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The growing stock of *Phyllostachys bambusoides* Siebold & Zucc. plantation: A case study of Apatani tribe from Ziro valley, Eastern Himalaya.

G. Pangging . B. Tavin. M. Sharma . C.L. Sharma

Department of Forestry, North Eastern Regional Institute of Science and Technology, Deemed to be University, Nirjuli, Arunachal Pradesh.

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ABSTRACT

The growing stock of *Phyllostachys bambusoides* plantation was studied in Ziro valley, Arunachal Pradesh. In this study, 51 quadrats of 10 m x 10 m were selected through random sampling. The number of culms per ha and basal area per ha were recorded in three different diameter classes i.e., 2-4 cm, 4-6 cm and 6-8 cm. The types of bamboo plantation were differentiated based on two criteria i.e., crop composition (pure bamboo and mixed bamboo with *Pinus wallichiana*) and proximity to village (near village and away from village). In overall categories, growing stock of bamboo culm and average basal area was found to be 7,047 sq.m per ha. and 15.248 sq.m per ha respectively. The highest no. of culms per ha and basal area per ha were reported from 4-6 cm diameter class. The plantation away from village have higher number of culm per ha than plantation near village in all diameter classes. Among all diameter classes, 4-6 cm diameter class had higher no. of culms per ha. The mixed bamboo plantation hae higher number of culms per ha and basal area per ha than pure plantation.

1. Introduction

Phyllostachys bambusoides Siebold & Zucc. belongs to the family Poaceae and sub-family Bambusoideae. It is considered as one of the renewable resource with multipurpose uses and also has high economic and cultural value. This bamboo has been planted in various parts of world viz., Texas, Lousiana and Ziro valley in Arunachal Pradesh, India (Malkania, 2008; Jones *et al.,* 1997, Rosen *et al.,* 2001). In India, *Phyllostachys bambusoides* is traditionally raised both as pure bamboo plantation and mixed bamboo plantation with *Pinus wallichiana* in Ziro valley, India (Tangjang and Nair, 2016; Melkania, 2008). The bamboo culms are generally harvested in 3 years which is considered as its rotational period. The presence of fungus on bamboo culm is considered as an indicator of its maturity (Tangjang and Nair, 2016).

Arunachal Pradesh is renowned worldwide as an integral part of Eastern Himalaya not only for its biological diversity but also for bamboo diversity with 46 spp. The most common bamboo species namely *Arundinaria spp., Bambusa spp., Chimonobambusa callosa, Dendrocalamus spp., Phyllostachys spp.* etc. are distributed widely from tropical forest to temperate forest (Loushambam *et al.,* 2017). The area under bamboo in the state is 14,981 sq.km (Anon, 2019).

Among all tribes, Apatani tribe is world widely popular for its unique land use pattern and natural resource management practices. There are 35 villages with a population of around 80,000 in Ziro valley (Census of India, 2011). The most common bamboo species of this valley are *Arundinaria sp., Cephalostachyum capitatum, Chimonobambusa* spp., *Dendrocalamus hamiltonii, Pleioblastus simonii* and *Phyllostachys bambusoides* (Sundriyal *et al.,* 2002). Of these, *Phyllostachys bambusoides* is considered as culturally important resource and exclusively used in material culture and magico-religious practices. The bamboo plantation is traditionally managed by the local people through their traditional knowledge system. It is a monopodial bamboo locally known as *Biji* and also popularly called as a giant

Corresponding author: gpangging@gmail.com

timber bamboo or a Japanese timber bamboo. Though various studies have been done on the management and utilisation aspects of *Phyllostachys bambusoides,* (Tangjang and Nair, 2016; Taka and Tangjang, 2015; Melkania, 2008; Upreti and Sundriyal, 2002) however, no study was done on estimation of its growing stock. Therefore, the present study is an attempt to evaluate the growing stock of *Phyllostachys bambusoides* in bamboo plantation of Ziro valley, Arunachal Pradesh.

2. Study site

The study site was located in the Ziro 1 circle of Lower Subansiri district, Arunachal Pradesh, India (Fig. 1). It is one of the major town and important cultural landscape of Apatani tribe. This circle consisted of 8 major villages and 100 sub villages based on the clans. It lies between 27°37'48.00" North latitude and 93°49'48.00" East longitude with altitude ranging from 1,500m to 2,438m.

3. Material and Methods

The growing stock of *Phyllostachys bambusoides* was studied with 10m x 10m size of quadrat following standard methodology of Misra (1968). The selection of bamboo plantation was done based on two criteria i.e., (i) Proximity to village i.e., bamboo plantation near village & far away from village and (ii) Crop composition i.e., pure bamboo and mixed bamboo with *Pinus wallichiana* (Bitariho and McNeilage, 2007). The number of sample plots laid down in bamboo plantation were 51 selected by adopting random sampling. The measurements of diameter of *Phyllostachys bambusoides* was done at breast height (1.37 m) (Wimbush, 1945; Bitariho and Mosango, 2005; Bitariho and McNeilage, 2007). The number of plants and basal area per ha were studied in three diameter classes i.e., 2-4 cm, 4-6 cm and 6-8 cm. Man-Whitney U test was used to analyse the difference between the mean values by using PAST software.

Fig. 1. Map of study site.

4. Results and Discussions

The plantations of *Phyllostachys bambusoides* were owned by Apatani tribe of Lower Subansiri district. Christian was the dominant religion (54.92%) followed by *Donyi Polo* and the average male female ratio was 1.14. The average number of family member per house hold was 5.83. About 47.27% of the informants had government jobs followed by farming occupation (29.09%) and self-employment (23.64%).

The overall growing stock of plantation of *Phyllostachys bambusoides* was 7,047 culms per ha (Fig. 2). The highest number of culms was reported from 4-6 cm diameter class followed by 6-8 cm diameter class and 2-4 cm diameter class. Sundriyal *et al.,* 2002 reported 4,000 to 5,100 culms of *Phyllostachys bambusoides* per ha from Ziro valley. The average basal area per ha was 15.248 sq.m per ha. The highest basal area was reported from 4-6 cm diameter class i.e., 7.598 sq.m per ha followed by 6-8 cm class (6.311 sq.m per ha) and 2-4 cm class (1.339 sq.m per ha) (Table 1).

The mean diameter of culm at DHB ranged from 3.4 cm to 6.5 cm (Table 2). Similar finding was reported by Melkania, 2008 in terms of girth of culm that ranged from 2.1-2.5 cm. Sundriyal *et al.* (2002) studied the diameter of many bamboo species in Ziro valley such as *Arundinaria sp.* that ranged from 0.5cm to 0.9 cm, *Cephalostachyum capitatum* (2.5-3.5 cm), *Chimonobambusa callosa* (2-3 cm), *Dendrocalamus*

hamiltonii (8-10 cm) and *Phyllostachys bambusoides* (4-7 cm) etc. Melkania, 2008 reported classification of *Phyllostachys bambusoides* plantation as pure bamboo and mixed bamboo with *Pinus sp.* whereas Tangjang and Nair (2016) also reported mixed plantation of *Phyllostachys bambusoides* with *Pinus wallichiana* and considered it as a traditional agroforestry practices of Apatani tribe.

The higher number of culms per ha were found in plantation away from village in all age classes because relatively lesser quantity of culms are harvested from the plantation away from village as compared to plantation near village. The proximity of bamboo plantation to village may be one of the factor to lead higher degree of harvesting of bamboo culm to meet their daily requirements. Among all diameter categories, highest number of culms per ha was found in 4-6 cm diameter class in both bamboo plantations i.e., near village and away from village (Fig. 4). It may be because of relatively higher degree of harvesting of the bamboo culms from 6-8 cm diameter class and they preferred more due to its bigger diameter which are commonly used for construction of traditional house, fencing etc. as compared to lower diameter classes viz., 4-6 cm and 2-4 cm.

The average diameter of culms present in bamboo plantation near village and away from villages shown in Table. 2 showed. There was no significant difference in mean diameter of culms between bamboo plantation near village and away from village within same diameter class.

A significant differences was found for basal area per ha in bamboo plantation near villages and away from villages within same diameter class in all three diameter classes (Table 3). It may be due to relatively higher density of culms present in plantation away from village.

Table. 1. Mean diameter and basal area of bamboo culms in overall categories in different diameter class (N=51)

Sl.no.	Diameter class	Mean diameter Number of quadrats (cm ± SD)	Basal area Number of quadrats (sq.m per ha ± SD)
1	2-4 cm	3.4 ± 0.51	1.339 ± 0.838
2	4-6 cm	5.1 ± 0.09	7.598 ± 3.333
3	6-8 cm	6.5 ± 0. 15	6.311 ± 3.235

Fig. 3a Pure bamboo plantation of *Phyllostachys bambusoides*.

Fig. 3b. Mixed bamboo plantation with *Pinus wallichiana*.

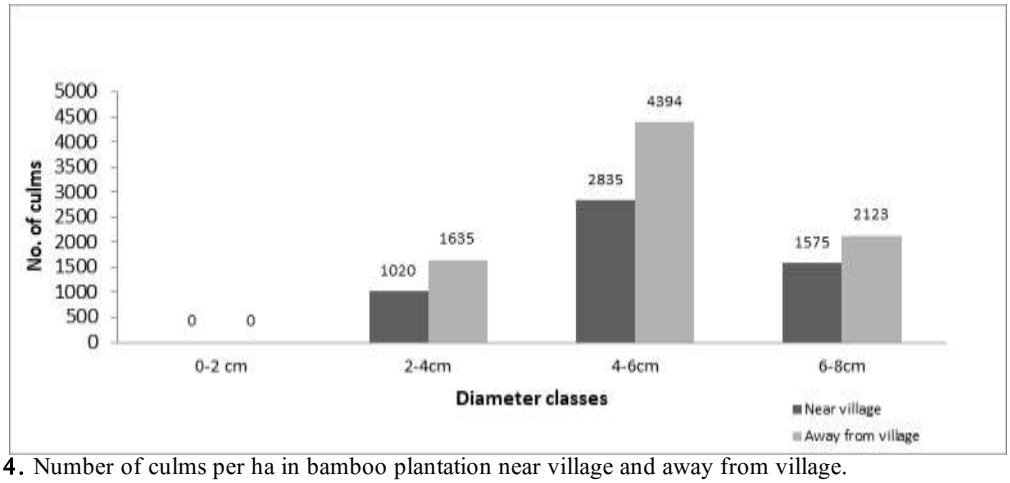

Fig. 4. Number of culms per ha in bamboo plantation near village and away from village.

Table. 2. Mean diameter of bamboo culm at different classes in bamboo plantation near village and away from village.

Sl. no.	Diameter class	Bamboo plantation near village (N=20) [Mean diameter (cm) ± S.D.]	Bamboo plantation away from village (N=31) [Mean diameter (cm) ± S.D.]
1	2-4 cm	3.37 ± 0.81[a]	3.48 ± 0.122[a]
2	4-6 cm	5.06 ± 0.12[a]	5.05 ± 0.077[a]
3	6-8 cm	6.54 ± 0. 22[a]	6.53 ± 0.086[a]

Same letter in the same row shows not significantly different at 0.05 probability level.

Table. 3. Basal area of culms per ha in bamboo plantation near village and away from village.

Sl. no.	Diameter class	Bamboo plantation near village (N=20) [Basal area (m^2 per ha ± SD)]	Bamboo plantation away from village (N=31) [Basal area (m^2 per ha ± SD)]
1	2-4 cm	0.959 ± 0.753[a]	1.583 ± 0.808[b]
2	4-6 cm	5.327 ± 2.214[a]	9.062 ± 3.124[b]
3	6-8 cm	4.644 ± 2.016[a]	7.387 ± 3.438[b]
	Total	**10.931**	**18.0318**

Same letter in the same row shows not significantly different at 0.05 probability level.

The higher number of culms per ha were found in mixed bamboo plantation in all diameter classes. Among all diameter classes, 4-6 cm diameter class had highest no. of culms per ha (Fig. 5). The lower density of culms was found in pure bamboo plantation which may be due to easy accessibility for higher number of extraction of culms.

The mean diameter of bamboo culm in pure and mixed bamboo plantation were shown in Table. 4. No significant differences was found in mean diameter between pure and mixed bamboo plantation within same diameter class in all diameter classes.

No significant differences was found in basal area between pure and mixed bamboo plantation at 2-4 cm diameter class (*p=0.117*). A significant differences was found in basal area per ha between pure and mixed bamboo plantation in both 4-6 cm (*p=0.023*) and 6-8 cm diameter classes (*p=0.0175*). In total, higher basal area was found in mixed bamboo plantation (16.934 sq.m per ha) than pure plantation (Table. 5).

In mixed bamboo plantation, both number of culms per ha (7,785) and basal area of culm (16.934 sq.m per ha) was higher than pure bamboo plantation. The number of *Pinus wallichiana* trees per ha and basal area per ha in mixed bamboo plantation was 212 per ha and 30.515 sq.m per ha respectively (Table. 6).

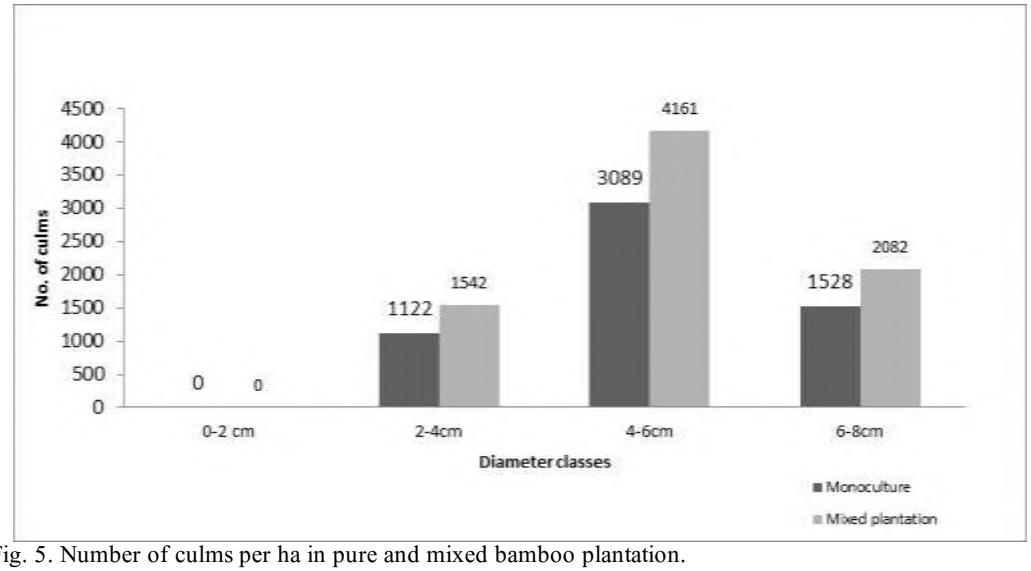

Fig. 5. Number of culms per ha in pure and mixed bamboo plantation.

Table. 4. Mean diameter class of bamboo in pure and mixed bamboo plantation.

Sl. no.	Diameter class	Pure bamboo plantation (N=18) [Mean diameter (cm) ± SD]	Mixed bamboo plantation (N=33) [Mean diameter (cm) ± SD]
1	2-4 cm	3.31 ± 0.84[a]	3.50 ± 0. 14[a]
2	4-6 cm	5.05 ± 0.10[a]	5.08 ± 0.09[a]
3	6-8 cm	6.49 ± 0.20[a]	6.57 ± 0.13[a]

Same letter in the same row shows not significantly different at 0.05 probability level.

Table. 5. Basal area of culms per ha in pure and mixed bamboo plantation.

Sl. no.	Diameter class	Pure plantation (N=18) (sq.m per ha ± SD)	Mixed plantation (N=33) (sq.m per ha ± SD)
1	2-4 cm	1.095 ± 0.8021[a]	1.469 ± 0.845[a]
2	4-6 cm	6.222 ± 3.035[a]	8.456 ± 3.478[b]
3	6-8 cm	5.033 ± 2.448[a]	7.008 ± 3.296[b]
		12.349	**16.934**

Table. 6. Growing stock of bamboo and pine in pure and mixed bamboo plantation.

Sl. no.	Particular	Remarks
1	**Pure (N=18)**	
1.1	No. of culms per ha	5,739
1.2	Culms basal area per ha	12.349 sq.m
2	**Mixed plantation (N=33)**	
2.1	No. of culms per ha	7,785
2.2	Basal area of culms per ha	16.934 sq.m
2.3	Mean diameter of Pine tree (m) ± S.D.	0.429 ± 0.099
2.4	No. of pine tree per ha	212
2.5	Basal area of Pine tree per ha	30.515 sq.m

5. Conclusions

Phyllostachys bambusoides plantations are traditionally practiced by Apatani tribes in Ziro valley, Arunachal Pradesh. The overall growing stock of *Phyllostachys bambusoides* in bamboo plantation was 7,047 culms per ha. The highest number of culms per ha was found in 4-6 cm diameter class i.e., 3,782. In overall categories, average basal area per ha was 15.248 sq.m per ha and ranged from 1.339 to 7.598 sq.m per ha and diameter of culms were ranged from 0.034 m to 0.065 m. No significant difference in mean diameter was found between bamboo plantations near and away from village. A significant differences was found in basal area per ha of culms in all diameter classes between bamboo plantations near and away from villages. The highest number of culms per ha was found in 4-6 cm diameter class in both pure and mixed bamboo plantation i.e., 3,089 and 4,161 per ha respectively. The pure and mixed bamboo plantation did not show any significant difference especially in mean diameter and basal area per ha in all diameter classes. The number of culms per ha in mixed bamboo plantation (7,785) was higher than pure (5,739) and the basal area of culm in mixed bamboo plantation (16.934 sq.m per ha) was also higher than pure (12.349 sq.m per ha). The no. of trees and basal area of *Pinus wallichiana* in mixed bamboo plantation was 212 and basal area was 30.515 sq.m per ha.

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