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Impact of moisture content of branch cuttings on rooting behaviour in genotypes of *Dendrocalamus strictus*

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Abstract

Dendrocalamus strictus is a drought resistant tropical bamboo with multifarious uses. Improvement in the species is required for various traits of economic importance. Evaluation and multiplication of superior germplasm is essential for quick production gains. The moisture content of bamboo is a critical factor for its use as a structural element resulting in its mechanical and physical properties. This study is an attempt to establish the relation between moisture content and rooting behavior of branch cuttings of bamboo. *Ex vitro* propagation of five genotypes was carried out along with total moisture content. Significant variation in rooting parameters such as rooting percentage and root length of the selected genotypes was observed. A maximum of 53.33% rooting was achieved in the cuttings of both G3 and G4. The maximum moisture content was recorded in G3 (70.40%) followed by G4 (63.97%) suggesting that the bamboo from dry areas retain more moisture in their culms which can be utilized by the plant for its growth and shows better rooting than that of the non-dry areas. A significant correlation between moisture content% and rooting response suggests that the high amount of moisture in the culm/ branch promotes faster rooting in cuttings. This could be beneficial for management and utilization of this species by the farmers as the water requirement reduces greatly and eventually the cost of production.

Keywords *Dendrocalamus strictus*; Genotype; Germplasm; Moisture content

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1. Introduction

Bamboo species are one of the most important non-timber forest products over the globe (d'Oliveira et al. 2013). Bamboo forests play a vital role in carbon sequestration and climate change mitigation (Jin et al. 2019). It's a versatile and fast-growing plant, plays a significant role in various sectors, including agriculture, forestry, construction, handicrafts, and environmental conservation. The demand for bamboo from industrial sector is high (Prasetyo et al. 2020). Bamboo forest management is a multifaceted approach for its sustainable cultivation, conservation, and utilization of bamboo resources. Effective management of bamboo forests is essential to maximize the ecological, economic, and social benefits while ensuring the long-term sustainability of these valuable resources. Bamboo propagation is one of the key aspects of bamboo forest management.

Dendrocalamus strictus, commonly known as "Solid or Male Bamboo," is a prominent bamboo species native to South Asia and regions of the Indian subcontinent. The species is renowned for its versatility, economic, and ecological importance. This bamboo species has been used as a crucial resource in construction, paper production, handicrafts, and environmental conservation efforts (Gupta et al. 2014). However, despite its high significance, *D. strictus* is facing various challenges related to its propagation and cultivation. Moisture is one of the most important resources necessary to bamboo's growth during early growth and development (Xiao 1983). It is observed that moisture content in lower part of the plant is notably higher compared to the remainder, owing to a greater presence of parenchyma cells (Zakikhani et al. 2017). It also aid in determination of several parameters such as tensile strength, dimensional stability, electrical resistivity and electrical conductance (Razali et al. 2015). As a pivotal aspect of bamboo growth, study of rooting behavior with respect to its moisture content is of high importance as it directly impacts the establishment and vitality of bamboo plants which in turn impacts the bamboo forest dynamics (Chen et al. 2015). In addition, it is also considered to significantly impact the life span of a bamboo as it attracts fungi and borer insects. Commonly, moisture content is defined as the mass of water in the substance expressed as a percentage of the oven-dry mass (Ahmad and Kamke 2005). The rooting phase is a critical stage in the life cycle of bamboo, as it marks the transition from the vegetative to the reproductive phase. During this stage, the culm base produces roots that are essential for nutrient and water uptake, anchorage, and stability (Scurlock et al. 2000). The ability of bamboo genotypes to root effectively can significantly impact their adaptability to different ecological niches and their overall health and vitality. The ability of different bamboo genotypes, including those of *D. strictus*, to adapt and thrive under varying conditions is crucial for their long-term survival and productivity within bamboo forests.

The present study aims to investigate the influence of moisture content of the branch cuttings on the rooting behavior of different genotypes of *D. strictus*. Understanding the impact of moisture content on the rooting behavior of different genotypes within the *D. strictus* species is essential for optimizing propagation techniques, conserving genetic diversity, and enhancing bamboo cultivation practices. This research aims to examine the manifestations of genotypic variations in bamboo root development under different moisture conditions. The findings from this comprehensive examination will offer valuable insights to bamboo cultivators, conservationists, and policymakers. These insights have the potential to revolutionize bamboo propagation and cultivation practices, contributing to the sustainable management and utilization of *D. strictus*. Implementing these practices will help bolster local economies and strengthen global efforts towards environmental sustainability. Additionally, this research sheds light on the adaptability of different genotypes and uncovers the genetic underpinnings of moisture tolerance within this species. These insights can provide useful information for breeding programs and conservation initiatives (Zhang et al. 2018).

2. Materials and Methods

2.1. Site of Study

The present investigations were carried out in the germplasm of *Dendrocalamus strictus* (Roxb.) Nees established at Forest Research Institute, Dehradun, Uttarakhand, India (30°21’10.31″ N latitude, 77°59’55.31″ E longitude and 650 m altitude (above mean sea level) which was established in year 2008 under the project entitled “Bamboo improvement for rural and tribal communities, integrating new technologies” funded by National Bamboo Mission, New Delhi. The laboratory work was carried out at Plant Physiology Discipline, Botany Division, FRI, Dehradun.

2.2. Selection of plant material

Five diverse genotypes of *D. strictus* collected widely from different parts of the country were selected based on their superior phenotypic characters as listed below in Table 1.

Table 1. Selected genotypes of *D. strictus* & their collection site

S.No.	**Genotype**	**Genotype no.**	**Collection Site**
1.	G1	71	Pinjor, Panchkula (Haryana)
2.	G2	107	Kalshi (Uttarakhand)
3.	G3	159	Udaipur (Rajasthan)
4.	G4	59	Amravati, Coimbatore (Tamil Nadu)
5.	G5	170	Mirzapur (Uttar Pradesh)

2.3. Moisture content estimation

The percent moisture content of the binodal branch cuttings was estimated by taking fresh weight and dry weight. The binodal branch cuttings of *D. strictus* were taken in three replicates for each genotype and fresh weight of each cutting was noted. The cuttings were placed in a hot air oven at 80 °C for drying for 24hr to reach a stable weight.

Fig. 1. Oven dried branch cuttings of genotypes of *D. strictus*

The formula used for estimating the moisture content is as follows:

Moisture Content % =

$$\frac{Weight\ of\ moist\ Bamboo\ shoot\ -\ Weight\ of\ oven\ dried\ bamboo\ shoot}{Weight\ of\ moist\ bamboo\ shoot} \times 100$$

2.4. Ex vitro Propagation

The binodal branch cuttings of two years old culms in cohorts of bamboo having unsprouted buds were extracted in the month of March with the help of a secateur and put in a bucket of water. Buds on the culm or branch segments were healthy and not injured, infected or old. The 20-25 cm long binodal branch cuttings were planted in plastic trays with three replicates having ten cuttings with a spacing of 5cm each in a Randomized Block Design (RBD). The binodal cuttings were pretreated with fungicide - Bavistin (1%) for 15 minutes. The cuttings were planted horizontally in plastic trays containing rooting medium sand+soil in the ratio of 1:1. The trays were kept in the glasshouse and watered. The temperature and relative humidity of the glasshouse was maintained at 25±5 °C and 85±5% respectively. After 12 days of planting, the cuttings started sprouting. Profuse sprouting followed by rooting was seen in two months. The cuttings were carefully transplanted in polybags into a 2 kg rooting media containing a mixture of soil, sand and farmyard manure (2:1:1). The polybags were kept in shade house for 15 days and then acclimatized and hardened in natural conditions.

2.5. Statistical analysis:

The data collected was subjected to the analysis of variance (ANOVA) and significant differences among the treatments were tested by Tukey’s test at 5 % level using STATISTICA 7.0.

3. Results and Discussion

3.1. Moisture content in genotypes

The moisture content of bamboo varies along the height during growth or even after harvesting. The top portions have lower moisture content than the middle or basal ones. The moisture content of the branch cuttings of all genotypes ranged from 54.85 % -70.40 % as cited in Table 2. The maximum moisture content was recorded in G3 from Rajasthan measuring 70.40% followed by G4 measuring 63.97% (Table 2.) suggesting that the bamboo from dry areas retain more moisture in their culms than that of the non-dry areas such as Haryana, Uttar Pradesh and Uttarakhand. Similar to our findings, Latif (1993) reported 57-97% moisture content in *Bambusa bluemeana* and 55-95% for *D. strictus*. The moisture content of bamboo is a critical factor for its use as a structural element resulting in its mechanical and physical properties. Wakchaure and Kute (2012) also studied the varying moisture content along the height of bamboo culm resulting in differences in the physical and mechanical properties of bamboo.

Table 2. Moisture content in branch cuttings of the selected genotypes

Genotype	Moisture Content %
1	$54.85^{a}\pm0.26$
2	$56.05^{a}\pm2.19$
3	$70.40^{b}\pm1.94$
4	$63.97^{ab}\pm3.24$
5	$55.18^{a}\pm1.77$
F value	9.56
p value	< 0.05
S/NS	S

3.2. Macro-propagation of genotypes

The multivariate analysis of variance showed significant variation in rooting response of the branch cuttings of *D. strictus* with respect to rooting% and root length of all the selected genotypes. However, the variation for number of roots was found to be nonsignificant. Maximum rooting was observed in G3 (53.33%) and G4 (53.33%) as shown in Table 3. Also, the number of root was found to be highest in G5 (Table 3) while maximum root length was seen in G3 (Table 3). Genotype G3 and G4 belonging to Rajasthan and Tamil Nadu respectively showed better rooting than others due to their geographical adaptations where the rooting medium is sandy and coarse, which is similar to the work reported by Banik, 2008 where, rooting was comparatively quick and maximum in sand medium than the conventional soil medium. Sand is chemically inert, has high porosity, provides aeration and drainage and maintains temperature in the rooting medium as studied by Banik (1994).

Table 3. Effect of genotype on rooting behaviour of *D. strictus*

Genotype	Rooting %	No. of Roots	Root length (cm)
G1	$43.33^{b}\pm1.34$	2.07±0.10	$13.64^{a}\pm0.86$
G2	$40.00^{ab}\pm1.61$	1.03±0.10	$18.26^{b}\pm0.70$
G3	$\mathbf{53.33^{c}\pm2.42}$	2.33±0.11	$\mathbf{40.31^{c}\pm1.53}$
G4	$53.33^{c}\pm2.00$	1.70±0.11	$34.17^{bc}\pm1.10$
G5	$36.66^{a}\pm1.58$	2.90±0.12	$16.53^{b}\pm1.12$
F value	10.199	0.753	18.516
p value	< 0.05	0.557	< 0.05
S/NS	S	NS	S

3.3. Correlation between moisture content and rooting behavior of the genotypes

The Pearson's correlation test between moisture content and rooting behavior of the branch cuttings of all the genotypes showed a significant and positive correlation for rooting % and root length among all the genotypes of *D. strictus* at 0.01 level of significance. A significant correlation (Pearson correlation coefficient = 0.691, p = < 0.05) was found between moisture content and rooting % in the genotypes of *D. strictus*. The correlation between moisture content% and root length (cm) was also found to be significant and positive (Pearson correlation coefficient = 0.697, p = < 0.05) in the genotypes of *D. strictus* as seen in Fig. 2. Moisture is one of the most important resources necessary to bamboo's growth during early growth and development as found in our study and also reported by Xiao (1983). These factors are known to contribute the rooting behaviour of the species. The high amount of moisture in the culm/ branch promotes faster rooting in cuttings as evident from Fig. 3, and it impose a drastic effect on the mechanical properties of bamboo (Ming et al. 2017). The better rooting in G3 and G4 can also be attributed to the high amount of moisture in their culm/branch which enhances the rooting in plants. Similar findings were corroborated in the study conducted by Qing et al. (2004) which suggests increase in root production and rhizome elongation at low moisture availability in the rooting medium of the bamboo species *Pleiobastus maculata*. In this study, high moisture content resulted in high shoot and root development which is essential to be capable of binding the topsoil which is the main trigger for slope instability, similar to the studies by Kumar et al. (2023).

	Genotype	Moisture	Rooting	Root number	Root length
Genotype	1				
Moisture	0.044	1			
Rooting	0.011	0.691	1		
Root number	0.501	0.171	-0.028	1	
Root length	0.285	0.697	0.826	0.04	1

Colour scale: 1.0 to - 1.0

** Correlation is significant at the 0.01 level (2-tailed).

Fig. 2. Correlation matrix depicting relation among various factors

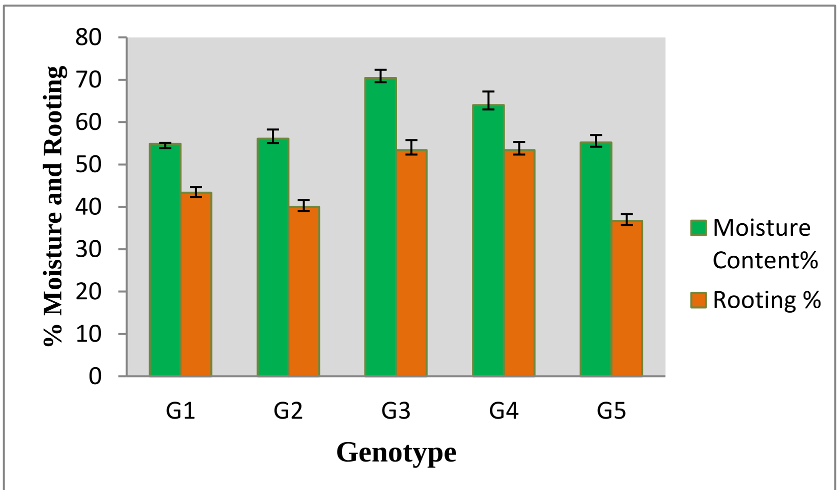

Fig. 3. Effect of moisture content on rooting percentage of *D. strictus* genotypes

4. Conclusion

Bamboo forest management should be adapted to local conditions and objectives, as bamboo ecosystems vary significantly across regions and climates. Sustainable bamboo management practices can contribute to environmental conservation, rural development, and economic growth while addressing global challenges such as deforestation and climate change. *D. strictus* genotypes exhibit significant genetic diversity, leading to variations in their response to environmental factors. Our study provided correlative evidence that the high moisture content of the culm/ branch promote better rooting in the cuttings. Therefore, response of different genotypes of *D. strictus* to varying moisture content leading to its rooting behaviour is of paramount importance. This can help identify genotypes that are well-suited to specific ecological conditions and provide insights into the genetic basis of moisture tolerance in this species. This can lead to develop an understanding on how different *D.strictus* genotypes respond to moisture levels can assist in optimizing bamboo forest management practices that enhance carbon sequestration, mitigate soil erosion, and contribute to biodiversity conservation.

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Conflict of Interest

The authors declare there is no conflict of interest.

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