Carbon Sequestration Potential of Jati Bamboo (*Bambusa tulda*)

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Abstract: *Bamboo can contribute lots to global climate change mitigation through carbon sequestration. However, it was overlooked in many studies as a carbon reservoir. The present study therefore, investigated the carbon storage potential of a common bamboo species Bambusa tulda. The result revealed that, the culm height, DBH, culm circumference, length of internode and number of node per culm completed their growth within one year. On the other hand, the biomass components increased gradually with age from one year to four years age of culm. The highest culm dry weight (21.35 kg culm*$^{-1}$*), branch dry weight (2.58 kg culm*$^{-1}$*), AGB (25.05 kg culm*$^{-1}$*), rhizome dry weight (2.17 kg rhizome*$^{-1}$*) and grand total biomass (27.22 kg culm*$^{-1}$*) were recorded in four years old culm. On the other hand the lowest culm dry weight (15.10 kg culm*$^{-1}$*), branch dry weight (1.78 kg culm*$^{-1}$*), leaf dry weight (0.36 kg culm*$^{-1}$*), AGB (17.77 kg culm*$^{-1}$*), rhizome dry weight (1.47 kg rhizome*$^{-1}$*) and grand total biomass (19.24 kg culm*$^{-1}$*) were recorded in one year old culm. Likewise, AGB of 196.08 t ha*$^{-1}$* and grand total biomass of 212.10 t ha*$^{-1}$* were recorded in 5*th* year old plantation which corresponded to carbon sequestration potential through AGB (86.49 t ha*$^{-1}$*) and total biomass (93.52 t ha*$^{-1}$*) of B. tulda at the rate of 21.62 t ha*$^{-1}$* year*$^{-1}$* and 23.38 t ha*$^{-1}$*year*$^{-1}$* in AGB and total biomass, respectively. The findings advocate the* Bambusa tulda *as a suitable plant species that could mitigate climate change impact more efficiently.*

INTRODUCTION

Carbon dioxide in the atmosphere has been increasing steadily since pre-industrial times from 280 ppm to the latest record of 401.57 ppm in October 2016 (Anonymous, 2016). CO_2 is one of the most important greenhouse gases responsible for warming of the Earth's atmosphere through the phenomenon of the greenhouse effect and thereby climate change. Currently, 30 billion tonnes of CO_2 equivalent is produced globally every year by human activities . Therefore, there is an urgent need to enhance carbon sequestration in the vegetation and to emphasize the various strategies through management of terrestrial ecosystems. Bamboos offer a wide range of potential solutions to address the problems that arise due to climate change. In order to mitigate the global climate change impact, the Kyoto protocol developed the clean development mechanism (CDM) which supports carbon credits for plantation activities in developing countries. Unfortunately, none of the CDM forestry projects included bamboo as a carbon reservoir. Although bamboo is an integrating part of tropical forest ecosystems, it was overlooked in the initial negotiating process (Sohel *et al.*, 2015).

The present study, therefore, investigated the carbon sequestration potential of a common bamboo species, *Bambusa tulda* at the experimental bamboo field of Assam Agricultural University. Bamboo, sequesters carbon dioxide from the atmosphere and converts the carbon into plant fibre. Since the bamboo is used to construct houses, or other durable products, so carbon is effectively stored till the life span of the house or the products. Thus, bamboo plantation become a carbon capture and storage system (Thokchom and Jadav, 2015).

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Bamboo can be integrated into land use-based climate change mitigation activities such as aforestation/reforestation or avoided deforestation, as they are the fastest growing plants on the planet with growth rate of up to 1.2 m a day. In this context bamboo offers one of the quickest ways to remove vast amounts of CO_2 from the atmosphere (Choudhary *et al.*, 2015). It can play a significant role in linking climate mitigation to sustainable economic development in the developing world. However, the role of bamboo in carbon sequestration is probably the least studied and very few information are available regarding the potential of bamboos as carbon storage (Zhihong *et al.*, 2011). Therefore, attempt was made to investigate the carbon sequestration potential of one of the most important bamboo species *Bambusa tulda* commonly known as "Jati Banh".

MATERIALS AND METHODS

The study was conducted during 2009-14 in B N College of Agriculture, Assam Agricultural University, Biswanath Chariali, Assam to assess the carbon sequestration potential of Jati Banh (*Bambusa tulda*). The bamboo field was established in 2008 with the financial and technical support of National Bamboo Mission, Government of India and is being maintained for the experimental purposes. The design of experiment was RBD with 4 replications and all recommended practices were followed (Choudhury *et al.*, 2015). For recording observation four clumps from each block and total sixteen clumps from four blocks were randomly selected and labelled them from each clump, culms of four different age groups (1 year, 2 year, 3 year and 4 year) were randomly selected during April, 2013. The morpho-logical observations like culm height, diameter at breast height (at 1.2 m from the base), circumference at four feet from the base, internodes length, internodes number per culm were measured. Then whole bamboo was separated into leaf, branch and main culm section and their fresh weight were recorded in the field itself with a spring balance. After felling the culm the respective rhizomes were dug out and after cleaning and drying fresh weight were recorded. Their dry weight were also recorded after oven drying. The samples were also made ash in Muffle furnish and their carbon content were estimated following the method of Yong *et al.*, 2011.

RESULTS AND DISCUSSION

The culm height, diameter at breast height (DBH), culm circumference, internodes length and internodes number per culm of *Bambusa tulda* completed their full growth within the first year of culm emergence and no further increment of the above mentioned parameters were observed with the advancement of the age of culm (Table 1). Similar results were also illustrated in different bamboo species by earlier workers (Choudhury *et al.*, 2015; Choudhury *et al.*, 2015a and Liese, 2003).

The biomass related parameters of bamboo were increased gradually with the advancement of age of culm. The highest branch weight (2.58 kg culm^{-1}), culm weight (21.35 kg culm^{-1}), above ground biomass (AGB) (25.05 kg culm^{-1}), rhizome weight (2.17 kg culm^{-1}) and total biomass (27.22 kg culm^{-1}) on dry weight basis were found in four years old bamboo while they were lowest in one year old culm with leaf weight (0.36 kg culm^{-1}), branch weight (1.78 kg culm^{-1}), culm weight (15.10 kg culm^{-1}), AGB (17.77 kg culm^{-1}), rhizome weight (1.47 kg culm^{-1}) and total biomass (19.24 kg culm^{-1}) on dry weight basis (Table 2).

However, leaf dry weight continued to increase gradually till three years age of culm only and thus the highest dry weight of leaf per culm (0.48 kg culm^{-1}) was found with three years old culm which

Table 1
Culm height, DBH, culm circumference, internodes length and number of node culm^{-1} at different ages of culm on 5th year of plantation of *Bambusa tulda*

Age of culm	*Culm height (m)*	*DBH (cm)*	*Culm circumference (cm)*	*Internode length (cm)*	*No of node culm^{-1}*
1 Year	17.93	6.65	20.88	60.70	29.51
2 Years	17.95	6.67	20.94	60.71	29.53
3 Years	17.98	6.68	20.98	60.73	29.54
4 Years	17.99	6.68	20.98	60.73	29.55
Mean	17.96	6.67	20.95	60.72	29.53
CD 0.05	NS	NS	NS	NS	NS

Table 2

Total biomass and its components of individual bamboo (kg culm^{-1}) at different ages of culm on 5th year of plantation

Age of culm	*Leaf weight (kg)*			*Branch weight (kg)*			*Culm weight (kg)*			*AGB (kg)*		*Rhizome weight (kg)*			*Total biomass (kg)*	
	Fresh	*Dry*	*MC (%)*	*Fresh*	*Dry*	*MC (%)*	*Fresh*	*Dry*	*MC (%)*	*Fresh*	*Dry*	*Fresh*	*Dry*	*MC (%)*	*Fresh*	*Dry*
1 Year	0.84	0.36	57.14	4.43	1.78	47.86	23.13	15.10	34.72	28.40	17.77	2.19	1.47	32.88	30.59	19.24
2 Years	0.97	0.46	52.58	4.86	2.31	40.53	28.74	19.72	31.39	34.57	23.07	2.31	1.65	28.57	36.88	24.72
3 Years	0.91	0.48	47.25	4.55	2.50	34.73	29.17	21.19	27.36	34.63	24.64	2.56	1.94	24.22	37.19	26.58
4 Years	0.74	0.44	40.54	4.64	2.58	29.74	27.97	21.35	23.67	33.35	25.05	2.73	2.17	20.51	36.08	27.22
Total	3.46	1.74	-	18.48	9.17	-	109.01	77.36	-	130.95	90.53	9.79	7.23	-	140.74	97.76
Mean	0.87	0.44	49.38	4.62	2.29	38.22	27.25	19.34	29.29	32.74	22.63	2.45	1.81	26.55	35.19	24.44
CD 0.01	0.20	0.09	1.81	0.23	0.13	1.33	1.09	0.89	0.96	1.14	0.86	0.19	0.14	1.37	1.21	0.91

* *AGB*: Above ground biomass, MC: Moisture Content

again decreased in four years old culm (0.44 kg culm^{-1}). The reduction in leaf dry weight in four years old culm might be because of decrease in the leaf number per culm owing to the process of senescence and shedding of older leaves as well as cessation of new leaf formation at that culm maturation stage. In contrast, the heaviest branch, culm, rhizome recorded with four years old culm indicated the continuation of dry matter partitioning and their accumulation to these parts till four years of culm age which led to highest AGB and total biomass per culm in four years old bamboo culm although, the morphological characters like culm height, DBH etc. were not increased with age of culm.

The culm production per clump increased every year (Table 3) In a five year old clump, the highest and lowest number of culm was recorded in one year and four year old culm respectively (Table 3). In, at 5th year age of bamboo plantation a total number of 32.21 culm clump^{-1} and 8947.29 culm ha^{-1} were maintained and these culm density produced 3.88 t ha^{-1} leaf, 20.36 t ha^{-1} branch, 171.84 t ha^{-1} culm, 196.08 t ha^{-1} AGB, 16.02 t ha^{-1} rhizome and 212.10 t ha^{-1} total biomass of *B. tulda.*

These biomass corresponded to the total of 1.35 t ha^{-1} carbon in leaf, 8.33 t ha^{-1} carbon in branch, 76.81 t ha^{-1} carbon in culm, 86.49 t ha^{-1} carbon in AGB, 7.03 t ha^{-1} carbon in rhizome and 93.52 t ha^{-1} carbon in total biomass of *B. tulda.* Again, per year basis *B. tulda* sequestered carbon at the rate of 21.62 t ha^{-1} year^{-1} in AGB and 23.38 t ha^{-1} year^{-1} in total biomas including rhizome. These results are in close conformity with the findings of earlier works conducted in different bamboo species (Choudhury *et al.*, 2014; Choudhury *et al.*, 2015 ; Choudhury *et al.*, 2015a; Lou *et al.*, 2010; Nath *et al.,* 2009 and Zhihong, *et al.,* 2011). The present study therefore, recognized *Bambusa tulda* as an efficient carbon sequester which may be a suitable plant species that could mitigate climate change impact more efficiently.

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Table 3
Biomass production and Carbon sequestration potential (t ha^{-1}) of bamboo at different ages of culm on 5th year of plantation

Age of culm	*No of culm clump^{-1}*	*No of culm ha^{-1}*	*Biomass of bamboo (t ha^{-1})*						*Carbon sequestration (t ha^{-1})*					
			Leaf	*Branch*	*Culm*	*AGB*	*Rhizome*	*Total*	*Leaf*	*Branch*	*Culm*	*AGB*	*Rhizome*	*Total*
1 Year	8.67	2408.35	0.87	4.29	36.37	41.53	3.54	45.07	0.31	1.77	16.50	18.58	1.57	20.15
2 Years	8.37	2325.02	1.07	5.37	45.85	52.29	3.84	56.13	0.37	2.20	20.64	23.21	1.70	24.91
3 Years	7.78	2161.13	1.04	5.40	45.79	52.23	4.19	56.42	0.36	2.20	20.44	23.00	1.83	24.83
4 Years	7.39	2052.79	0.90	5.30	43.83	50.03	4.45	54.48	0.31	2.16	19.23	21.70	1.93	23.63
Total	32.21	8947.29	3.88	20.36	171.84	196.08	16.02	212.10	1.35	8.33	76.81	86.49	7.03	93.52
CD 0.01	0.05	30.51	0.16	0.27	1.77	1.85	0.28	1.95	0.06	0.10	0.71	0.79	0.12	0.82

*AGB: Above ground biomass, MC: Moisture Content

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