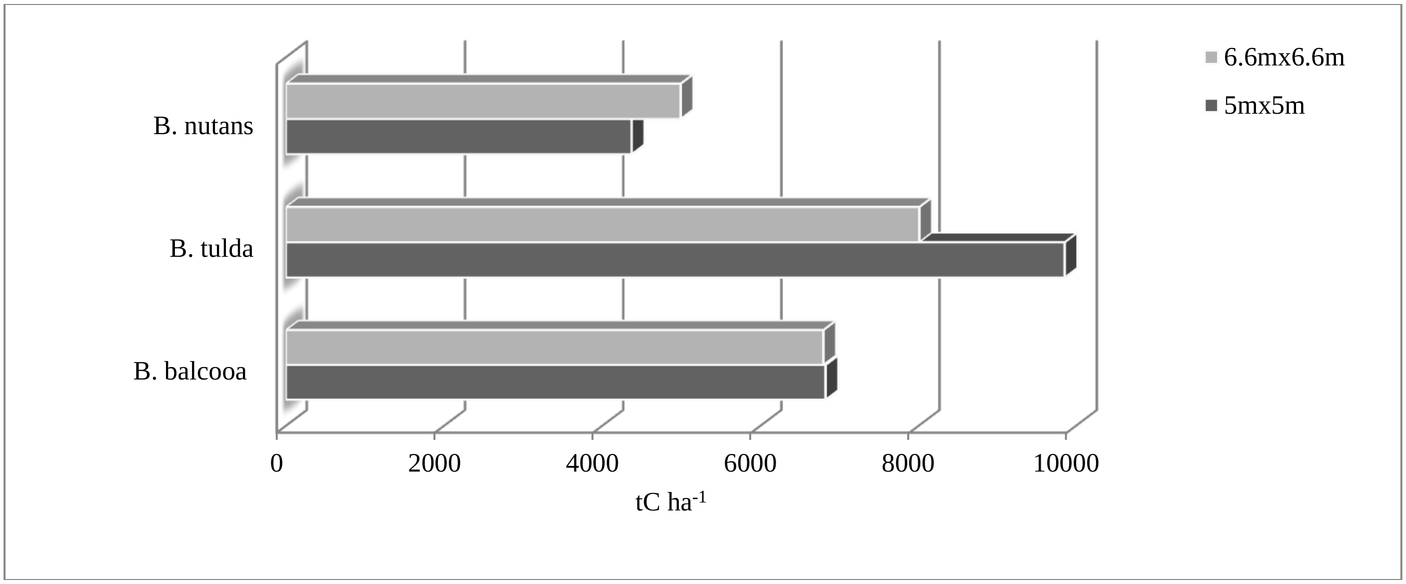

Figure-3a: Total carbon stock in four year old bamboo plantation raised from rhizome.

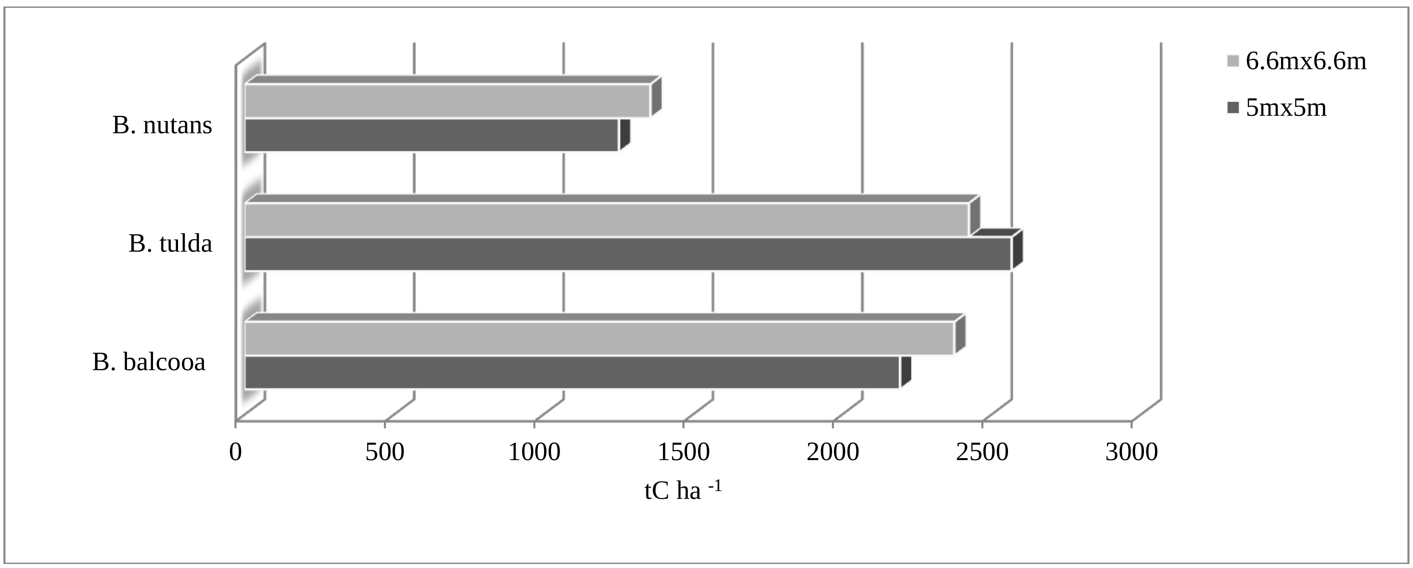

Figure-3b: Total carbon stock in four year old bamboo plantation raised from seedling.

Conclusion

Bamboos has a huge potentiality in restoration of degraded land due to jhum cultivation and have an impact towards soil erosion control, biodiversity conservation as well as offers livelihood security to jhum dependent communities. Thus, to meet the twin goal of economic benefit and sustainable conservation of ecosystem cultivation of bamboo in degraded land can be a promising biological tool. The study concluded that *B. tulda* has potential in terms of carbon sequestration and the best species to rehabilate degraded jhum fallow in North East India. There is also a need to create awareness among the traditional communities inhabiting this North eastern region to check deforestation and conserve biodiversity through plantation of bamboo in degraded jhum land which is identified as the best option to bring greenery, improve degraded jhum land and fulfils the demands in future in a sustainable manner.

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