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Review article

Diversity, Threats and Conservation Aspects of Bamboo: A Review on Green Gold

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ABSTRACT

Bamboo, commonly known as “Green Gold” or “Poor Men’s Timber,” is an arborescent grass belonging to the Poaceae family. It is continuously gaining attention due to its diverse life forms, flowering patterns, and multipurpose utilities. Bamboos are cosmopolitan in distribution, widely adaptable, and growing naturally in Asia’s tropical, subtropical, and temperate regions. India is the second richest country regarding species diversity (136), most of which are found in the northeast region and the Western Ghats, along with endemism. Over the past few years, bamboo has been on the verge of being swept due to multiple threats. Overexploitation coupled with limited measures to replenish resources has resulted in shrinking the natural bamboo resource base, necessitating bamboo conservation in forest and non-forest areas. What matters most is that resources must be conserved sustainably without compromising utility. For efficient utilization of bamboo, different propagation techniques and strategies, viz. tissue culture, bamboosetum, seed orchards, multilocation trials, seed cryopreservation, and bamboo-based agroforestry can be improvised with the motive of conserving bamboo resources.

Key words: Bamboo, Conservation, Flowering, Diversity, Endemic

INTRODUCTION

Bamboo is a key forestry resource in the socioeconomic-cultural-ecological-climatic-functional context of India and other South and Southeast Asian nations. More than 1500 traditional uses of bamboo are known worldwide (Kumar et al. 2017). Its wide range of practical applications has given rise to phrases like “poor man’s timber”, “Green Gold”, “the cradle to coffin plant”, “friend of the people”, “Green Gasoline”, “The Plant with Thousand Faces”, etc. (Chongtham et al. 2011). Food, shelter, medicine, raw materials for construction, a wood alternative, and pulp and paper for industry are all provided by bamboo. Additionally, they are used to make boats, rafts, fishing poles, musical instruments, furniture, handicrafts, containers, tool handles, poles, and other items. For centuries, the Indians and other countries have also used the leaves as animal feed. It is a resource that is improving the environment and has the potential to provide economic security, food security, ecological security, and livelihood security in the future in both rural and urban areas. Bamboo acts as a carbon sink, an oxygen provider, a decomposer of organic matter, a preventer of soil erosion, and an enhancer of slope stability, all contributing to maintaining environmental balance (Kaushal et al. 2021). Bamboo is recognized as a promising species for programs to reduce poverty in several regions. Over the past few years, bamboo has been on the point of being swept owing to multiple threats such as climate change, restricted locality, uncertain flowering patterns, environmentally unsound harvesting, and various natural and anthropological factors, etc. The natural bamboo resource base has dwindled because of overexploitation and insufficient efforts to restore resources, necessitating bamboo conservation in forest and non-forest areas. We are left with severe scarcity as opposed to the extensive bamboo forests seen in South and Southeast Asia at the beginning of this century. Most importantly, resources must be conserved sustainably without sacrificing usefulness. An attempt has been made to review earlier literature and compile about bamboo resources diversity and distribution range, alarming threats, and conservation status, and accordingly, for efficient utilization of bamboo, different propagation techniques and strategies are discussed with the motive of conserving bamboo resources.

DIVERSITY AND DISTRIBUTION OF BAMBOOS

As a cosmopolitan distributed species, bamboo naturally grows in the tropical, subtropical, and temperate regions of all continents except Europe and western Asia, occurs between the latitudinal range of 46° N and 47° S and altitudinal up to 4000 m altitude above mean sea level. It is found abundantly between 15° N and 25° N latitude in Asia. There are 1662 bamboo species globally belonging to 121 genera, adapted to different regions (Canavan et al. 2017). India is the second richest country in terms of diversity, with 136 species (Fig. 1) (Anonymous 2021a) after China-861 (Liu et al. 2018). Out of these, 125 are native, and 11 are exotics belonging to 23 genera (both wild and cultivated; Kumari 2019). India introduced 8.4% of species, which is much lower than the USA (80.8%), Australia (96.2%), and Japan (14.4), mainly due to the multifunctional nature of these products (Canavan et al. 2017). Factors that govern the geographical distribution of bamboo are mostly temperature, altitude, rainfall, and soil conditions. In India, they are usually found in all the states with tropical to temperate climates, elevations up to 4,000 m amsl, and from alluvial plains to high mountains except Kashmir. Bamboo prefers sandy loams with good drainage over loamy clay soils from river alluvium or the underlying rock with rainfall of 1,270 to 4,050 mm/yr and temperatures of 8.8 to 36°C. Some species, however, may resist limited winter frost and can be found in higher rainfall zones.

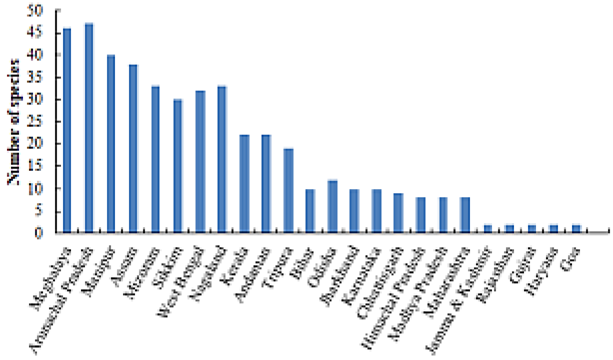

Figure1. Diversity of bamboo species in different states

Bamboos are rarely found as pure crops except when they form secondary breaks. Instead, they are commonly found on a forest floor as an understorey intermixed within tropical evergreen, tropical dry deciduous, tropical moist deciduous, montane wet temperate, montane sub-tropical, and Himalayan wet temperate forests. Some of the principal genera of bamboos are *Arundinaria, Bambusa, Dendrocalamus, Melocalamus, Gigantochloa, Chimonobambusa, Melocanna, Ochlandra, Dinochloa, Phyllostachys, Pseudoxytenanthera, Schizostachyum, Thyrsostachys*. *Bambusa* is the largest genera with 37 spp. and 2 varieties, followed by *Dendrocalamus* (18 spp.) and *Ochlandra* (11 spp. and 1 variety). Together, these three genera represent about 45% of the total bamboo species found in India. Almost 66% of the bamboo species from India are found in the Eastern and Northeastern regions of India. The maximum species concentration is found in the deciduous and semi-evergreen regions of the northeast and the tropical moist deciduous forests of North and South India.

Bamboo is diverse in life forms: woody, shrubby/ reed bamboo, and climbing bamboo. *Bambusa, Dendrocalamus, Gigantochloa, Oxytenenthera, Schizostachyum*, and *Cephalostachyum* are woody bamboo genera that form 75% of the total kind. Shrubby/ reed bamboo account for 48 species belonging to the genera *Ochlandra* (11 spp. 1 var.), *Yushania* (9 spp.), *Drepanostachyum* (6 spp.), *Oxytenenthera* (5 spp.), *Phyllostachys, Arundinaria, Chimnobambusa, Chimnocalamus, Thamnocalamus*, and *Neomicrocalamus*. Climbing bamboos of India belong to the genera *Dinocloa, Melocalamus, Ochlandra*, and *Oxytenenthera*. Reedy and Climbing bamboo are mostly restricted to the tropical, humid, semi-, and wet-evergreen forests of the Western Ghats, Northeastern region, and Andaman-Nicobar Island. Based on their stem/clump-forming nature, bamboos are classified as monopodial (non-clump forming, mostly temperate) and sympodial (clumping, tropical species). Monopodial bamboos in India include *Arundinaria* and *Phyllostachys* genera (temperate climate), whereas sympodial are dominated by *Bambusa* and *Dendrocalamus* genera (tropics). Sympodial bamboos grow faster and have higher productivity than monopodial bamboos; thus, within a few years of being harvested, they can rejuvenate back into a full-grown stand. Out of all sympodial bamboos in India, *Dendrocalamus strictus* counts for 45% followed by *Melocanna baccifera* 20%, *Bambusa bamboos* 13%, *D. hamiltonii* 7%, *B. tulda* 5%, *B. pallida* 4%, and remaining species count for 6% of the total growing stock (Tewari et al.2019).

ENDEMISM OF BAMBOOS

Most bamboo species in India are concentrated in the northeast and south of India. A total of 41 species show endemism in northeast India, where the Western Ghats and Peninsular India, northwest and Central Himalayan region, and Andaman and Nicobar Islands are home to 14, 6, and 6 species, respectively. Naturally, restricted taxa are *Gigantochloa rostrata* in Andaman and Nicobar Island, *D. strictus* in semi-arid and moist deciduous forest areas of India; *D. Stocksii* in Western Ghats; *B. balcooa, Melocanna baccifera, D. hamiltonii* in Northeast region; *B. bamboos* in moist deciduous areas of India (Sharma and Nirmala 2015). Most of these are neo-endemic species (species located in the origin region and evolved through divergence and reproductive isolation or hybridization and polyploidy). India is home to two genera that are endemic to the country. *Stapletonia*, an indigenous genus with two species, has been found in Arunachal Pradesh, while *Munrochloa* has been found in several states in Peninsular India. *Bambusa* has ten endemic species in the northeast, and *Ochlandra* has 11 in the Western Ghats. *Dendrocalamus* has two species in the northeast and one each in the north and south of India. *Cephalostachyum* is found only in four Northeastern states: Arunachal Pradesh, Meghalaya, Nagaland, and Sikkim. Two indigenous species, *Melocalamus* and *Sinarundinaria*, are found in the northeastern India. *Schizostachyum* species are found in the Andaman and Nicobar Islands, with two being indigenous to the country. *Dinochloa nicobariana* is a member of the genus *Dinochloa*, which is confined to the Andaman and Nicobar Islands. *Chimonobambusa, Thamnocalamus, Drepanostachyum, Melocanna*, and *Chimonocalamus* each have one endemic species in North-east India, whereas *Teinostachyum* and *Pseudoxytenanthera* have one endemic species in Kerala. One endemic *Gigantochloa* species has been recently documented in the Bastar district of Chhattisgarh. Endemic species (42) and their distribution throughout India are listed in Table 1 along with the latest IUCN threatened list criterion version 3.1 (Anonymous 2001) based on their area of occupancy, the extent of occurrences, and the number of individuals (Singh and Kumari 2018).

MOLECULAR APPROACH FOR ASSESSING DIVERSITY

Bamboo is difficult to analyze due to its polyploidy and forced cross-pollination genetically. Because of their many peculiarities, molecular markers are said to be more relevant for assessing genetic diversity. It is possible to use molecular tools to investigate the genetics of tropical Indian bamboo (Sharma et al. 2008). Molecular data can help deal with many issues of plant taxonomy classification (Das et al. 2008). Molecular markers such as restriction fragment length polymorphism (RFLP), random amplified polymorphic DNA (RAPD), amplified fragment length polymorphism (AFLP), single nucleotide polymorphism (SNP), simple sequence repeat (SSR), and inter simple sequence repeat (ISSR) can be employed for exploring and analyzing genetic diversity of bamboos (Nilkanta et al. 2017). The RAPD method is simple and quick, although it is sensitive to the reaction environment. Intra-

Table 1. Conservation status of threatened endemic bamboos and their distribution

Sr.No.	Bamboo species	Conservation status	Endemic distribution
1	*Bambusa alemtemshii*	VUD2	Assam, Nagaland
2	*Bambusa dampaeana*	CRB1ab(iii)+2ab(iii)	Mizoram, Dampa
3	*Bambusa garuchokua*	VUD2	Assam
4	*Bambusa majumdarii*	CRB1ab(iii)+2ab(iii)	Meghalaya
5	*Bambusa manipureana*	VUD2	Manipur
6	*Bambusa mohanramii*	CRB1ab(iii)+2ab(iii)	Meghalaya
7	*Bambusa nagalandeana*	VUA2cd	Nagaland, Mizoram
8	*Bambusa nairiana*	CRB1ab(iii)+2ab(iii).	Meghalaya
9	*Bambusa pseudopallida*	VUD2.	Meghalaya, Assam
10	*Bambusa tulda Roxb. var. gamblei*	CRB1ab(iii)+2ab(iii)	Meghalaya
11	*Cephalostachyum capitatum Munro*	DD	Sikkim, Meghalaya
12	*Cephalostachyum longwanum*	CRB1ab(iii)+2ab(iii).	Nagaland
13	*Cephalostachyum mishimieanum*	VUD2	Arunachal Pradesh
14	*Chimonobambusa arunachalensis*	VUD2	Arunachal Pradesh
15	*Chimonocalamus lushaiensis*	CRB1ab(iii)+2ab(iii).	Mizoram
16	*Dendrocalamus manipureanus*	CRB1ab(iii)+2ab(iii).	Manipur
17	*Dendrocalamus sahnii*	CRB1ab(iii)+2ab(iii)	Arunachal Pradesh
18	*Dendrocalamus somdevae*	CRB1ab(iii)+2ab(iii)	Uttarakhand
19	*Dinochloa nicobariana* *	LC	Nicobar Islands
20	*Drepanostachyum suberectum*	LC	Meghalaya, Arunachal Pradesh, Sikkim
21	*Gigantochloa bastareana*	CRB1ab(iii)+2ab(iii).	Chhattisgarh
22	*Melocalamus gracilis*	CRB1ab(iii)+2ab(iii)	Assam
23	*Melocalamus indicus* *	CRB1ab(iii)+2ab(iii).	Assam, Manipur
24	*Melocanna clarkei**	VUD2	Meghalaya, Manipur, Mizoram, Nagaland
25	*Munrochloa ritcheyi*	LC	Karnataka, Kerala, Maharashtra
26	*Ochlandra beddomei**	CRB1ab(iii)+2ab(iii)	Kerala
27	*Ochlandra ebracteata*	CRB1ab(iii)+2ab(iii)	Kerala
28	*Ochlandra keralensis*	CRB1ab(iii)+2ab(iii).	Kerala
29	*Ochlandra scriptoria*	VUD2	Karnataka, Kerala, Tamil Nadu
30	*Ochlandra setigera*	VUA2cd	Kerala, Tamil Nadu
31	*Ochlandra spirostylis*	CRB1ab(iii)+2ab(iii)	Kerala
32	*Ochlandra talbotii*	VUA2cd	Karnataka, Goa
33	*Ochlandra travancorica*	VUD2	Karnataka, Kerala, Tamil Nadu
34	*Ochlandra wightii*	VUA2cd	Kerala, Tamil Nadu
35	*Pseudoxytenanthera bourdillonii* *	VUA2cd	Kerala
36	*Schizostachyum andamanicum*	VUA2cd	Andaman & Nicobar Islands
37	*Sinarundinaria arunachalensis*	UD2	Arunachal Pradesh
38	*Sinarundinaria nagalandiana*	VUA2cd	Nagaland
39	*Stapletonia arunachalensis*	VUA2cd	Arunachal Pradesh
40	*Stapletonia seshagiriana*	VUA2cd	Arunachal Pradesh
41	*Teinostachyum beddomei*	VUA2cd	Karnataka, Kerala
42	*Thamnocalamus arunachalensis*	VUA2cd	Arunachal Pradesh

* also reported as rare and threatened by Sharma and Nirmala 2015)

[Critically Endangered (CR), Data Deficient (DD), Least Concern (LC), Vulnerable (VU); The first level of the hierarchy under the criterion A to C and D under Vulnerable is indicated by the use of numbers (1-4), and if more than one is met, they are separated by the '+' symbol. The usage of lowercase alphabetic characters designates the second level (a-e). Roman numerals in lower case are used in the third level of the hierarchy under Criteria B and C (i-v). If more than one is listed, they are enclosed in parentheses (without a space between the previous alphabet character and the beginning of the parenthesis) and separated by commas] genomics and inter-genomics diversity are assessed using ISSR markers (Yeasmin et al. 2015). For genetic diversity studies and bamboo identification, many researchers have used RAPD and ISSR. Lalhruaitluanga and Prasad (2009) used RAPD and ISSR markers to assess genetic diversity among 12 *M. baccifera* accessions from Mizoram. For the identification and genetic relationship investigation of 12 bamboo species, Nayak et al. (2003) used 30 decamer random primers. Fifty primers (8 AFLP and 42 RAPD) revealed 914 polymorphic loci in reed bamboo (*O. travancorica*) from the Kerala region of India, indicating a high level of genetic diversity (Nag et al. 2013). A combination of AFLP and RAPD data showed that most of the variation occurred inside the population (54%) rather than between populations (46%). Sharma et al. (2008) employed 59 SSR from sugarcane and rice to examine the genotype of 23 bamboo accessions. For the identification of *B. balcooa* and *B. tulda* two species-specific Sequence Characterized Amplified Region (SCAR) markers - 'Balco836' for *B. balcooa* and 'Tuldo609' for *B. tulda* - were created and verified (Das et al. 2005), whereas Peng et al. (2013) reported the draft genome of Moso bamboo.

PRODUCTION STATUS

As per the Forest Survey of India (Anonymous 2021a), the total bamboo bearing area of the country has been estimated to be 15 million ha (mha). Madhya Pradesh has a maximum bamboo bearing area of 1.84 mha followed by Arunachal Pradesh (1.57 mha), Maharashtra (1.35 mha) and Odisha (1.12 mha). The total number of culms at the national level is 53,336 million, out of which 73.40% are green-sound culms. The maximum number of green culms is found in Arunachal Pradesh, followed by Assam and Madhya Pradesh. The total estimated green weight of bamboo culms at the national level is 402 million tonnes of green sound bamboo, contributing 66%. The weight of green sound culms is maximum in Arunachal Pradesh, followed by Assam and Nagaland. India's annual bamboo production potential is 4.8 million tonnes. Due to its versatile nature, utility, and part of livelihood, social, and environmental security over 10 million people depend on bamboo as a livelihood source. However, the country's demand is around 28 million tonnes against the supply of 14 million tonnes. To curtail this gap National Bamboo Mission (Anonymous 2021b) has recommended 18 economically important bamboo species for cultivation in peninsular India such as *B. bamboos, D. hamiltonii, B. nutans, D. stocksii, B. pallida, D. strictus, B. polymorpha, D. asper, B. tulda, Guadua angustifolia, B. vulgaris, Melocanna baccifera, B. balcooa, Ochlandra travancorica, D. brandisii, Schizostachyum dulloa D. giganteus,* and *Phyllostachys bambusoides*. These species are integrated with the farm system to break the monocropping system and for income diversification.

THREAT TO BAMBOO RESOURCES

As bamboo has the potential to replace forest trees due to high biomass production, short rotation, and multipurpose utility (both domestic and industrial), it is heavily exploited in natural areas. It also feeds livestock (grazing/browsing) and wild fauna by consuming nutritive leaves and fruits. Overgrazing and browsing, coupled with the increasing extent of deforestation and shifting cultivation, uncontrolled forest fire, and negligence at vulnerable and remote genetic resources, are raising serious concerns about declining bamboo resources. Unusual mass flowering and death of bamboo at longer intervals and the inaccessibility of bamboo become even more problematic. However, in most flowers, morphological factors *viz*. pistils are shorter than the palea, and this, coupled with the close covering of the lemma and palea, forces the anterior to remain within the floret, preventing pollination, as seen in *B. cacharensis* and *B. vulgaris* (Singha et al.2003). Further, flowering may occur, but seeds are not setting or less in quantity; others may produce but show variation in viability, difficulties in collecting and processing, poor seed storage traits, and poor regeneration potential are also practical issues with bamboo resources in natural as well as in the controlled environment. In natural forests, after mass flowering and seed set, the growth of the naturally regenerated seedlings is suppressed by weeds such as *Mikania micrantha, Pueraria phaseoloides, Merremia umbellata,* and *M. vitifolia* (Gopakumar and Motwani 2013). As discussed earlier, boars, rodents, elephants, and insects' predation of fruits, seeds, spikelets, and seedlings seriously hampers and inhibits natural regeneration. Currently, 60-70% of India's bamboo stock is consumed by the paper and pulp industries, with much of it sourced from natural forests (Chaudhary et al. 2024). The demand for bamboo resources is substantial, and projections indicate that future demand may soon exceed the available stock, given the current supply-demand ratio of 1-3 million tonnes to a demand of 27 million tonnes annually (Shrivastava et al. 2017). This growing demand, especially from the paper and pulp industry, poses a major threat to global bamboo diversity, particularly in countries like India, where nearly all bamboo supply comes from natural populations. Unsustainable and indiscriminate harvesting had driven by rising demand risks the depletion of natural bamboo populations, leading to habitat loss, genetic erosion, and potentially irreversible biodiversity loss at both the species and population levels (Uma Shaanker et al. 2004). Shifting cultivation, a traditional agricultural practice involving clearing forests for temporary cultivation, especially in India's northeastern states, further intensifies these challenges. This practice involves the felling of bamboo stocks and hampers natural regeneration, leading to genetic erosion in several bamboo species (Katwal et al. 2003). In addition to destroying bamboo habitats, shifting cultivation degrades soil quality and fragments landscapes, restricting gene flow and increasing the vulnerability of bamboo populations. Overall, all the above constraints have an impact on the species' small- and large-scale expansion and development, sustainable use and management, and genetic resource conservation. As a result, a specific focus and effort must be given to the sustainable advancement of bamboo resources in India.

BAMBOO CONSERVATION STRATEGIES

Conservation of existing bamboo stands without compromising their utility, exploiting and destroying natural existence, is the major approach for today's scenario as bamboo is an integral part of the subsistence and livelihood of rural society and community. For this task, there is a need to extend the area under bamboo cover by propagating it outside the native range of occurrence, which may reduce the impact of the vulnerability of species in the future. Conservation can be achieved by employing in-situ and ex-situ conservation methods.

In-situ conservation

In situ conservation provides more advantages than ex-situ conservation because the species stay part of nature's continuing evolutionary process, which allows them to adapt to changing environmental conditions and compete with other species, whereas ex-situ conservation disrupts the evolutionary process. The area where the bamboo forest is located can be declared a protected area by considering the plant and faunal community. The declaration of a protected area can be based on the extent and degree of threat to bamboo resources. The involvement of local people and creating awareness among them will be effective in conservation efforts. There are many downsides of in-situ conservation efforts, more data on what to conserve and whom to conserve it. Obtaining information on (a) the distribution pattern of the species, (b) the degree and type of the species' threat, and (c) the genetic variation of the cohorts is critical for effective conservation planning of genetic resources. Based on this information, judgments can be made about which areas should be prioritized for conservation and which populations to harvest germplasm. In the lack of such vital knowledge, in situ conservation efforts are often erratic and wasteful, resulting in long-term cost inefficiency.

Ex-situ methods

Ex-situ conservation measures are essential for preserving bamboo genetic diversity outside natural habitats. Bamboosetums, or bamboo parks, are gardens where diverse bamboo species from various regions are collected and cultivated, effectively preserving native and exotic species. Examples include the bamboosetums in Cherra and Basa, Arunachal Pradesh, which safeguard 35 and 30 species, respectively, and Kerala Forest Research Institute, conserving 72 species across 14 genera. Other notable centers include Tripura's Anandnagar, Dehradun's Forest Research Institute, Solan's Dr. Y.S. Parmar University of Horticulture and Forestry, and Bhubaneswar's Regional Plant Resource Centre.

Multilocation trials further assess the suitability and performance of bamboo species across different agro-climatic regions; for instance, Tewari et al. (2014) evaluated 15 species in diverse Indian regions, while trials in North-East India and the Western Ghats have supported conservation efforts for species such as *B. bamboos*, *B. balcooa*, and *D. hamiltonii*. Seed orchards and clonal orchards ensure the availability of perennial seeds and facilitate the propagation of bamboo, complementing genetic conservation with large-scale production. Cryopreservation techniques provide a method for long-term germplasm preservation, especially for bamboo seeds that quickly lose viability under normal conditions. For example, species like *D. membranaceus* and *B. bamboos* have shown improved cryopreservation outcomes through controlled drying processes (Krishnapillay et al. 1993), and CSIR-IHBT has successfully cryopreserved *D. hamiltonii* using vitrification. Bamboo-based agroforestry systems have also gained attention for their rapid growth, ecological adaptability, and role in carbon sequestration. Traditionally integrated into rural landscapes in states like Assam, Kerala, and Jharkhand, bamboo-based agroforestry supports biodiversity, promotes ecosystem resilience, and contributes to poverty alleviation, reflecting bamboo's versatility and sustainability in agroforestry practices.

Propagation efforts

Macropropagation

Propagation and cultivation of endemic bamboo can help to save the species from extinction. Bamboo multiplication is done primarily by seed, but many bamboo flowers and seeds lead to bamboo dying after a long period (Ntirugulirwa et al. 2012). However, bamboo multiplication is difficult due to low seed viability, limited storage facilities, diverse seedling populations, poor seed set, and wild animal consumption (Singh et al. 2013a). To develop bamboo plantations from seed, the only reliable option is to use vegetative techniques like rhizome cutting, culm and branch cutting, layering methods, offset planting, and macro proliferation (Seethalakshmi 2015, Pathak et al. 2008).

Micropropagation

Applying biotechnological tools under the tissue culture for micropropagation is one of the rapid ways of propagation and gives assurance of success. Several studies have been usefully reported for micropropagation by using explants like rhizomes, inflorescences, mature embryos, auxiliary shoot, and nodal segments (Singh et al. 2013b, Negi and Saxena 2011, Mishra et al. 2008). 3 mg/L BAP (Benzyl amino purine) was reportedly efficient for bud break and shoot proliferation of *B. tulda* and *M. baccifera* (Waikhom and Louis 2014). For the first time, the devised technique successfully produced *B. tulda* rhizome in half-strength MS basal medium with 3 mg/L IBA, 10 mg/L coumarins, and 3% sucrose.

CONCLUSIONS

Based on the literature survey and reviews, it is concluded that bamboo is mainly and widely distributed in the Asian sub-continent. India is one region with the highest potential for bamboo resource production and development. There are numerous threats to the bamboo, and continuing with the identical facet may put them to extinction. Fewer studies focus on bamboo phenology and its life cycle. Also, several conservation strategies must be prioritized to change bamboo resources significantly. The main conservation has been focused on micropropagation so far. The reliability and surety of developing bamboo resources can only be achieved by combining all the available strategies. From the above review, further research is needed to enhance a promising result in the conservation process through bamboo seeds and their preservations.

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