

Introduction of *Bambusa tulda* Roxb. along with shifting cultivation as a sustainable bioresource in North East India

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***Bambusa tulda* Roxb. (synonym *Dendrocalamus tulda*), commonly known as Bengal bamboo or Indian timber bamboo, is a tropical species found in North East (NE) India of length up to 25 m (80 ft) having a thick hollow stem and clump. The length, strength, rapid growth and availability in huge clusters make the species an excellent choice for many domestic and commercial purposes. It has considerable usage in handicrafts and construction. The tender shoots are also being harvested by many tribals of NE India as a food delicacy. The present study focuses on introducing this bamboo along with shifting cultivation as a counter-measure to soil erosion. The bamboo species can be cultivated either along the edge of a field during crop cultivation or inside the field after crop harvest to avoid competition. Either way, the bamboo species can grow in abundance and prevent soil erosion, besides providing several bamboo products which can be a sustainable bioresource. Vegetative method of bamboo propagation involves cutting the premature side stem along with its fully functional roots to be planted apart from its parent cluster. The traditional practice also includes cutting down and burning the bamboo to enrich the soil with phosphate before chilli cultivation.**

Keywords: *Bambusa tulda* Roxb., bamboo products, shifting cultivation, soil erosion, sustainable bioresource.

OVER a 1000 bamboo species have been identified and described under 90 genera. The current rate of discovery indicates that many of the species are yet to be identified¹. India is rich in bamboo diversity with at least 124 indigenous species under 23 genera, either cultivated or found naturally^{2,3}. The bamboo species are distributed between 46°N and 47°S lat. up to 4000 m asl. They are commonly found in Africa, Asia and Central America⁴. About 25% of bamboo species in the world are found in the Western Ghats and North-East (NE) India^{5,6}. Varmah and Bahadur⁷ had estimated that bamboos could occupy 13% of the total forest cover in the country, growing from the coastal plains to elevations of 3700 m asl in the Himalaya⁸. NE India harbours about 90 species, of which 41 are endemic to the region⁹.

Bamboo is considered as 'green gold' because of its several uses such as in handicraft, construction, decoration¹⁰, medicinal value¹¹, food, fuel, timber, shelter and

paper production¹². Bamboo has been used in medicine in China and other Asian countries¹³. A diabetic animal treated with *B. tulda* leaf extract showed increased body weight. The loss of body weight due to diabetic condition (hyperglycaemia) could thus be reverted by supplementing *B. tulda* leaf extract¹⁴.

India is next only to China in the production of bamboos¹⁵. The most important bamboos used as vegetables and as a food delicacy belong to the genera *Bambusa*, *Dendrocalamus* and *Phyllostachys*¹⁶. Bamboo is an important non-wood resource found in the forest as well as non-forest areas of the country. Bamboo, known as the poor man's timber, is one of the most important forest products having a wide range of distribution throughout India and has immense potential to make a major contribution to the rural economy of the country. Bamboo also plays an important role in carbon sequestration and biodiversity conservation. Average potassium content in bamboo is much higher than in trees of the same biomass, thus beneficial for soil enrichment¹⁷. In many fields where the soil is loose, bamboos are used to prevent soil erosion, as their roots grow horizontally and produce fine roots¹⁸.

Cultivation of bamboo has gained huge interest in recent years, with the National Bamboo Mission envisaged covering 1.7 m ha of land with bamboo, which would require around 70 million plants in India¹⁹. Also, there is an increased demand from Government and non-Government organizations and farmers for quality bamboo. However, unlike other members of the plant kingdom, useful as they may be, bamboos are grasses (Poaceae) and monocarpic (single flowering cycle), but they are not annual monocarpic; so seeds of a particular species are not available every year. The seeds also have low viability and poor storage characteristics²⁰⁻²². Culm cuttings are preferred as planting materials for nursery raising of large-sized and thick-walled bamboo species by vegetative means. However, growing bamboos by culm cutting is a destructive process as it requires many culms to be harvested, which ultimately affects the clump productivity²³. Kaushal *et al.*²⁴ have shown the comparative rooting potential of some of the commonly used bamboo species in the following order: *Bambusa vulgaris* > *Bambusa balcooa* > *Dendrocalamus hamiltonii* > *Dendrocalamus giganteus* > *Bambusa bambos* > *Bambusa tulda* > *Bambusa nutans* > *Dendrocalamus asper*. The secondary branch cuttings of all the bamboo species, except *B. vulgaris* fail to produce roots. *B. tulda* seeds show orthodox behaviour. The seeds stored in a desiccator had 11% germination by the third month, which dropped to 2% after 18 months²⁵.

Location of the study area: The Mon district (Figure 1) is one of the important districts in Nagaland, NE India, with regard to bioresources, demographically and geographically, and also its international trade importance due to sharing of international boundary with Myanmar. The district is located at 26.75°N lat. to 95.1°E long. with an average elevation of 655 m asl. The Konyak Nagas are the

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single dominant tribe of Mon district, where the hierarchical 'Angh' system has been practised for generations.

Planting of *B. tulda* (Figure 2) – It was done using vegetative means, where the recently emerged culms with roots, internodes and some sub-branches were separated from the parent stock and planted deep in soft suitable soil. The bamboo saplings were monitored for over a year, which is the necessary duration to indicate their survival. Some bamboo stocks were allowed to survive the slashing and burning of jhum field and recover to fully functional stock during the fallow years of the field.

During the two-year jhum cultivation, the first year involved active cutting cultivation and the second year pre-fallow cultivation. The whole culm stock was slashed and burnt to increase the potash content of the soil. During the first year it was used to cultivate crops like Naga king chilli (*Capsicum chinense*), cucumber, pumpkin, turnip, melon, etc. During the second year, cultivation was mostly focused on *C. chinense*.

Importance of *B. tulda* as a bioresource along with shifting cultivation. *B. tulda* has immense importance due to its thickness, length, durability and wide range of applications. Some of the benefits observed during the present study are as follows.

(i) Once the culm of the plant is rooted, the species multiply rapidly like other grasses. Also, *B. tulda* grows at the rate of at least 25 cm per day at the shoot stage and can act as carbon stock.

(ii) It was observed that the leaves grow well and cover the plant. However, compared to other plants, the leaves are shed frequently, at least once every season. Nevertheless, the species can act as a wind-breaker that could have a drastic effect on conventionally cultivated jhum field crops.

(iii) Huge amounts of biomass are usually observed with the growth of bamboo. This biomass during shifting cultivation is usually dried and burnt, enriching the potash content of the soil compared to other locations. This potash content has been traditionally exploited by villagers to cultivate *C. chinense* alongside local vegetables. Interestingly, during the second harvest, it was observed that the overall size of the chilli had reduced, but its spiciness had increased.

(iv) The locals consume the species as bamboo shoots only at a very early stage of sprouting from the culm before it becomes 1 ft in length. During this stage, the nodes and internodes are tender and soft, which can be cooked, consumed or fermented to make other delicacies. Some wild animals like rodents consume the root of mature bamboo culm by burrowing holes. Worms infest the lengthening stage of bamboo internodes. Birds usually consume the seeds of dying bamboo plants, which occurs only once in the life of a bamboo (anytime between 30 and 60 years for *B. tulda*), for a brief period of six months.

(v) Bamboo species have been used for construction purposes such as support poles, in concrete house construction, wall plastering, fencing, housing and firewood, etc.

B. tulda in the handicraft industry: Bamboo handicrafts have a good market and provide a livelihood to thousands of families in rural areas. The following handicrafts are made using *B. tulda*.

(i) Basketry – The art of basket-making is a male-oriented task. It is being handed down through generations and perfected with age in the Konyak society. The type and design of basketry depend on its purpose. Many of these baskets have huge demand within as well as outside Nagaland.

(ii) Tools like knife (local dao), hammer, spade, spear, hoe, axe and chisel.

(iii) Containers, trays, mugs and cups.

(iv) Indigenous craftsmen make river fish traps, high-quality stretchable seats (local mora), cross-bows, spoons, tongs, mouse traps and mats.

(v) Housing – Many indigenously built houses are made of *B. tulda* harvested at a specific time during growth. This time factor is a traditional knowledge handed down through generations, which will later predict the hardness, tensile strength and susceptibility to attack by insects. This particular species has been used in furniture products as an alternative to nails due to its properties as described previously, but it is used after a year of drying in the fire place.

According to the literature review and field-work done in four villages of Mon district, it was found that *B. tulda* grows at a rapid rate if there is adequate humidity in the soil. The chance of survivability depends on the moisture content of the soil for the newly planted saplings. At the initial stage of sprouting, each bamboo is susceptible to attack from external infestation such as woodworms and rodents. The harvest of *B. tulda* shoots is mostly done for cooking and



Figure 1. Map of Mon district, Nagaland, India.



Figure 2. *Bambusa tulda* Roxb. (a) Culm and (b) leaves.



Figure 3. Handicraft made from *B. tulda* Roxb.

not intended for fermentation, as in the case of the Kon-yak Naga tribes. The hardened sheaths of bamboo are inedible and thus discarded. However, the sheath of mature bamboo just before shedding is used to make decorative shovels by the villagers.

During the windy season, the soft stem can be broken and is not regenerated like other plants. The over-dependence on one species of bamboo, particularly in the absence of adequate resource regeneration operations, is a threat to bamboo-based economic activities. The handicraft industry is yet to realize the full potential of *B. tulda* as well as the people who are knowledgeable about it in the rural areas. The same bamboo species have been used by different people of different villages to make a wide variety of basketry products. Some craftsmen have perfected the craft to such an extent that the baskets are well-knitted and can be used to store or transport rice and powdered products. Hence the basketry craft have higher demands in the market and exchange for money. Many of the traditional weaving equipment are made using *B. tulda* due to the strength of mature plants. Tourism has a huge impact on the utility of *B. tulda* in Nagaland, where several handicraft items are being made and sold to tourists (Figure 3).

Thus, an extensive study of *B. tulda* has been done in four villages of Mon district, Nagaland. The Government has emphasized that the future rural economy shall focus on the development of bamboo industry, where *B. tulda* is

a key member selected along with *B. balcooa*, *D. hamiltonii* and *D. asper*.

However, we have to raise public awareness about bamboo and how the local rural population can benefit from it if the species is introduced along with jhum cultivation on a large scale. Also, knowledge must be spread about sustainable harvesting of bamboo at the shoot stage for consumption, as unlike other smaller species *B. tulda* has lesser saplings (maximum up to 20) in one stock growth. Therefore the focus should be more on planting new culms to obtain higher yields of bamboo.

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Rainwater management for sustainable production of citrus in central India

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A study was conducted involving (i) continuous trench (CT), (ii) CT with rainwater harvesting tank (RWHT) and basin irrigation (BI), and (iii) CT with RWHT and drip irrigation (DRI) to identify a suitable rainwater management strategy for citrus orchards in central India. CT with RWHT and DRI was found most suitable under which fruit production, net profit and economic water productivity were enhanced by 3.19, 3.98 and 2.30 times respectively, compared with rainfed treatment. The energy use efficiency improved by 87% with a 49% increase in sustainability yield index in CT with RWHT and DRI than the rainfed treatment.

Keywords: Citrus, rainwater harvesting, micro-irrigation, water productivity, yield.

CITRUS is extensively grown in tropical climates. Water for irrigation becomes a limiting factor in citriculture in the tropics¹. The excessive overland flow of rainwater during the wet season and shortage of available soil moisture during the dry period affect the productivity and productive life of citrus plantations². Thus conservation of rainwater using appropriate measures and reuse of conserved water effectively are imperative for sustainable citriculture.

‘Nagpur’ santra (*Citrus reticulata* Blanco), a globally recognized loose-skin citrus cultivar, is extensively grown in 0.25 m ha of central India. The cultivar is mainly planted and grown in a climate with soil enriched with clay (45–60%)³. Inadequate soil moisture during the non-rainy period affects productivity and causes the drying of mandarin plantations¹. The underground water level in the aquifers has declined at an alarming rate due to overuse during last few decades in the region⁴. Despite water scarcity, a favourable climate and higher economic return help boost the cultivation of citrus in this region⁵. Drip irrigation (DRI) has also promoted cultivation of the crop in sloped and rolling lands⁶. Adoption of appropriate rainwater harvesting techniques such as continuous trench (CT) and water harvesting tank, and use of harvested water through DRI could increase the productivity of citrus in the region. Energy use analysis in crop production is crucial for sustainable agriculture. However, studies on run-off harvesting and reuse of water utilizing DRI and input-output energy analysis in citriculture are limited. The present study was therefore conducted to assess the response of citrus orchards to rainwater conservation and its reuse through DRI in a hot, sub-humid region of central India.

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