Bamboo productivity under traditional silvicultural management practice in upper Brahmaputra valley agroclimatic zone (UBVZ), Assam, N. E. India.

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Abstract - Field survey on homestead garden, community plantation sites and also in rural patch vegetations was conducted to find out the dominant bamboo species under cultivation in upper Brahmaputra valley agroclimatic zone, Assam, N. E. India. Bamboo population comprised of mainly *Bambusa tulda, B. balcooa, B. nutans, B. pallida, Dendrocalamus hamiltonii and D. giganteus. Bambusa tulda, B. balcooa, B. nutans* are the dominant species and occupies 90 % of area under bamboo cultivation. Preference of these bamboo species is largely governed by their utilization in domestic, commercial or industrial sector and current market price. Data on different yield attributing character was collected from bamboo plantations up to 5 years age. Above ground biomass was estimated and with spacing of 5 x 5 m it was found 240 tonnes/ha in *B. tulda*, 257 tonnes/ha in *B. Balcooa* with spacing of 7 x 7 where as in case of *B. nutans* it was 414 tonnes/ ha with 5 x 5 m spacing. Yield attributing parameters of different bamboo species was recorded. The circumference of *B. tulda* was 11.93 m ± 7.09, *B. balcooa* was 7.90 m ± 5.33 and *B. nutans* was 14.02 m ± 5.06. Culm length was 22.65 m ± 6.01 in *B. tulda*, 23.33 m ± 7.05 in *B. balcooa* and19.79 m ± 6.66 in *B. nutans*. Culm girth was recorded 23.88 cm ± 1.25 in *B. tulda*, 27.81 cm ± 3.71 in *B. balcooa* and 21.78 cm ± 1.6. in *B nutans*. Internode length was 43.21 cm ± 2.5 in *B. tulda*, 24.07 cm ± 1.48 in *B. balcooa* and 40.64 cm ± 2.29 in *B. nutans*. Number of shoot production was recorded in 9.20 ± 1.48 in *B. tulda*, 7.60 ± 1.14 in *B. balcooa* and 11.2 ± 2.48. in *B. nutans*.

keywords **- Keywords –Bamboo, Productivity, Yield attributes, dominant, species.**

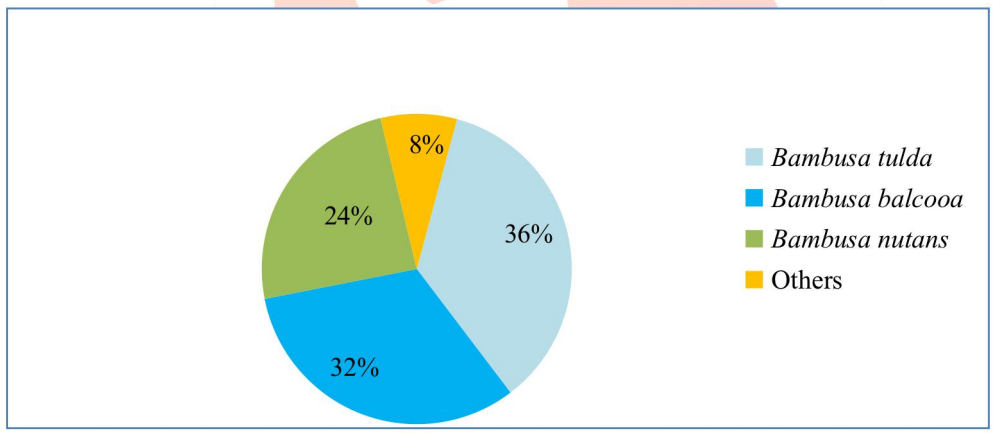
Introduction

Bamboo is a versatile plant or more precisely we can say it is a fastest growing tree -grass with manifold uses belonging to family *Gramineae* or *Poaceae* and sub family *Bambosoideae*. Bamboos comprised a group of 1575 species of non wood forest plants (Brahma *et al*., 2014) and widely distributed in diverse climatic conditions of tropical and subtropical countries of the world (Handique *et al*., 2010, McClure, 1966, Liese, 2001). In India it is estimated to cover 8.96 million ha out of total 63.3 million ha forest land (Yengkopam, 2013). According to India state of forest report the extent of bamboo bearing area in India increased and estimated as 15.69 million ha in 2017. India is the second richest country in bamboo genetic resources after China. These two countries together have more than half of the total bamboo resources globally. Bamboo is represented by 75 genera and 1250 species in the world. The reports on total number of genus and species found in India and N. E. region of India varied however in Indian climatic and soil condition 125 indigenous and 11 exotic species belonging to 23 genera are found (FSI, 2017). From N. E. region 63 species and 15 genera can be account (Biswas Sas. 1988). The whole region is very rich in bamboo diversity and bamboo stock (Bisht *et al.*, 2011). In India out of 78438 km^2 of total geographical area bamboo occupies 1813 km^2 (Sharma *et al.,* 2010). The genus *Bambusa* is the predominant species of the N. E. region and found in association with moist deciduous forest in natural conditions. Important species found are *Bambusa tulda*, *B. balcooa*, *B. nutans, B. pallida, B. bambos, B. polymorpha, B. vulgaris, B. wamin, Melocanna baccifera, Dendrocalamus hamiltonii, D. giganteus*, *D. asper,* etc. Bamboo is used by rural folks in many ways from time immemorial and it forms an integral part of their homestead gardens and farm lands. It performs an important role in the life of ethnic and indigenous people (Das and Nath, 2008) but in recent decades its uses increased in many folds, about 1500 uses are documented so far and therefore is in high demand. Previously regarded as poor man's timber now being addressed as "green gold" or " timber of future" because of its endless utilizations in the field of paper and pulp industry, food and beverage, fodder, medicinal industry, fiber and fabric, handicrafts, dye and engineered building materials. Bamboo has also reduced pressure on forest by substituting wood thereby mitigating climate change and limiting deforestation (Goyal *et al*., 2010 Ogunjinmi *et al*., 2009). Due to long felling period of other timber yielding forest tree species bamboo has become an alternative material that can replace woods. An ever increasing demand for bamboo leads to continuous harvesting of bamboo from forest which resulted in shrinking of its population in natural state. At present it is found in some bamboo grove under reserve forests, foot hills and predominantly in homestead gardens and in patch vegetation in villages. In N. E. India it is seldom cultivated as block plantation. As the availability of bamboo from forest is lessening our focus has to be solely on bamboos present in homestead gardens, farm fields or in other plantation sites. Another option is to cultivate bamboo in non agricultural land with proper silvicultural practice to meet the national demand. It is found that there is a vast gap between demand and supply of bamboos. Due to unorganized and unscientific way of cultivation the productivity is not up to the mark,

therefore lagging behind of other countries like China and Myanmar. The main reason might be probably due to low productivity from different plantations. Poor productivity is due to poor management of clump, lack of interest in cultivators, lack of market knowledge and unscientific approach. The shortfall in supply can be overcome by improving productivity per hectare through scientific management of the stands

Dominant Bamboo species and market demand

Survey was conducted to find out the dominant species of bamboo in the homestead gardens and patch vegetation in rural areas in three districts of Upper Brahmaputra Valley Agroclimatic Zone (UBVZ) of Assam, N. E. India. Bamboo population comprised of mainly *Bambusa tulda*, *B. balcooa*, *B. nutans*, *B. pallida*, *Dendrocalamus hamiltonii* and *D giganteus*. It was observed that Farmers mainly prefer *Bambusa tulda, B. balcooa and B. nutans* and these three species occupies 90% of their bamboo plantations. Preference of these bamboo species is largely governed by their utilization and current market demand either as commercial or industrial bamboo. These bamboos are mostly used as wood substitutes. The physico-chemical and mechanical property of bamboo makes it most suitable substitute as natural fiber because of high tensile strength of bamboo fiber. The woody material in bamboo has long fiber making it easy splitting. They also give great flexibility as well as strength to bamboo culms. These desired characteristics are more prominent in *B. tulda* and *B. balcooa*. Bamboo culms are marketed as whole bamboo or cut pieces of different size based on purpose. Depending upon diameter, length and maturity of culm, their price varies from Rs 80-120/ piece for *B. tulda,* Rs80-100/ piece for *B. nutans* however *B. balcooa* fetch more prices, it may range from Rs 100- 150. They are used in constructional purpose, making pole, different bamboo craft materials, tender shoots used for making pickles and other fermented products which are in high demand in rural and urban areas, a 250 gm of pickle bottle get Rs. 100 easily. On screening of different bamboo species for suitability of fermented food *B. balcooa* was found to be most suitable (Bhagwati and Deka, 2004). Other than pickle many indigenous fermented products can be made from tender shoots of bamboo (Narzary and Das, 2016). There are many small scale and cottage industries developed in UBVZ which uses these species of bamboo for making cutlery materials, mattress, bamboo baskets, sofa, bed, fishing materials, ornamental materials etc. *Bambusa nutans* are mainly used for fencing purpose and basket making. *Bambusa balcooa* is in high demand for paper and pulp. Many value added products and wood substitutes are being made from these three species of bamboo so they are in high demand in market. Recently Assam Bio Refinery Private limited in collaboration with Numaligarh Refinary limited has setup ethanol and biodiesel extraction industry in Numaligarh, Golaghat district of Assam, India. This industry will require huge quantity of bamboo annually as raw material that is to be meet through the bamboo available in the farm lands, plantations by different agencies because bamboo in forest alone cannot meet the requirement. So there is a golden road ahead for bamboo cultivators.



Characteristics and local uses of the bamboo species:

Name of species	Characteristics	Local uses
Bambusa tulda 	1. A clump forming bamboo 2. Young culms with white scurfy cover while it is grey in older culms 3. Leaves glabrous above, glaucent and puberulous beneath. 4. Culm sheath has brown hairs 5. Above nodal ring white ring present. 6. Culms mostly remains unbranched on top portion	Paper and Pulp, furniture, wood substitute, board and lamellate, household items and craft materials, younger shoot edible
Bambusa balcooa	1. Internodes are swollen and basal internodes are short with prominent brown hairs.	Building and construction, household items and craft materials, fishing materials, edible,

	2. White rings present at the nodal ring of young culm. 3. Leaf sheath with brown hairs. 4. Auricle is either very short or absent on culm sheath. 5. At developing stage culm tips are dome shaped.	agricultural tools.
Bambusa nutans 	1. Young shoot has unequal caterpillar like auricle. Dark brown body. Culm sheath densely covered with long curved reddish brown bristles. 2. Stem sulcate. 3. Prominent branching at lower nodes. 4. Branches usually 3, middle one is prominent.	Bamboo structure, fencing, board and lamilate, edible, basket and mattress.

Production and economic return

Based on the data collected it was found that *Bambusa tulda* occupies major portion of bamboo cultivation in farm lands of UBVZ, it was followed by *B. balcooa, B. nutans* and others bamboo species. The yield per hectare is determined by different growth parameters such as circumference of clump, number of shoot production, length and diameter of of culm and also soil quality, incidence of pest and disease and silvicultural practices. Commercially important bamboo becomes harvestable from the culm age of 3-5 years and there after it can be harvested every alternative year upto several years and may exceeds up to 120 years, if properly managed. Productivity of bamboo estimated to be 3.2 million tons per annum in North east India. Every house hold in the studied region has minimum of 0.5-2 bigha of their land under bamboo cultivation to meet their domestic demand besides selling 50-300 bamboo culms annually to vendors or in local market. Total annual income generated from bamboo varied from 6000-36000 on average from per bigha.

Productivity and economic return of bamboo species (5 yrs age)

Species	Spacing	No of plants /ha	Production (Above ground biomass) Tonnes/ ha	Approx economic Return (lakhRs)
Bambusa tulda	5x5	400	240	7.20
Bambusa balcooa	7x7	204	257	4.77
Bambusa nutans	5x5	400	414	9.20

Measurement of yield attributes of bamboo species

The yield attributes of three species were recorded in the field survey. It was observed that clump circumference of *B. tulda* ranged from 3.4 – 25 m with mean value of 11.93 ± 7.09, *B. balcooa* ranged from 4 - 15.5 m with mean value of 7.90 ± 5.33 and *B. nutans* from 7.5 - 23.5 m with mean value of 14.02 ± 5.06. Culm length was found 14.68 - 25.79 m in *B. tulda* with mean value of 22.65 ± 6.01, 11.41 - 29.12 in *B. balcooa* with mean value of 23.33 ± 7.05 and 11.52 - 28.65m in *B. nutans* with mean value of 19.79 ± 6.66. Culm girth was recorded 22.0 – 25.5 cm in *B. tulda* with mean value of 23.88 ± 1.25, 25.5 – 34.0 cm in *B. balcooa* with mean value of 27.81 ± 3.71 and 19.12 - 23.31 cm in *B nutans* with mean value of 21.78 ± 1.6. Internode length ranged from 40.50 – 47.40 cm in *B. tulda* with mean value of 43.21 ± 2.5, 22.1 – 25.5 cm in *B. balcooa* with mean value of 24.07 ± 1.48 and 37.20 – 45.50 cm *in B. nutans* with mean value of 40.64 ± 2.29. Number of shoot production in five years old plantation was recorded 9 – 11 in *B. tulda* with mean value of 9.20 ± 1.48, 6-9 in *B. balcooa* with mean value of 7.60 ± 1.14 and 9- 15 in *B. nutans* with mean value of 11.2 ± 2.48.

Mean value of different yield attributes of bamboo clumps (5 yrs age)

Species	Circumference (m)	Culm length (m)	Culm Girth (cm)	Internodes length (cm)	No of shoots
Bambusa tulda	11.93±7.09	22.65±6.01	23.88±1.25	43.21±2.5	9.20±1.48

Bambusa balcooa	7.90±5.33	23.33±7.05	27.81±3.71	24.07±1.48	7.60±1.14
Bambusa nutans	14.02±5.06	19.79±6.66	21.78±1.6	40.64±2.92	11.2±2.48

Major limitation on higher productivity

Although soil and climatic condition found to be very suitable for bamboo cultivation in UBV agroclimatic zone yet per ha production is very low. Poor production of bamboo may be attributed to many reasons,

1. The most important ones are unscientific management, lack of interest, poor supply of quality planting materials *etc.*
2. It is seen that due to ignorance and poor stand management and unscientific harvesting of bamboo has resulted in low productivity and poor culm quality.
3. Harvesting of mature bamboos at longer time intervals is causing yield loss and clump congestion which ultimately resulting in twisted culm formation, creates problems for extraction of bamboo, poor culm growth and mortality of mother clumps.
4. Traditional management practices comprised of occasional soil loosening and mulching with rice husk, fallen leaves and rice straw from cattle shed. Soil mounding or heap making are some other practices adopted. Sometimes ash or cow dung is also applied.
5. Use of fertilizers and FYM or compost is less than 5 %. No disease or pest control methods adopted by farmers.
6. Lack of post harvest technology and knowledge on value addition cause loss of many culms.

Unscientific and poor management of bamboo stands leads to low yield

A: Culm congestion B: Diseased culm : Faulty harvesting

Technical guidance on management of bamboo plantation

Considering the high demand and low productivity of bamboo various trainings, field trials and demonstration activities under different project were taken up during past few years to provide technical support and scientific guidance in bamboo cultivation to farmers. This comprised of site selection, site preparation, plantation geometry, Planting method, silvicultural management practice, application of fertilizer and biofertilizers, Maintenance of mother culm, timely harvesting with proper method, removal of unwanted bamboo to avoid clump congestion, post harvest treatment *etc*. Plantation of bamboo with proper spacing results high productivity

Conclusion

From this survey work it can be concluded that although bamboo forms an integral part of day to day life of rural and upto some extent of urban people this high potential crop has not been taken seriously. It was found that the major causal factor involve in low productivity is the negligence and lack of knowledge on bamboo cultivation, management and low interest in farmers to take bamboo cultivation as a business like any other cash crop such as tea. Most of the bamboo plantations were raised from uncertified poor planting stock. Different package of practices were suggested to increase bamboo productivity to farmers, traders and people associated with bamboo cultivation. Knowledge on bamboo crafting, and

marketing was provided by scientific and government organizations to motivate people so that they consider bamboo an equally important crop parallel to agricultural, horticultural and other case crop.

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