International Research Journal of Environmental Sciences ISSN 2319–1414
Vol. **7(7),** 23-28, July **(2018)** *Int. Res. J. Environmental Sci.*

Aboveground biomass production of *Melocanna baccifera* and *Bambusa tulda* in a sub-tropical bamboo forest in Lengpui, North-East India

Angom Sarjubala Devi*, Kshetrimayum Suresh Singh and H. Lalramnghinglova
Department of Environmental Science, Mizoram University, Tanhril, Post Box 190, Aizawl, India
angom75@yahoo.com

Available online at: www.isca.in, www.isca.me
Received 1st May 2018, revised 10th July 2018, accepted 21st July 2018

Abstract

Bamboo forests contributes about half of the total forest cover (49.1%) of Mizoram- one of the eight states of North-East India. Melocanna baccifera (Mb) and Bambusa tulda (Bt) are the two most common bamboo species found here. In the present study it was found that culm age structure was preponderant towards older culm age class than younger age class in both types of stand. The total aboveground biomass of Mb was 106.68Mg/ha and Bt was 97.00Mg/ha. Leaf biomass was higher than branch biomass in both species. Culm component have higher carbon storage in both species and least carbon storage was observed in branch component in Mb and leaf component in Bt. Soil organic C was more (2.40%) in Mb stand than Bt stand (1.96%).

Keywords: Age-class, carbon credit, culm, monopodial, sympodial.

Introduction

Bamboo diversity of North-East India is high with prevalence of 63 different species under 15 genera. With 49.1 percent out of the total forest cover Mizoram state have the highest bamboo forest cover. *Melocanna baccifera* (Roxb.) Kurz. the monopodial bamboo contributes 98% out of the total bamboo forest, whereby clump forming (sympodial) species including *Bambusa tulda* Roxb contributes to the remaining 2%[1]. Bamboo forest have faced extreme biotic pressure since the last three to four decades. Young shoots of culms were harvested for consumption as vegetable, whereas mature culms are in great demand for paper and pulp industries, for household purposes and for cottage industries. The biotic pressure, fire and unscientific management have remarkably reduced the bamboo growing stock[2]. Biomass studies have been reported for *Dendrocalamus strictus*[3], *Phyllostachys pubescens*[4], *Bambusa bambos*[5], *Bambusa cacharensis*[6], *Phyllostachys makinoi*[7], *Guadua angustifolia*[8]. The present study emphasizes a comparative study of above ground biomass production of *Melocanna baccifera (*Mb) and *Bambusa tulda* (Bt) in a sub-tropical bamboo forest in Lengpui.

Materials and methods

Study site: The study site is situated in Lengpui area of Aizawl district, Mizoram in North-Eastern region of India at an elevation of 384m, located at 23°50'33.7"N longitude and 92°38' 19.8" E latitude. The topography of Lengpuiis characterized by rugged hilly terrain. The area experienced sub-tropical warm and humid with annual average rainfall of 350mm, most of which was received during South-West monsoon season (June to October). The study was conducted in a protected bamboo forest. The site has a temperature range of 11°C to 29°C and yellow lateritic type of soil.

Selection of bamboo stands: Within the protected bamboo forest *Melocanna baccifera* (Mb) was found to occupy 90% of the total forest area. It was followed by clumps of *Bambusatulda* (Bt) (8%). Therefore three plots each were selected randomly under these two types of bamboo stands.

Density and aboveground biomass: Stand characteristics were studied during November and December, 2015. Three quadrates having 10×10m were laid randomly in each of the three plots in each stand. The number of culms within the quadrates were recorded according to the age of the culms and culm density was calculated per hectare. The age class was divided into 1 year, 2 year and ≥3 year old culms. Culm diameter was measured at 9.8 to 13.7cm in the middle point of the internode from the ground. In each quadrate 3 culms per age class were harvested for both the species. A total of 27 bamboos were harvested for each type of bamboo. The fresh weight of culms, branches and leaves were weighed separately. Three sections of each bamboo were sampled at the upper, middle and lower portion of the culm and weighed for analysis.

The samples were oven-dried at 105^{0}C for 2-3 weeks until the absolute dry weight was obtained. Biomass estimation was based on the ratio of absolute dry weight to fresh weight. For analysis of C content samples of culm, branch and leave were ground into powder form and determined by using CHNS Analyzer.

Percentage C content of each section of the biomass was multiplied with biomass of each section to give total aboveground biomass carbon storage.

Soil organic C: Soil samples were randomly collected monthly from March, 2015 to December, 2015 from the selected plots from a depth of 0-30cm. A composite soil sample was prepared for the three plots of each stand and maintained three replicates. Large pieces of plant materials were removed and the field-moist soil was sieved through a 2mm mesh screen. Organic C was determined by dichromate oxidation and titration with ferrous ammonium sulphate[9]. Bulk density was estimated by using soil corer method. Soil organic C storage (Mg/ha) was computed by multiplying soil weight per given soil volume with respective C values.

Statistical calculation: Analysis of variance for statistical difference among the culm biomass and C content of all the components of culm for both the species were performed. Correlation between the different biomass components and C content was also determined. Data analysis was performed by using Excel-2010.

Results and discussion

Density and age structure: The density of Mb was 31225 culms/ha and Bt was 21450 culms/ha. The culm girth size ranged from 9.8 to 12.0cm for Mb and 13.0 to 18.0cm for Bt. The structure of culm age of both the species was found to have preponderance towards older culm age class (Figures-1 and 2). The structure of age class was 1:2:6 for Mb and 2:3:5 for Bt. The population structure of *Melocanna baccifera* and *Bambusa tulda* in the present study reveals a preponderance of older culm age classes than younger age class. The result is due to lack of harvesting of mature culms and overharvesting of young shoots illegally by local people for food especially *Melocanna baccifera* as it is a favorite food. The skewness towards older culms leads to low productivity of bambo[10]. Harvesting of mature culms is necessary to attain 3:3:3:1 for 1-4 year old in Bt as it is a sympodial bamboo as recommended by Yuming et al.[11] for the monopodial Mb culms harvesting of mature culms is necessary for producing higher yields and to sustain the forest. Culm density of Mb was more than Bt as Mb is monopodial having capability to propagate in a larger area.

Above ground biomass structure: Out of the total aboveground biomass in both the species culm component shared the highest proportion (73.03%) followed by leave (15.81%) and branch (11.16%) in Mb (Figure-3); culm (80.52%), leave (10.16%) and branch (9.32%) in Bt (Figure-4). Total aboveground biomass of Mb was 106.68Mg/ha and 97.00Mg/ha for Bt. The ≥ 3 year age class represented the highest proportion of the stand biomass having 74.17Mg/ha for Mb and 52.25Mg/ha for Bt (Table-1). Least stand biomass was contributed by the 1 year old age class in both the species. Analysis of variance revealed significant variation among different age classes for branch and leaf biomass ($P<0.05$) within the three plots of each bamboo stand.

The average biomass of leaf component for the three age class was higher than branch biomass in both the species which was not found in majority of other studies[6,7,12,13]. Aboveground biomass of 97.00Mg/ha to 106.68 Mg/ha in the present study is comparable to 105.33Mg/ha in *Phyllostachys makinoi*, central Taiwan[7]; 96.54-105.76Mg/ha in *Phyllostachys pubescens*, China[14], but greater than 23.70 Mg/ha for *Fargesia spathacia*[15] China and lower than 74.70Mg/ha for *Dendrocalamus stictus*[13], India. In the present study although Bt has lesser density the aboveground biomass was as much as high as Mb. The reason could be due to thick walled culm structure of Bt, whereas Mb has thin walled culm structure. Least aboveground biomass was contributed by one year old age class culms and maximum aboveground biomass was contributed by ≥ 3 year old age class culms in both species because the number of older culms were more than younger culms.

Cstorage in culm: The average C content in different components of culm was in the order of branch (49.0%), leave (45.0%) and culm (37.7%) for Mb; and branch (55.9%), culm (51.9%), and leave (44.2%) in Bt (Table-2). In Mb C concentration increased in ≥ 3 year old age class in both leave and culm components from the 1 year old age class. Significant positive correlation between biomass of culm, branch and leave with respective C content for Mb were found (Table-4), whereas for Bt only biomass of culm component was significantly correlated with the respective C content. The average C storage in the aboveground biomass was 51.12Mg/ha for Bt and 44.71Mg/ha for Mb (Table-3). Allocation of C was more in culm component in both bamboo species. However least was observed in leave component in both species.

Table-1: Biomass (Mg/ha) in culm components of different age classes for Mb and Bt.

	Mb				Bt			
Age class	Culm	Branch	Leave	Total	Culm	Branch	Leave	Total
1yr	5.20	-	-	5.20	13.70	-	-	13.70
2yr	17.90	3.71	5.70	27.31	21.05	2.64	4.35	28.04
≥3yr	54.80	8.20	11.17	74.17	43.35	6.40	5.50	55.25
Total	77.90	11.91	16.87	106.68	78.1	9.04	9.85	96.99

Table-2: C concentration (% dry matter) in culm components of different age classes of Mb and Bt.

	Mb				Bt			
Age class(yr.)	1	2	≥3	Average	1	2	≥3	Average
Culm	36.73	33.27	37.7	113.10	52.83	43.00	59.89	51.9
Branch	-	50.18	49.0	137.12	-	60.33	51.57	55.9
Leave	-	42.16	45.0	128.33	-	45.19	43.29	44.2

Table-3: C storage in the aboveground biomass of bamboo stand (Mg/ha).

	Mb				Bt			
Age class(yr.)	1	2	≥3	Total	1	2	≥3	Total
Culm	1.90	5.95	23.61	31.46	7.24	9.03	25.93	42.2
Branch	-	1.75	3.91	5.66	-	1.39	3.30	4.69
Leave	-	2.28	5.31	7.59	-	1.85	2.38	4.23
Total	1.90	9.98	32.83	44.71	7.45	12.27	31.61	51.12

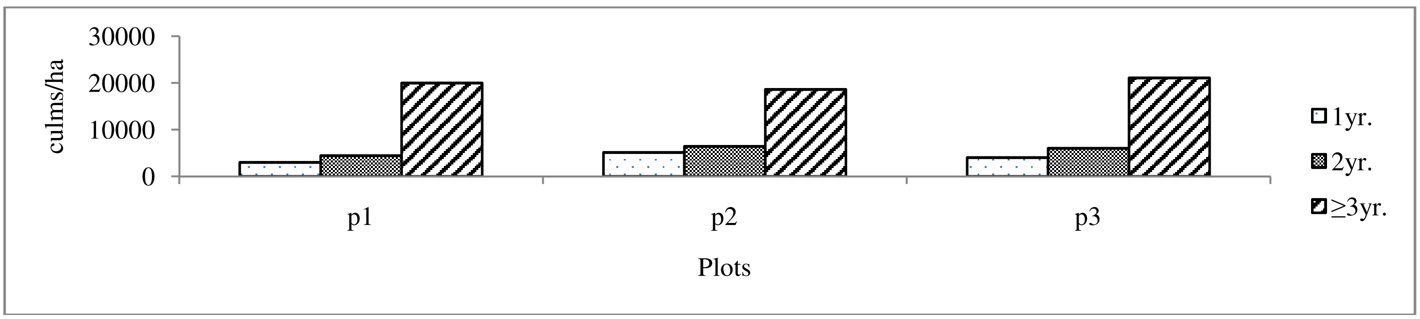

Figure-1: Population structure of different culm age classes of Mb in the three plots.

Table-4: Correlation between biomass of culm components and respective C content within age classes (P<0.05), n=3.

	r	
	Mb	Bt
Culm	0.82	0.65
Branch	0.67	0.42*
Leave	0.99	-0.21*

*insignificant.

C content in Bt in all culm components were higher than Mb. Within the age classes C content increased with progress of age in Mb and no such trend was observed in Bt. There was significant positive correlation between culm, branch and leaf biomass and their respective C content in Mb, whereas in Bt culm component only have significant positive correlation with its C content. Since the C content of Bt was higher the capability of storing C in above ground biomass was more than Bt. The size of Bt was also much larger than Mb and have thick-walled culm structure. Lesser density in Bt could be attributed to its sympodial nature of propagation. The average range of C storage in the aboveground biomass of 50.00- 51.33Mg/ha is comparable with 52.30Mg/ha in *Phyllostachys bambusoides* in central Japan[16], 51.93Mg/ha in *Bambusa oldhami* plantation in Huatusco Veracruz[17] and lower than 91.35-103.70 Mg/ha in *Dendrocalamus strictus* plantation, India[18] and 77.38 Mg/ha in *Phyllostachys pubesccens*, China[14].

Soil C storage: Soil C storage upto the depth of 30cm was 53.28Mg/ha in Mb and 38.8Mg/ha in Bt (Figure-4). Analysis of variance shows significant variation of organic C within the two types of bamboo stands (P<0.05). Average organic C was found to be more (2.40%) in Mb forest than Bt forest (1.96%). Average bulk density was 0.74g/cm^3 for Mb and 0.66g/cm^3 for Bt.

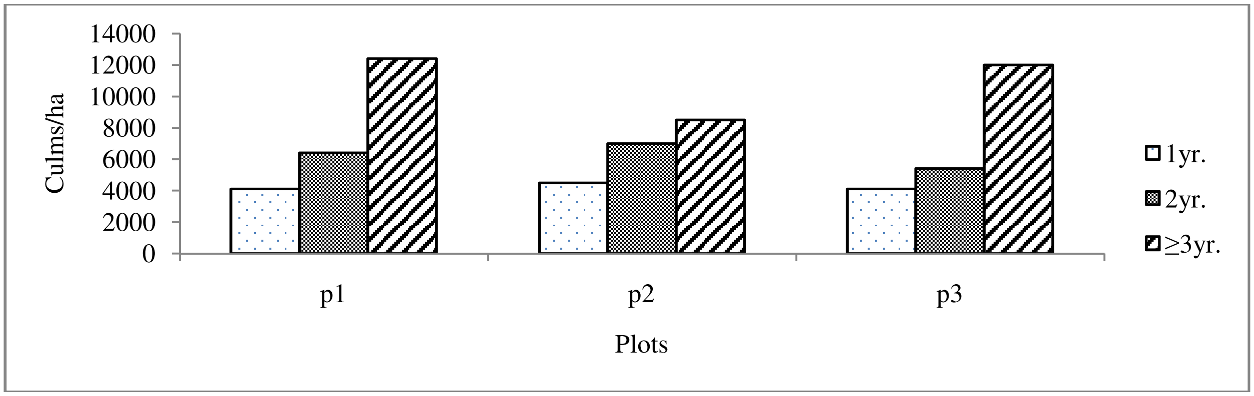

Figure-2: Population structure of different culm age classes of Bt in the three plots.

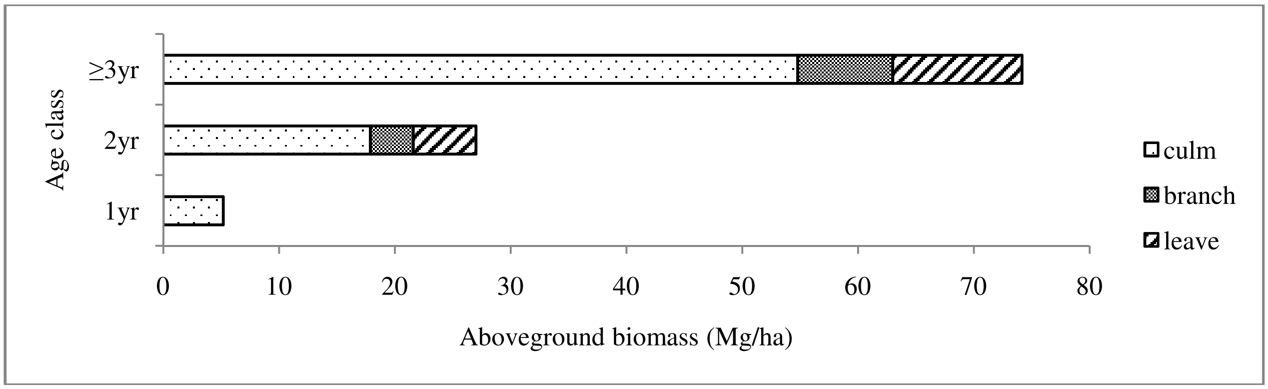

Figure-3: Biomass structure for different age classes of Mb culms.

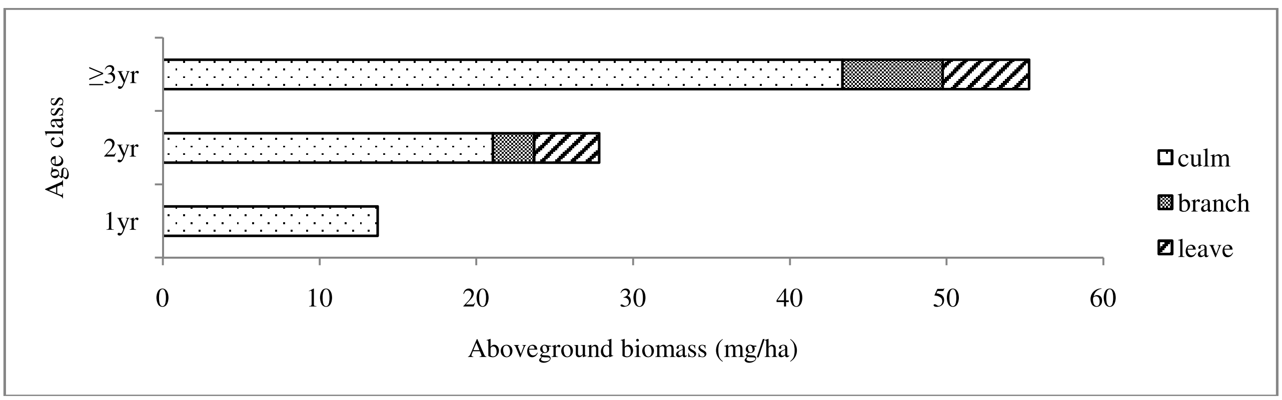

Figure-4: Biomass structure for different age classes of Bt culms.

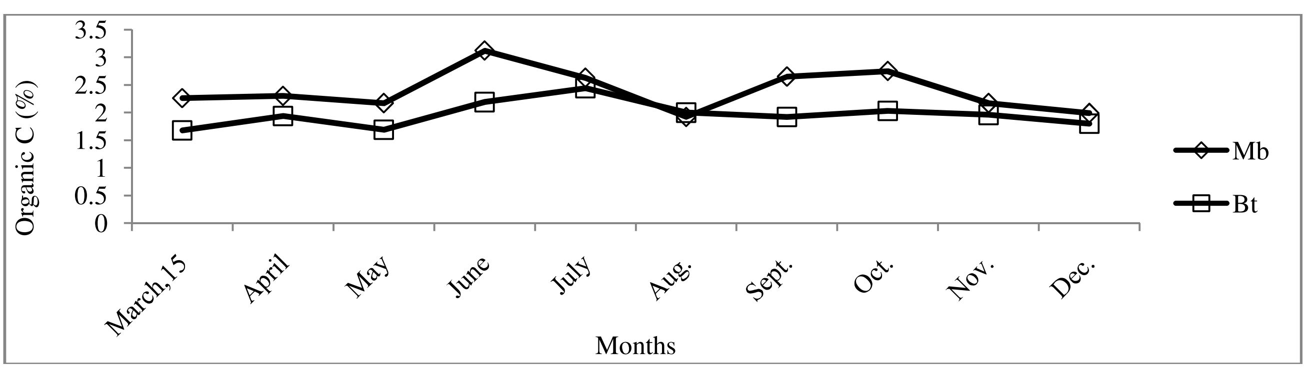

Figure-5: Monthly variation in soil organic C in the two types of forest.

The average soil organic C storage upto 0-30cm of 46.04Mg/ha was lower than the above ground biomass C storage. In tropical forest the C in soil is roughly equivalent to or less than the above ground biomass[19]. The average C content for closed forest is assumed to be 133Mg/ha in the top 100cm and 72Mg/ha in the top 40cm, for open forest equivalent estimates are 80 Mg/ha in top 100cm and 49Mg/ha for top 40cm[20]. The present C storage is comparable to C storage in the top layer of open forest. However the short periodicity of culm growth, rapid culm elongation rate, brief clump development period and ability to survive with least management approach in the bamboo forests have a great prospective resource to sink atmospheric CO_2[6]. Although the C storage in aboveground biomass of Bt was higher than Mb, the organic C content of soil was higher under Mb stand. The reason could be attributed to more decomposability of the culm components due to its thin walled culm structure of Mb. Moreover the main contributor to soil organic matter i.e. leaf biomass was more in Mb than Bt stand.

Conclusion

From the observations made it can be conclude that although having lesser density *Bambusa tulda* has more aboveground C storage capability compared to *Melocanna baccifera* due to its thick walled culm structure, however due to its culm structure the decomposability was lesser leading to a decline in soil C storage compared to *Melocanna baccifera* st and.

Acknowledgements

The research work is supported by DST-New Delhi [Sanction Letter No. DST/IS-STAC/ CO2-SR-197/14(G)].

References

1. Jha L.K. (2010). Bamboo based agroforestry systems to reclaim degraded hilly tracts (jhum) land in northeastern India: study on uses, species diversity, distribution and growth performance of *Melocanna baccifera*, *Dendrocalamus hamiltonii*, *D. longispathus* and *Bambusa tulda* in natural stands and in stands managed on a sustainable basis. *Bamboo science and culture, The journal of the American Bamboo Society*, 23(1), 1-28.
2. Jha L.K. (2003). Community forest management in Mizoram: As part of the environmental law capacity building project. Technical report, SFES, MZU.
3. Tripathi S.K. and Singh K.P. (1996). Culm recruitment, dry matter dynamics and carbon flux in recently harvested and mature bamboo savannas in the Indian dry tropic. *Ecological Research*, 11(2), 149-164.
4. Isagi Y., Kawahara T., Kamo K. and Lto H. (1997). Net production and carbon cycling in a bamboo *Phyllostachys pubescens* stand. *Plant Ecology*, 130(1), 41-52.
5. Kumar B.M., Rajesh G. and Sudheesh K.G. (2005). Aboveground biomass production and nutrient uptake of thorny bamboo [*Bambusa bambos*(L) voss] in the home garden of Thrissur, Kerala. *Journal of Tropical Agriculture*, 43(1-2), 51-56.
6. Nath A.J., Das G. and Das A.K. (2009). Aboveground standing biomass and carbon storage in village bamboos in North East India. *Biomass and Bioenergy*, 33(9), 1188-1196.
7. Yen T.M., Ji Y.J. and Lee J.S. (2010). Estimating biomass production and carbon storage for a fast growing makino bamboo (*Phyllostachysmakinoi*) plant based on the diameter distribution model. *Forest Ecology and Management*, 260(3), 339-344.
8. Quiroga R.A.R., Li T., Lora G. and Andersen L. (2013). A measurement of the carbon sequestration potential of *Guaduaangustifolia* in the Carrasco national Park, Bolivia. Development Research Working Paper Series No. 04/2013.
9. Moore P.D. and Chapman S.B. (1986). Chemical analysis. *Methods in Plant Ecology*, Blackwell Scientific Publications, 589.
10. Embaye K., Weih M., Ledin S. and Christersson L. (2005). Biomass and nutrient distribution in a highland bamboo forest in southwest Ethiopia: implications for management. *Forest Ecology and Management*, 204(2-3), 159-169.
11. Yuming Y., Chaomao H., Jiarong X. and Fan D. (2001). Techniques of cultivation and integrated developemrnt of sympodial bamboo species. In Zhaohua Z (ed.). Sustainable development of bamboo and rattan sectors in tropical China. PR China: China Forester Publishing House, 48-66.
12. Shanmughavel P. and Francis K. (1996). Aboveground biomass production and nutrient distribution in growing bamboo (Bambusa bambos (L.) Voss). *Biomass and Bioenergy*, 10(5-6), 383-391.
13. Singh A.N. and Singh J.S. (1999). Biomass, net primary production and impact of bamboo plantation on soil redevelopment in a dry tropical region. *Forest Ecology and Management*, 119(1-3), 195-207.
14. Wang B., Wei W.J., Liu C.J., You W.Z., Niu X. and Man R.Z. (2013). Biomass and carbon stock in moso bamboo forests in subtropical China: Characteristics and implications. *Journal of Tropical Forest Science*, 25(1), 137-148.
15. Taylor A.H. and Zisheng Q. (1987). Culm dynamics and dry matter production of bamboos in the Wolong and Tangjiahe Giant Panda Reserve, Sichuan, China. *Journal of Applied Ecology*, 24(2), 419-433.
16. Isagi Y. (1994). Carbon stock and cycling in bamboo *Phyllostachys bambusoides* stand. *Ecological Research*, 9(1), 47-55.

17. Castaneda-Mendoza A., Vargas-Hernandez J., Gomez-Guerrero A., Valdez-Hernandez J.I. and Vaquera-Huerta H. (2005). Carbon accumulation in the aboveground biomass of *Bambusa oldhamii* plantation. *Agrociencia*, 39(1), 107-116.

18. Singh P., Dubey P. and Jha K.K. (2006). Biomass production and carbon storage at harvest in superior *Dendrocalamusstrictus* Nees plantation in dry deciduous forest region of India. *Indian Forester*, 29(4) 353-360.

19. Bundestag G. (1990). Protecting the tropical forests: a high priority international task Bonn. Bonner Universitats-Bruchdruckerei, 968.

20. Bolin B., Doos B.R., Jager J. and Warrick R. (1986). The greenhouse effect, climate change and ecosystems. SCOPE 29, Chichester, Wiley.