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Mass Propagation of *Guadua angustifolia* Kunth through Branch Cuttings

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ABSTRACT: Guadua bamboo (*Guadua angustifolia*) is a remarkable plant known for its strength, versatility, and ecological significance. Long flowering cycle, poor seed setting, and low germination necessitate vegetative propagation in this commercially important species. In this study, we explored the feasibility of propagating Guadua bamboo through branch cuttings to attain 30% plantlet production. Over four years we meticulously recorded the survival and emergence of shoots as well as the growth of leading shoots to evaluate the survival and growth dynamics of Guadua bamboo propagated from branch cuttings beyond its native range. The result shows that primary branches of *G. angustifolia* can propagate without using any hormone treatment. This method can be applied in this region to multiply the species for large-scale plantations with easy and low-cost transportation of plantlets.

Keywords: Guadua, Vegetative, Propagation, Branch, Cutting.

INTRODUCTION

Guadua angustifolia Kunth is a woody bamboo species native to the tropical regions in Central and South America, which has also been successfully introduced to other countries of Europe and Asia (Riaño *et al*., 2002). This species grows naturally near rivers either as pure stands or with trees. *Guadua angustifolia* is a large spectacular, sympodial bamboo species with culms up to 30m tall and 20cm in diameter. Guadua is frequently referred to as "Vegetable Steel" because of its exceptional mechanical strength and endurance. It is mostly utilised as a substitute for wood in a variety of construction activities, including the construction of homes, furniture, handicrafts, veneer, and flooring (Viswanath *et al*., 2012). It has the potential to become an industrial commodity that contributes to the economy as its fibers are naturally strong and flexible, making it an ideal low-cost, sustainable raw material for a wide range of products such as flooring, furniture, and paper sold on the national and international markets (Londoño *et al.,* 2002).

Bamboo propagation is an important aspect of resource management due to non -non-availability of seeds at regular intervals and the inadequacy of traditional method through rhizome propagation (Ginwal, 2021). It has a big advantage of producing true types of plants sustainably. Usually, every node of the segmented axis of a bamboo bears a bud or a branch, and branches in turn have buds in their axils. Most vegetative propagation procedures in bamboo aim at transforming the innumerable buds present at every node into planting material (Banik, 1980).

Branch cuttings make excellent vegetative propagules as they are comparatively less economical parts of bamboo; available in requisite numbers; easy to handle because of their small size and light weight; and cause minimal damage to clump when extracted (Singh *et al*., 2004). The technique of rooting branch cuttings of bamboo is inexpensive, producing a large number of planting materials with high survival potential in a short duration, and reduces the labour and transportation costs (Hossain *et al.,* 2005, 2006; Singh *et al.,* 2011; Hossain & Arefin 2012). The method of adventitious rooting in branch cuttings has also been successfully adopted for propagating many species of bamboo such as *Bambusa vulgaris, Dendrocalamus strictus, B. nutans, D. asper, B. nagalandiana* (Palanisamy *et al.,* 1995; Agnihotri & Ansari 2000; Palanisamy & Bisen 2001; Singh *et al*., 2002; 2004; Banerjee *et al*., 2011; Deb *et al.,* 2016).

The need for vegetative propagation in *G. angustifolia* arises due to its long flowering cycle, poor seed setting, and low seed germination capacity. Insignificant information is available about specific techniques of vegetative propagation of species (Ramanuja Rao & Zamora 1995). An easy practice is through separation of the tillers that arise after culms are felled (matamba or chusquin method). A method of air layering has also been reported by Verma *et al.* (2013). However, both of these procedures cannot fulfill the demand for plantlets for large-scale planting. Similarly, large-scale plantation through vegetative propagation by rhizome or offset cuttings is not suitable due to bulkiness and difficulties in collection and transportation (Pattanaik *et al*., 2004). Therefore, rooting of branch cuttings of *G. angustifolia* was evaluated in the present investigation along with recording of their survival and growth dynamics.

MATERIAL AND METHOD

The study was conducted in the year 2019 during the rainy season in the first week of July at Central Nursery of ICFRE- ERC, Prayagraj. The region lies in the central plains of Uttar Pradesh having coordinates 25°32′42″N 81°53′25″E with 96m elevation. The region receives on average 979 mm of rainfall; the climate ranges from dry sub-humid to semi-arid and the soil is alluvium calcareous sandy loam (Srivastav *et al*., 2018).

Primary branches of healthy mother culms were collected in the month of June. Two node branch cuttings with rhizomatous swelling were collected for the experiment. All the cuttings were collected from Tripura and treated with 0.01% bavistin solution and thereafter transported to Prayagraj in sphagnum mosses. The cuttings reached the Centre on the fourth day and the same day it was planted in the field. The experiment was established in four replicates in which ten branch cuttings, each having two nodes were planted horizontally in the bed. The nursery bed was prepared with a mixture of soil, sand, and FYM in a 1:1:1 ratio. All the cuttings were placed horizontally; 2 cm deep inside and it was covered with polythene during the afternoon in humid conditions. Regular watering at 2-dayintervals was done through the sprayer. Data collection for shoot emergence was started after 10 days of experimental trial and continuously observed till 90 days. After one year, the data of various growth factors *viz*. number of the shoots that emerged and the diameter, height, and internode length of the 4th node of the leading shoots was collected every year in July. The data collected was analysed using SPSS 27.

RESULTS AND DISCUSSION

Shoot emergence was observed in branch cuttings after 42 days, which continued till 72 days in different replicates. However, the maximum shoot emergence was seen between 52-60 days. Overall 30% of the branch cuttings exhibited shoot emergence and the range of shoot emergence varied from 42 to 72 days. After 3 months adventitious rooting was also recorded in all the branch cuttings having shoot emergence corresponding to 30% root induction. It was found that root, shoot, and rhizome were developed even without any rooting hormone. Almost all cutting formed rhizome at the base with in one year.

It has been observed that most of the bamboo species root satisfactorily without any hormonal treatment. However, rooting hormones and synergists have been found useful in some difficult to root bamboo species such as *B. polymorpha*, *B. tulda*, *D. giganteus, T. oliveri,* and thin-walled species like *S. dullooa* (Singh *et al.,* 2011). The result shows that primary branches of *G. angustifolia* can propagate new plantlets without using any hormone treatment. Further investigation with the employment of root growth regulators may enhance the propagation success in the species.

In this study, we also investigated the growth of shoot emerged and its different parameters from branch cuttings. The data of number of shoot emergence and other parameters was observed from 2020 onwards after the rhizome formation in the cuttings. Over the subsequent four years (2020–2023), data on the number of the shoots emerged and the diameter, height, and internode length of the 4th node of the leading shoots was collected. The purpose of conducting studies on branch cuttings lies in understanding their potential for vegetative propagation to investigate the success rate of propagating new plants from branch cuttings and to assess whether this method is a viable alternative to seed-based propagation.

Descriptive statistics and one-way ANOVA were used to assess the statistical variations in *G. angustifolia* over four years regarding shoot emergence, leading culm height, leading culm diameter, and length of the fourth internode.

The result of ANOVA analysis indicated a highly significant difference in shoot emergence over four years, $F (3, 12) = 58.024$ $p= 0.00$, and acceptance of the alternative hypothesis. A post hoc analysis was conducted to examine these differences further. The post hoc multiple comparisons identified significant differences in the groups and the results are summarized in Table 2. The average no. of shoots that emerged was significantly higher in 2021 (M=10.00, SD =.81) and lower in the year 2023 (M=1.75, SD = .95). These findings suggest that 2021 *i.e*., second year of planting of *G. angustifolia* exhibited a significant improvement compared to other years of planting in terms of the average number of shoot emergence. The initial increase in shoot emergence suggests successful establishment and adaptation while the decline in the average number of shoot emergence over time possibly indicates increased competition among the shoots for essential resources (light, water). Despite fluctuations, the ability of *G. angustifolia* to maintain some level of shoot emergence indicates its resilience and capacity for regeneration. This trait is crucial for the species long-term survival and it also validates the successful propagation of bamboo through branch cutting.

The ANOVA analysis revealed a highly significant variation in leading culm diameter across four years, with $F (3, 12) = 19.30$ and $p = 0.00$. A post hoc analysis was conducted to examine these differences further. The average height of the leading shoot (in m) was found to be 4.60 (SD =0.4), 3.70 (SD=.40), 7.46 (SD=1.4), and 8.02 (SD = 1.0) in the years 2020, 2021, 2022 and 2023 respectively. The findings suggest that the average height of the leading culm in 2020 was statistically similar to that in 2021 and likewise, in 2022 it was comparable to 2023. Moreover, there was a notable enhancement in the average height of the leading culm after the completion of two years since the plantation. The increasing culm height of *G. angustifolia* indicates its maturity and stability in growth with time. Overall, it demonstrates a successful natural growth rate of *G. angustifolia* through branch cutting over four years.

A highly significant difference in leading culm diameter over four years was indicated by the result of the ANOVA analysis, with $F (3, 12) = 55.46$ and $p = 0.00$. The mean diameter at the fourth internode was found to be 11.07 (SD = 0.52), 11.75 (SD = 0.44), 14.75 (SD =1.11), and 16.77 (SD =0.55) in the years 2020, 2021, 2022 and 2023 respectively. The findings suggest that *G. angustifolia* had initial stabilization of leading culm diameter after two years, followed by incremental growth in the third year and substantial increases in the fourth year. The observed pattern of the leading culm diameter at the fourth internode indicates the maturation process and continued development of *G. angustifolia* structural integrity. These growth dynamics will ultimately lead to the utility of *G. angustifolia* in various sectors such as construction, furniture making, etc.

The result of ANOVA analysis indicated a highly significant difference in the length of the fourth internode over four years, $F(3, 12) = 53.11$ $p= 0.00$, and acceptance of the alternative hypothesis. A post hoc analysis was conducted to examine these differences further. The post hoc multiple comparisons identified significant differences in the groups and results are summarized in the Table 1. The average internodal length at the fourth node (in cm) was found 12.32 (SD=0.24), 12.02 (SD=0.8), 13.56 (SD=0.38), and 17.68 (SD=1.06) in the year 2020, 2021, 2022 and 2023 respectively. The finding suggests that *G. angustifolia* followed a similar pattern of increment in the length of the fourth internode as in the case of the leading culm diameter. The observed pattern of increase in length of the fourth internode adds a flexibility factor to the overall increasing strength potential of *G. angustifolia* over the four years.

Table 1: Growth Performance of branch cuttings.

Year	Avg. shoot emerged (Nos)	Avg. Height of leading shoot (in m)	Diameter at 4th node (in mm)	Inter-node length at 4th node (in cm)
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
2020	4.75 ±.957	4.60 ±.497	11.07±.527	12.32±.245
2021	10.00 ±.816	3.70 ±.409	11.75±.446	12.02±.844
2022	3.75 ±.957	7.46 ±1.446	14.75±1.118	13.56±.384
2023	1.75 ±.957	8.02 ±1.098	16.77±.557	17.68±1.06

Table 2: One-way ANOVA test of significance in different growth variables.

Variables	Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
Leading Culm Diameter (mm)	Between Groups	84.840	3	28.280	55.461	.000
	Within Groups	6.119	12	.510		
	Total	90.958	15			
Leading Culm Height (cm)	Between Groups	53.746	3	17.915	19.303	.000
	Within Groups	11.138	12	.928		
	Total	64.883	15			
Length of 4 internodes of leading culm	Between Groups	81.608	3	27.203	53.119	.000
	Within Groups	6.145	12	.512		
	Total	87.753	15			
No. of New shoots emerged	Between Groups	148.688	3	49.563	58.024	.000
	Within Groups	10.250	12	.854		
	Total	158.938	15			

Fig. 1. Establishment of Guadua branch cutting experiment.

Fig. 1. Data collection and clump formation after one year.

Fig. 2. Shoot emergence in the branch cuttings.

Fig. 4. Rhizomeformation after one year.

CONCLUSIONS

The results demonstrate the viability of using branch cuttings for Guadua bamboo propagation and the establishment of new shoots indicates successful vegetative growth. Further research should explore optimal cutting lengths, hormone treatments, and environmental factors to enhance propagation success. In remote villages where the availability of rooting hormones may not be possible, this technique of propagation of *G. angustifolia* will be very fruitful and cost-effective. Vegetative propagation through branch cuttings holds promise for sustainable Guadua bamboo cultivation. Understanding the survival and growth dynamics of propagated plants contributes to effective bamboo management and conservation efforts.

FUTURE SCOPE

Guadua bamboo is highly versatile and prized for its applications in scaffolding, construction, and furniture production. However, its growth patterns remain under-researched, and its full potential is yet to be harnessed. This gap presents valuable opportunities for future research to explore and optimize its utilization in various industries.

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Conflict of Interest. None.

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