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Biomass and Carbon Stock estimation in woody grass (*Dendrocalamus strictus* L.) in Doon Valley, India

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Introduction

Bamboos commonly kown as woody grass are one of the most important species particularly in Asia, where it is frequently considered as the "timber of the poor" (Rao *et al*., 1985). With about 23 genera and 136 species, India is the second largest reservoir of bamboos, next only to China (SFR, 2013 and Nath *et al*., 2009). Bamboos occur extensively in the managed ecosystems of India—both as plantations (and in agroforestry (scattered clumps, hedgerows on farm boundaries etc.

Dendrocalamus strictus L. is most commonly found bamboo in India. It is widely distributed in dry deciduous forests and grows rapidly in all climatic conditions and occupies about 53 % of total bamboo area in India. It grows better in the drier parts and on sandstone, granite and coarse grained soils with low moisture- retaining capacity and soils with pH range 5.5–7.6. It grows more than 8 feet in 6–8 months. The species is used widely for as raw material in paper mills and also for variety of purposes such as construction, agricultural implements, musical instruments, furniture etc. The species is also suitable for reclamations of degraded and ravine lands.

The accurate assessment of biomass estimates of a forest is important for many applications (Brown, 2002; Chave *et al*., 2004; Arora *et al*., 2014; Verma *et al*., 2014). In recent years, the carbon cycle has become an important issue in the world and plants play a major role in carbon storage. Biomass estimation enables us to estimate the amount of carbon dioxide that can be sequestered from the atmosphere. However, most of the carbon and biomass studies focus on assessing the capability of trees *viz*., poplar, eucalyptus, shisham, chir teak, subabul *etc*. The studies related to biomass and carbon stock estimation in bamboos is limited. The present study examine specifically the above ground stand biomass, biomass structure and C storage in *D. strictus.*

Materials and Methods

The study was conducted in the sub-humid, subtropical climate of north-west India the Himalayan foothills at ICAR-Indian Institute of Soil and Water Conservation, Research Farm, Selakui, Dehradun (30º20´N and longitude of 77º52´E) in north India at an altitude of 516.5 m MSL. *D.strictus* is one of the important species in north India.

Twenty eight plots of 0.04 ha representing 6-20 year age clumps were randomly selected for measuring clump girth, crown diameter, culm number, culm diameter and culm age. The diameter and age of each bamboo culm was measured at breast height (DBH). Four age classes *viz.*, 1, 2, 3 and 4 years old were distinguished for culms. From each plot, one clump was randomly selected for harvesting different aged bamboo culms (1-4 years) at 15cm above the ground. In total, 112 culms (28 clumps x 4 ages) were harvested and separated into leaf, branch and culm components and their respective fresh weights were taken in the field. Subsamples from upper, middle, and lower portion of the culms of different ages were oven-dried at 65^0C to constant weight to calculate the dry matter of each component. Predictive models were developed for fresh weight and dry weight using the regression model Regression model: $Y = a + b(D^2 \times h)$ where Y = Dry weight of the component (kg $culm^{-1}$) and D = Culm diameter at breast height (cm) and H = Height (m). For validation, original dataset of 112 culms were randomly splitted into two mutually exclusive and pseudo-independent datasets; 75 culms for model estimation and the remaining 37 culms for ‘‘testing’’ the models (Ajit *et al*., 2011). Developed models were used to estimate the biomass of *D. strictus* plantation in Doon valley. Carbon stock in different plant components was obtained by multiplying the dry weight of the different components by their average carbon content. Carbon content was assumed to constitute 50 per cent of ash free dry mass.The ash content was determined by igniting 1 g of powdered sample at 550°C for 6 h in a muffle furnace (Allen *et al.,* 1989). The carbon stock obtained in different components was then summed to obtain total carbon stock in different aged plantation.

Results and Discussion

The fresh weight and dry weight of different culm components were fitted to linear equation using D^2H as independent variable. The R^2 for fitted functions and t and p values for model validation is given in Table 1 and Fig.1. R^2 was found to be highest for fresh culm (0.9789) followed by dry culm (0.9763). The model is well suited for all components except for dry branch and dry leaves due to variations in estimated mean values and observed mean values. Branch weight and leaves weight are not increased with increase in culm diameter. This may be due to the growth character of *D. strictus*.

Table 1. Equations and validation statistic for estimating dry biomass (kg culm^{-1}) of *D. strictus*

Biomass component	Parameter estimate (standard error)		R-square	Observed mean	Estimated mean	Paired t-test	
	a	***b***				***t-statistic***	***P(T<=t) two-tail***
Fresh culm	0.3173 (0.0952)	0.0236 (0.0004)	0.9789	3.34	3.30	0.62	0.540
Total fresh	0.8213 (0.1466)	0.0314 (0.0006)	0.9720	4.662	4.781	-0.78	0.438
Dry culm	0.2298 (0.0448)	0.0105 (0.0002)	0.9763	1.596	1.555	1.21	0.234
Dry branch	0.0066 (0.0535)	0.0031 (0.0002)	0.7183	0.3814	0.3945	-0.24	0.808
Dry leaf	0.3141 (0.0329)	0.0001 (0.0001)	0.0127	0.2782	0.3311	2.70	0.015
Total dry	0.5505 (0.0754)	0.0137 (0.0003)	0.9616	2.255	2.280	-0.31	0.756

The above ground biomass of a plant includes all parts such as foliage, branches, stems and of the plant. The total biamass of 5 year old *D. strictus* plantation of the current study was 18.91 t ha^{-1}and 20 year old plantation was 109.30 t ha^{-1} (Table 2). Based on the equation, biomass table was also generated for *D. strictus*. Considering the wide use of bamboos these days, the biomass tables may provide useful information on above ground biomass to forestry professionals, bamboo growing farmers, forest user groups and other interested parties.

Table 2: Biomass stock (t ha^{-1}) in different culm components of *D. strictus* plantation

Clump age (culm age) / Biomass component	Fresh weight		Biomass			
	Culm	**Total**	**Culm**	**Branch**	**Leaves**	**Total**
5	27.42±5.54	39.10±7.83	12.83±2.57	1.30±0.35	3.41±0.54	18.91±3.71
20	166.74±21.96	233.91±28.96	76.77±9.52	13.02±4.91	12.15±1.51	109.30±11.76

The above ground carbon stock of 5 and 20 year old plantation of *D.strictus* was 8.39 and 49.08 t ha^{-1}which was much higher than many short rotation species.

From the study, it is concluded that the models developed for biomass estimation using and diameter and height as explanatory variable were found to be good fit on account of statistical criteria. The developed equations can be safely used for determining fresh weight and culm biomass in *D. strictus*. Further, *D. strictus* plantations have huge potential in carbon sequestration which should be explored for carbon trading.

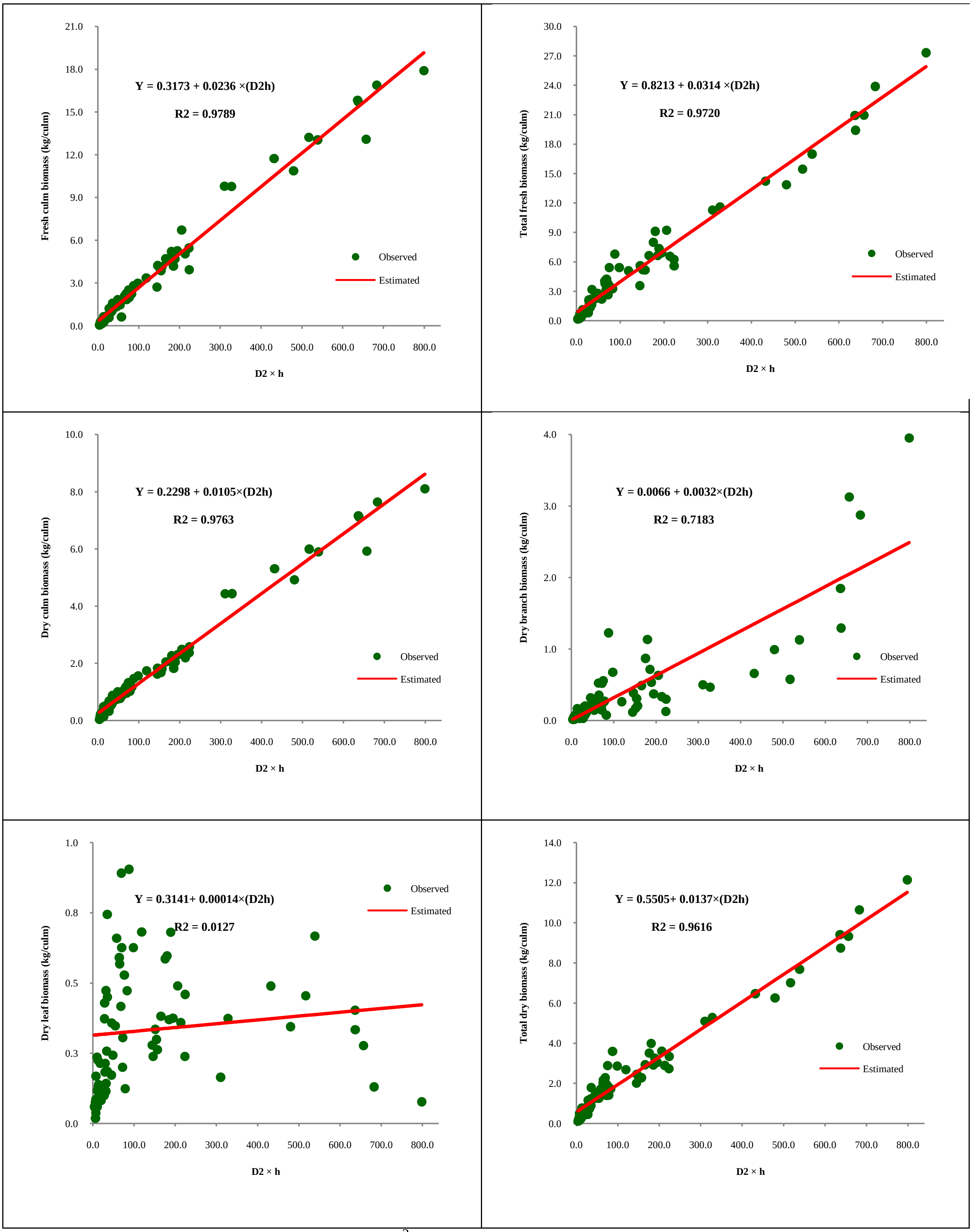

Fig . 1 Regression lines and equations ($Y=a+b(D^2h)$) showing relationship between biomass and culm diameter of *D. strictus*

References

Ajit, D. K. Das, O. P. Chaturvedi, Jabeen Nighat and S. K. Dhyani. 2011. Predictive models for dry weight estimation of above and below ground biomass components of *Populus deltoides* in India: Development and comparative diagnosis. *Biomass and Bioenerg* 35: 1145- 1152

Arora,G, S. Chaturvedi, R. Kaushal, A. Nain, S. Tewari, N.M. Alam and O.P. Chaturvedi. 2013. Growth, biomass, carbon stocks and sequestration in age series *Populus deltoides* plantations in *tarai* region of central Himalaya. *Turk J Agric For*. 38:550–560

Allen, S. E., H. W. Grimshaw, J.A. Parkinson and C. Quarnby. 1989 Chemical analysis of ecological materials. Oxford: Blackwell Scientific Publications Brown S2002. Measuring carbon in forests: current status and future challenges. *Environ Pollut* 116:363-372

Chave, J., R. Condit, S. Aguilar, A. Hernandez, S Lao, R. Perez, J. Chave, R. Condit, S. Aguilar, A. Hernandez (2004) Error propagation and scaling for tropical forest biomass estimates. *Philos Trans R Soc Lond B Biol Sci* 359:409-420

SFR, 2013. State of Forest Report (2013) *Forest Survey of India*. Government of India, Dehradun.

Nath, A.N., G. Das, A.K. Das 2009 Above ground standing biomass and carbon storage in village bamboos in North East India. *Biomass and Bioenergy*, 33:1188- 1196.

Rao A. N., G. Dhanarajan, C. B. Sastry. 1985. Recent research on bamboos. *Proceedings of the International Workshop Recent Research on Bamboos*. Hangzhou, China. IDRC, Ottawa.