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Dendrocalamus brandisii (Munro) Kurz: Unveiling the Significance of an Essential Bamboo Species

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Dendrocalamus brandisii is a very large evergreen bamboo with a dense tufted growth habit, commonly known as `Burma bamboo'. Burma bamboo is renowned for its distinctive attributes, including its substantial size, straight growth pattern, and notably, its lack of thorns, distinguishing it from other local bamboo varieties. This comprehensive article explores the significance of *D. brandisii*, encompassing its morphology, flowering patterns, habitat, and distribution. The emphasis is on its adaptability to diverse altitudes and soil types, enhancing its value in agroforestry and environmental conservation. Detailed discussions highlight the economic importance of *D. brandisii*, elaborating on its versatile applications in construction, crafts, and pulp fiber production. Various applications of the bamboo, ranging from manufacturing value-added products to potential health

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food uses, are explored. Furthermore, the examination of silicon variation and phytolith morphology provides intriguing insights into the physiological aspects of the plant. The article also highlights the positive impact of varying planting durations of *D. brandisii* on soil bacterial communities, indicating its role in enhancing soil quality. This thorough examination positions *D. brandisii* as a versatile and economically significant bamboo species with promising applications in sustainable land use, resource conservation, and diverse industries.

Keywords: Burma bamboo; evergreen bamboo; morphology; agroforestry; soil bacterial community; restoration.

1. INTRODUCTION

The *Dendrocalamus* genus, member of the Poaceae family, encompasses about 30 species, including *D. brandisii, D. asper, D. giganteus, D. hamiltonii, D. hookeri, D. latiflorus, D. longispathus, D. membranaceus, D. merrillianus, D. sikkimensis*, and *D. strictus*, all of which hold significant economic value [1]. Among which, *D. brandisii,* formerly known as *Bambusa brandisii* Munro, is an expansive evergreen tufted bamboo, featuring culms with an ashy-gray to greenish-gray hue, averaging between 19-33 m in height and 13-20 cm in diameter (Fig. 1). *D. brandisii*, like other bamboos achieve rapid growth, reaching maturity in just four to five years. Harvesting is often viable at this stage for many bamboo species due to their early maturation. The robust internodes possess a thickness of 30-38 cm, while the nodes exhibit slight swelling, with visible rootlets on the lower nodes. The young shoots showcase a dark-gray color with a dark-brown blade. It exhibits numerous clustered branches, characterized by one larger dominant branch. The arrow-shaped leaves measure between 20-30 cm in length and 2.5-5 cm in width, featuring tiny short white hairs that cover the leaf surface in their early stages of growth. The species is recognized for its sporadic and gregarious flowering patterns, featuring a lengthy flowering cycle spanning 40-45 years. The latest instance of collective flowering in Kodagu was observed between 2010 and 2012, as documented in previous reports [2]. Histochemical and biochemical examinations of bamboo culms reveal a reduction in starch content in *D. brandisii* culms following flowering [3]. The distinctive qualities of Burma bamboo, which set it apart from many local bamboo kinds, are its sizeable size, straight growth pattern, and, most importantly, its lack of thorns.

2. HABITAT AND DISTRIBUTION OF BURMA BAMBOO

Thriving in wet evergreen tropical forests, *D. brandisii* reaches its optimum growth in elevations of up to 1,300 m. While adaptable to various soil types, this bamboo species exhibits a preference for well-drained loamy soil. Its natural habitat encompasses a diverse range of ecosystems, reflecting its resilience and ability to flourish in different environmental conditions. The adaptability of *D. brandisii* to different altitudes and soil types stresses its ecological versatility and highlights its value in agroforestry practices

Fig. 1. Plantation of *D. brandisii*

and environmental conservation efforts. The indigenous distribution of *D. brandisii* in India is confined to tropical forests at altitudes up to 1300 m in Manipur and the Andaman Islands. However, extensive cultivation of this species is prevalent in Karnataka and Kerala. Its native range extends from northeastern India and Myanmar to northern Thailand, Indo-China, and the Andaman Islands. In Burma, it ranges from the Kachin hills to Tavoy (Tenasserim) at altitudes up to 1,200 meters. In Thailand, the bamboo is found in the northern part at altitudes ranging from 1,000 to 1,300 meters. It is also present in Laos, Vietnam (specifically Tonkin), and in China, particularly in Yunnan, spanning altitudes from 380 to 1,900 meters [4].

3. METHODS OF PROPAGATION

Bamboos, as a vast genetic resource, hold significant potential for generating higher biomass, benefiting society. To address the indigenous demand, bamboo extraction from forests, though depleting, can be supplemented by viable plantations outside the forest. However, a scarcity of quality planting material hinders large-scale, productive bamboo cultivation, highlighting the importance of tapping into bamboo genetic diversity for enhanced productivity, product quality, and sustainable utilization. In the recent past, with the backing of the National Bamboo Mission, several initiatives were sustained through an inter-institutional project spanning the nation. Executed by five ICFRE institutes—FRI Dehradun, TFRI Jabalpur, IWST Bangalore, IFP Ranchi, RFRI Jorhat—the project focused on ten priority bamboo species, including *D. brandisii* for standardising the propagation methods. Rhizomes/offsets from these superior clumps were gathered to facilitate additional multiplication and to establish rhizome banks [5].

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3.1 Macro-propagation Methods Adopted for Bamboo Propagation

3.1.1 Propagation through cuttings

Rooting can be induced in culm (Fig. 2), branch, and nodal cuttings. Planting two nodal cuttings in suitable media and conditions, with one node exposed outside and another inside the media [6,7,8]. To prevent fungal attacks, the upper portion of the cutting is covered with Parafilm. Additionally, the choice of growth regulators, treatment method, collection time of cuttings, and the culm part (base, middle, or top) are critical factors influencing the process across different species.

Fig. 2. Planting of *D. brandisii* cuttings in sand bed for propagation

3.1.2 Rhizome splitting/macro-proliferation

Propagation involves allowing young seedlings to grow for six months to one year before initiating macro-proliferation. To enhance growth, Nitrogen, Phosphorus and Pottasium (NPK) fertilizer is applied monthly from the day of planting. In this technique, rhizomes are separated from the plant using secateurs and then planted in fresh polybags for further development [8,7,9].

3.1.3 Propagation through rhizomes and offsets

This involves selecting preferably one to two-year-old culms from the peripheral portion of a clump. These identified culms are cut in a slanting manner, leaving two to three nodes at the base. Cutting can also be done right above the node without damaging the basal portion of the branches. Care should be taken not to damage the attached rhizome and roots while collecting offsets, ensuring that the buds remain intact. Planting offsets can be done along with pre-monsoon showers or just before the rainy season [8,7,9].

3.2 Micro-Propagation for Bamboo Propagation

In the micropropagation (tissue culture) of bamboo, the selection of primary materials, such as seeds or adult plants, and the choice of the propagation method are crucial factors [10]. The use of seedlings offers two significant advantages: the establishment of a new generation and the simplicity of the technology. Additionally, tissue culture holds immense potential for bamboo improvement, facilitating mass multiplication of selected superior genotypes, production of homozygous lines through anther culture or ovary culture, hybridization through protoplast fusion, and in vitro flowering and pollination. The technique of micro-propagation or in vitro vegetative propagation can yield faithful duplicates of an original parent plant. From the selected superior plant nodal segments, 10-15 mm in length were collected from the secondary and tertiary branches. For sterilization of explants generally, $HgCl_2$ is used. They can be inoculated in an artificial medium. This involves inoculation of the explant on MS medium supplemented with 0.51 mg^{-l} of BAP and 0.1 to 1 mg^{-l} of NAA. Even though shoot induc-tion was successful rooting per cent was very low i.e., 4-15 per cent [10].

4. CULTIVATION PRACTICES OF BURMA BAMBOO

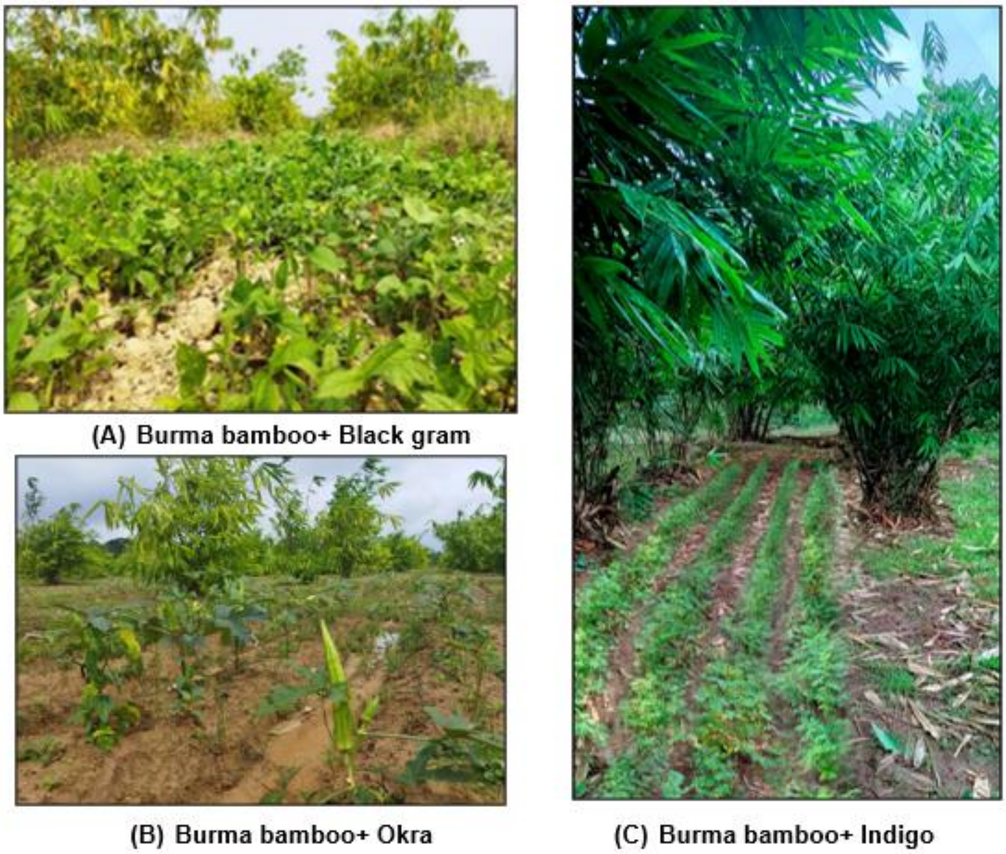
The species is predominantly cultivated in the Indian states of Karnataka and Kerala, thriving in tropical forests, particularly in areas with calcareous rocks, up to altitudes of 1300 meters [11]. Its introduction to Kodagu District dates to 1913 [12]. It thrives in various soils but performs exceptionally well in well-drained sandy loam alluvial soil. A minimum soil depth of 45 cm is recommended, considering bamboo's surface-feeding nature. To prevent waterlogging, main trenches (1.00 m width × 1.50 m depth) and sub-trenches (0.35 m width × 0.45 m depth) should be excavated for proper drainage (specially while planted in abandoned rice fields). Bamboo flourishes in open sunlight, so avoid planting in heavy shade. The cultivation area needs to be cleared of existing vegetation, levelled, ploughed, and equipped with drainage trenches [13]. Pits measuring 45 × 45 × 45 cm^3 should be excavated at designated positions before planting. Each pit can receive a basal dosage of specific combination of NPK fertilizers based on the required followed by the addition of 1 kg of vermicompost, topped with another layer of soil.

Innovative silvicultural practices involving *D. brandisii* shoot production have been proposed for the sustainable management of 5-year-old plantations, ensuring food security [14]. Research indicates that adjusting thinning intensity, specifically by retaining 2-1 culms (Two 1-year-old & one 2-year-old mother culms clump–1), significantly enhances shoot emergence and production, particularly for market-oriented edible shoots. This suggests a potential avenue for further investigation into combined factors such as spacing, fertilization, and irrigation to optimize shoot production. In the context of southwestern China, the influence of various fertilizer regimes on *D. brandisii* was explored [15]. Six different regimes, ranging from compost to NPK, were tested, revealing diverse effects on culm height, Diameter at Breast Height (DBH), soil properties, shoots, and yield. Notably, NPK fertilizers outperformed mixed and compost treatments, while mixed fertilizers exhibited higher yields compared to NPK, compost, and control treatments.

A direct relationship between litter production and stand density was observed, indicating that higher stand density with a uniform canopy structure leads to a larger foliage mass on the forest floor. Additionally, a positive association between litter production and canopy Leaf Area Index (LAI) suggests that a uniform canopy structure enhances light interception in the forest canopy, resulting in larger canopy leaf area and improved canopy LAI. Conversely, an inverse relationship was found between litter production and culm DBH size, connected with reduced stand density, leading to decreased stand cover and, ultimately, a decline in foliage mass on the forest floor. The *D. brandisii* plantation, characterized by relatively dense stands and a closed canopy, exhibited a negative correlation between lower canopy leaf area and higher canopy spread area, possibly due to uneven foliage distribution limiting light interception in the forest canopy. Therefore, managing dense stands and a closed canopy structure through thinning practices in *D. brandisii* plantations could enhance efficient light interception and result in larger DBH size [16].

5. SIGNIFICANT UTILIZATION OF BURMA BAMBOO

The importance of *D. brandisii* lies in its unique characteristics and versatile applications, making it a significant asset in various contexts. This versatile bamboo is extensively utilized in various industries, including house construction, basket weaving, handicrafts, and furniture production. Owing to its uses, the National Mission on Bamboo Application (NMBA, Government of India) has recognized *D. brandisii* as among India's most valuable multipurpose bamboo species [17]. The species is also well-suited for pulp fiber production, adding to its economic significance [18,19]. Traditionally, bamboo species have been employed for crafting ladders, weaving baskets, and harvesting edible shoots. However, Burma bamboo has found a contemporary application as fencing poles for ginger cultivation in upland rice fields. *D. brandisii*'s rapid growth rate positions it as one of India's most valuable multipurpose bamboo species. Its adaptability makes it suitable for cultivation in various agroforestry models (Fig. 3), including farm forestry, social forestry, and homesteads in the humid tropics. Additionally, the species has been observed to contribute significantly to soil conservation due to its extensive root system.



(A) Burma bamboo+ Black gram

(B) Burma bamboo+ Okra

(C) Burma bamboo+ Indigo

Fig. 3. *Dendrocalmus brandsii* based agroforestry models

Due to its non-thorny and upright growth characteristics, *D. brandisii* is highly preferred for homestead cultivation. Studies have highlighted the financial viability of cultivating *D. brandisii* in Kodagu District, particularly when intercropped with ginger [20]. This approach featured the potential of well-managed *D. brandisii* plantations as a practical alternative in abandoned rice fields, requiring minimal financial investment. Similar findings have been documented in agroforestry models centered on *D. brandisii*, demonstrating its effectiveness in restoring abandoned rice fields [13]. Additionally, a study assessing bamboo performance within an agroforestry model involving *D. brandisii* + *Indigofera tinctoria* further supports its versatile applications [21]. Recognizing its myriad uses and economic importance, the National Mission on Bamboo Application (NMBA), under the Government of India, has identified *D. brandisii* as one of the country's most valuable multipurpose bamboo species [17]. Hence, *D. brandisii*, or Burma bamboo, stands out as a versatile and economically significant bamboo species. Its applications span construction, craftsmanship, and pulp fiber production, making it a valuable resource in agroforestry and various industries, while its adaptability and low cultivation costs position it as a promising choice for sustainable land use and resource conservation in India.

Because of its simple propagation, rapid growth, and impressive productivity, *D. brandisii* is recognized as a highly promising renewable nonwoody forestry resource for manufacturing value-added products derived from its lignocellulosic components, including hemicelluloses and starch [22]. It has been observed that *D. brandisii* attained a clump height of 4.17 m, with individual culm collar diameters ranging from 2 to 3 m at the age of 2 years [13]. Additionally, spectroscopic analyses revealed that the lignin in bamboo exhibited characteristics typical of grass lignin, comprising p-hydroxyphenyl, guaiacyl, and syringyl units [23]. Due to its scarcity of thorns and the substantial, straight culms it boasts, this species holds an advantage over other native counterparts such as *D. strictus* and *B. bambos*. This makes it a promising candidate for the production of bamboo composites, including Laminated Bamboo Lumber (LBL) [24]. The mechanical properties of laminated bamboo boards derived from *D. brandisii* are noteworthy, exhibiting outstanding bending and compressive strengths [25]. Additionally, the strength characteristics of flowering culms of *D. brandisii* have been observed to be comparable to those of non-flowered culms, indicating their potential suitability for structural applications at levels equivalent to their non-flowered counterparts [26]. Beyond its structural applications, *D. brandisii* shows promise in the realm of health foods, as it has the potential to serve as a natural antioxidant and anti-inflammatory agent. This opens avenues for its utilization as a food fortifier, enhancing the nutritional value of the species' shoots and contributing to the development of functional foods centered on dietary fiber [27].

6. DISTINCTIVE ATTRIBUTES OF BURMA BAMBOO

Regarding wood anatomical features, *D. brandisii* displays three identifiable types of vascular bundles in its culms [19]. The radial length-to-tangential diameter ratio of these bundles varies across different culm zones but maintains consistency throughout various age stages. As the culm ages, there is an increase in fiber length (L), wall thickness (W), and the Runkel ratio. Conversely, the fiber length-to-outer diameter ratio (L/D) and lumen diameter (Ld) decrease with age. Additionally, the chemical properties of *D. brandisii* show age-related variations, with holocellulose and ash content decreasing from age 1 to 2 years, then increasing at year three. Acid-insoluble lignin, alcohol-toluene extractives, and silica contents increase with age class, whereas acid-soluble lignin exhibits the opposite trend. The fiber characteristics of *D. brandisii* suggest its suitability for pulp fibers, although its lignin content is relatively high compared to other bamboo species [19]. Polysaccharide fractions, comprising water-soluble (W), 1,2-Cyclohexanediaminetetraacetic acid (CDTA)-soluble (CA), sodium carbonate (Na_2CO_3)-soluble (SC), 1 M potassium hydroxide (KOH)-soluble (PH1), and 4 M KOH-soluble (PH4) fractions, were isolated through the use of water, CDTA, Na_2CO_3, and KOH solutions from the species [28].

In a study, researchers investigated silicon variation and phytolith morphology in different organs of wild *D. brandisii* plants [29]. They found that bamboo leaves displayed significantly higher silicon content compared to other organs, and the phytolith morphotypes in the leaves were highly diverse. Likewise, in a separate observation, it was noted that mature leaves of *D. brandisii* seedlings, raised through various methods, exhibited higher concentrations of ash, silicon, and phytoliths compared to young leaves [30]. Tissue-cultured seedlings displayed significantly higher moisture content than grafted seedlings, and the order of ash and silicon concentrations was grafted seedlings > tissue-cultured seedlings > seed-cultured seedlings. The varying planting durations (5, 10, 20, and 40 years) of *D. brandisii* impacted the structure, diversity, and functional groups of the soil bacterial community, primarily influencing soil environmental factors. This serves as an effective and sustainable strategy for managing *D. brandisii* and enhancing soil quality [31]. Incorporating *D. brandisii*, into mixed-use agroforestry models not only enhances productivity but also positively influences soil nutrient levels, transforming barren fields into arable land, showcasing potential benefits for both productivity and environmental protection [13].

7. CONCLUSION

D. brandisii, or Burma bamboo, stands out as a remarkable bamboo species with diverse applications. Thriving in varied environments, its adaptability contributes to agroforestry and environmental conservation. Cultivated extensively, its innovative silvicultural practices enhance shoot production and food security. Beyond its economic significance in construction, crafts, and pulp fiber, it plays a pivotal role in soil conservation. Recognized for its unique properties and applications, Burma bamboo emerges as a promising resource for sustainable land use, resource conservation, and diverse industries, embodying a harmonious blend of ecological and economic importance.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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