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Carbon sequestration through Bhaluka Bamboo (*Bambusa balcooa*)

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Abstract: *During the study the total biomass and its components of Bambusa balcooa were estimated for one, two, three and four years old culm separately. 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 and did not increased after that. However, the biomass components increased gradually with age of culm from one year to four years age of culm. The highest culm dry weight (28.14kg culm^{-1}), branch dry weight (3.18 kg culm^{-1}), AGB (32.10 kg culm^{-1}), rhizome dry weight (2.82 kg rhizome^{-1}) and grand total biomass (34.92 kg culm^{-1}) were recorded in four years old culm. On the other hand the lowest culm dry weight (18.62 kg culm^{-1}), branch dry weight (2.41 kg culm^{-1}), leaf dry weight (0.37 kg culm^{-1}), AGB (21.41 kg culm^{-1}), rhizome dry weight (1.85 kg rhizome^{-1}) and grand total biomass (23.26 kg culm^{-1}) were recorded in one year old culm. During investigation AGB of 226.87 t ha^{-1} and grand total biomass of 246.13 t ha^{-1} were recorded in 5th year old bamboo plantation which corresponded to carbon sequestration potential through AGB (101.49 t ha^{-1}) and total biomass (110.00 t ha^{-1}) of Bambusa balcooa at the rate of 25.37 t ha^{-1}year^{-1} and 27.50 t ha^{-1}year^{-1} in AGB and total biomass respectively.*

Climate change and global warming is one of the most discussed problems of the new millennium and global increase in green house gases specially the atmospheric CO_2 is considered as the major cause of this climate change (Anonymous, 2014). The global annual mean CO_2 concentration in the atmosphere has increased from 280 ppm in the Industrial Revolution to 395 ppm in 2013 (Anonymous, 2013). Therefore, removal of CO_2 from the atmosphere and long term storing of them in some reservoirs (carbon sequestration referred by UNFCCC, Anonymous, 2010) may be one of the most effective climate mitigation strategy. The carbon sequestration through trees and plants is playing the key role in this aspect. Again, bamboos which are extensively grown in the forest, homestead garden and road sides of the entire north eastern region of India may remove CO_2 efficiently from the atmosphere because of their fast and profuse growth pattern. However, the role of bamboo plantation in carbon sequestration is probably the least studied and as such very few information are available regarding the potential of bamboos as carbon storage and as carbon sinks (Zhihong *et al*., 2011). Therefore, the present study was conducted to investigate the carbon sequestration potential of one of the most important bamboo species *Bambusa balcooa* commonly known as *"Bhaluka Banh"*.

MATERIALS AND METHODS

The study was carried out during 2011-14 at the experimental field of B N College of Agriculture, Assam Agricultural University, Biswanath Chariali, Assam to quantify the carbon sequestration potential of Banh (*Bambusa balcooa*). The field was established in 2008 with the financial and technical support from National Bamboo Mission, New Delhi, Government of India and is being maintained for the experimental purposes. Bamboo seedling were planted at a spacing of 6m X 6m to accommodate 278 clump ha^{-1}. The design of experiment was RBD with 4 replications. All recommended practices were followed and each bamboo culm (individual bamboo) was also marked with a red paint in April each year during the study period to recognise the age of culm by counting the number of mark. For recording observation four clumps from each block and total sixteen clumps from

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four blocks were randomly selected and labelled them. Again from each clump, culms of four different age groups (1 year, 2 year, 3 year and 4 year) were randomly selected during April, 2013, they were harvested by felling them at above the first node. Then morphological observations like culm height, Diameter at breast height (at 1.2 m from the base), circumference at four feet from the base, internode length, internode number per culm were measured and average were tabulated. 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 that represented sample of leaf, branch and culm were brought to the laboratory with proper labelling and their fresh weights were again measured, then kept them in oven at 70°C for 48 hours to get their constant dry weight. After felling the culm the respective rhizomes were dug out washed in running tap water and removed all adhered soil and other foreign materials, rubbed with dry clothes to soak all surface water and then their fresh weight were recorded. Their dry weight were also recorded after oven drying them. The samples were also made ash in Muffle furnish and their carbon content were estimated (Yong *et al*., 2011).

RESULTS AND DISCUSSION

The culm height, diameter at breast height (DBH), culm circumference, internode length and internode number per culm of *Bambusa balcooa* completed their full growth within the first year of culm emergence and no further increments in the above parameters were found with the advancement of the age of culm (Table 1). Similar results were also illustrated by earlier workers in bamboo (Choudhury *et al*., 2014 and Liese, 2003). On the other hand, biomass related parameters of bamboo were increased gradually with the advancement of age of culm. The highest branch weight (3.18 kg culm^{-1}), culm weight (28.14 kg culm^{-1}), above ground biomass (AGB) (32.10 kg culm^{-1}), rhizome weight (2.82 kg culm^{-1}) and total biomass (34.92 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 (0.37 kg culm^{-1}), branch weight (2.41 kg culm^{-1}), culm weight (18.63 kg culm^{-1}), AGB (21.41 kg culm^{-1}), rhizome weight (1.85 kg culm^{-1}) and total biomass (23.26 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 (0.90 kg culm^{-1}) was found with three years old culm which again decreased in four years old culm (0.78 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 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. During the study the culm production per culm increased every year so, highest number of one year old culms were recorded than two and three years old culms while lowest number of four years old culms per clump were recorded (Table 3). Thus, at 5th year age of bamboo plantation a total number of 28.67 culm clump^{-1} and 7963.96 culm ha^{-1} were maintained and these culm density produced 5.54 t ha^{-1} leaf, 23.28 t ha^{-1} branch, 198.05 t ha^{-1} culm, 226.87 t ha^{-1} AGB, 19.26 t ha^{-1} rhizome and 246.13 t ha^{-1} total biomass of *B. balcooa.* These biomass corresponded to the total of 1.99 t ha^{-1} carbon in leaf, 9.71 t ha^{-1} carbon in branch, 89.79 t ha^{-1} carbon in culm, 101.49 t ha^{-1} carbon in AGB, 8.51 t ha^{-1} carbon in rhizome and 110.00 t ha^{-1} carbon in total biomass of *B. balcooa.* Again, per year basis *B. balcooa* sequestered carbon at the rate of 25.37 t ha^{-1} year^{-1} in AGB and 27.50 t ha^{-1} year^{-1} in total biomas including rhizome. These results satisfied the findings of earlier workers (Choudhury *et al*., 2014; Lou *et al*.,

Table 1
Culm height, DBH, culm circumference, internode length and number of node/culm of bamboo at different ages of culm on 5th year of plantation of *Bambusa balcooa*

Age of culm	*Culm height(m)*	*DBH(cm)*	*Culm circumference(cm)*	*Internode length(cm)*	*No of node Culm^{-1}*
1 Year	16.33	10.85	34.07	33.85	48.23
2 Years	16.36	10.86	34.10	33.85	48.24
3 Years	16.39	10.87	34.13	33.86	48.24
4 Years	16.41	10.88	34.16	33.87	48.25
Mean	16.37	10.87	34.12	33.86	48.24
CD 0.05	NS	NS	NS	NS	NS
CD0.01	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 of *Bambusa balcooa*

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	0.82	0.37	54.88	3.96	2.41	39.14	27.45	18.63	32.13	32.23	21.41	1.81	1.85	25.40	34.71	23.26
2 Years	1.58	0.77	51.27	4.65	3.01	35.27	36.55	26.32	27.99	42.78	30.10	1.86	2.35	22.70	45.82	32.45
3 Years	1.61	0.90	44.10	4.58	3.16	31.00	35.76	27.19	23.97	41.95	31.25	2.21	2.75	19.12	45.35	34.00
4 Years	1.19	0.78	34.45	4.23	3.18	24.82	35.16	28.14	19.97	40.58	32.10	2.41	2.82	15.82	43.93	34.92
Total	5.20	2.82	–	17.42	11.76	–	134.92	100.28	–	157.54	114.86	8.29	9.77	–	169.81	124.63
Mean	1.30	0.71	46.18	4.36	2.94	32.56	33.73	25.07	26.02	39.39	28.72	2.07	2.44	20.76	42.45	31.16
CD 0.05	0.15	0.07	1.37	0.17	0.10	1.01	0.83	0.68	0.73	0.87	0.66	0.14	0.11	1.04	0.92	0.70
CD0.01	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

Table 3

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

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	7.75	2152.80	0.80	5.19	40.11	46.10	3.98	50.08	0.29	2.18	18.40	20.87	1.78	22.65
2 Years	7.45	2069.46	1.59	6.23	54.47	62.29	4.86	67.15	0.58	2.61	24.93	28.12	2.16	30.28
3 Years	6.88	1911.13	1.72	6.04	51.96	59.72	5.26	64.98	0.62	2.51	23.37	26.50	2.31	28.81
4 Years	6.59	1830.57	1.43	5.82	51.51	58.76	5.16	63.92	0.50	2.41	23.09	26.08	2.26	28.26
Total	28.67	7963.96	5.54	23.28	198.05	226.87	19.26	246.13	1.99	9.71	89.79	101.49	8.51	110.00
CD 0.05	0.04	23.21	0.12	0.21	1.35	1.41	0.21	1.48	0.04	0.08	0.54	0.60	0.09	0.62
CD0.01	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

2010; Nath *et al.,* 2009 and Zhihong, *et al.,* 2011). The present study therefore, recognizes *Bambusa balcooa* as an efficient carbon sequester which could contribute tremendously to mitigate the impact of climate change as elevated atmospheric carbon dioxide is considered as the major cause of unnatural climate change.

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