Advances in Bamboo Science 14 (2026) 100224

Contents lists available at ScienceDirect

Advances in Bamboo Science

journal homepage: www.journals.elsevier.com/advances-in-bamboo-science

Effect of plastic covering, manure and harvesting season on the propagation of branch cuttings from *Dendrocalamus giganteus* Munro

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ARTICLE INFO

Keywords:
Bamboo propagation
Branch cuttings
Plastic cover
Manure
Survival rate

ABSTRACT

We examined the effects of plastic cover, manure application, branch cutting position and season of cutting on the propagation of *Dendrocalamus giganteus* using branch cuttings under nursery conditions. We undertook the following treatments: 1) branch cuttings with and without a supplement of manure 2) differing positions of branch cuttings (basal part of the branch vs. middle part of the branch) 3) different seasons of branch cuttings (December vs. April), and 4) with and without plastic covering (cuttings covered by plastic vs. no plastic cover). A completely randomized design (CRD) was used for the experiment. Survival data were collected for 90 days. Root development, shoot growth and biomass data were collected at the end of the study period. One-way ANOVA and t-tests were used for the data analysis. Basal branch cuttings collected in December had a survival rate of 61.2 % under plastic covering (PC) and 26 % without plastic cover (NPC). Basal branch cuttings harvested in April had a lower survival rate (42 % with PC and 4.2 % without PC). The mean survival rates of the mid-branch cuttings for both the December and April cuttings that were treated with PC and NPC were poor (0–8 %). Basal branch cuttings planted with manure plus plastic cover (MPC) and no manure with plastic cover (NMPC) achieved survival rates of 37.5 % and 60 %, respectively. In contrast, basal branch cuttings with manure but no plastic cover (MNPC) recorded the highest survival rates of 82.6 %. The one-way ANOVA result revealed no significant differences in the dry root biomass among the MNPC, NMNPC, NMPC or MPC treatments ($p = 0.58$). These findings suggest that *D. giganteus* can be propagated using the basal part of the branch cuttings without using a growth hormone, especially when a plastic cover is used and manure is added to the soil mix.

1. Introduction

Bamboos, belonging to the *Poaceae*, have an estimated 1662 species across 121 genera, and are widely distributed in tropical, subtropical, and temperate regions (Canavan et al., 2017; Ohrnberger, 1999; Phillips, 1995). Approximately 14 % of bamboo species have been introduced beyond their native ranges, reflecting their high adaptability and value (FAO, 2007; Meredith, 2001). Bamboos are globally recognized for their ecological, economic and cultural significance (Phillips, 1995; Ohrnberger, 1999). Globally, bamboo stands cover nearly 36 million hectares, accounting for about 3.2 % of the World's total forest area (Lobovikov et al., 2007). Renowned for their rapid growth and high biomass production, bamboos are believed to support the livelihoods of over 2.5 billion people worldwide. They contribute more than 20 million metric tonnes to global annual production, generating approximately US $60 billion in economic value (Musau, 2016; Lou, 2007; Scurlock et al., 2000).

Despite the immense value of bamboos, large-scale propagation remains a major challenge due to their unique reproductive biology. Most bamboos exhibit sporadic and unpredictable flowering, often with cycles spanning 40–50 years (Kalanzi and Mwanja, 2023; Razvi et al., 2015). The seeds, when available, have a short viability, which limits their utility for propagation. Consequently, vegetative propagation has become the primary method for bamboo multiplication, including rhizome division, offset planting, layering, and culm and branch cuttings (Sreejith and Chichaghare, 2022; Banik, 1995). Among these, culm cuttings have been particularly effective for species such as *Bambusa vulgaris* Schrad. ex J.C.Wendl. (Ntirugulirwa et al., 2013; Satapathy et al., 2020), *Oxytenanthera abyssinica* (A.Rich.) Munro (Gebrehiwot et al., 2016) and *Dendrocalamus giganteus* Munro (El-Keltawi and Abdel Rahman, 2010). However, propagation using culm cuttings is labour-intensive, costly in terms of transportation and preparation, and

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https://doi.org/10.1016/j.bamboo.2026.100224
Received 26 August 2025; Received in revised form 27 January 2026; Accepted 4 February 2026
Available online 7 February 2026

often causes damage to the mother clumps. Branch cuttings offer an alternative vegetative propagation method that is simple, easy to handle and less destructive (Seethalakshmi et al., 2008). However, this method is less commonly used due to low rooting success, lack of standardisation and limited availability of branches in species that only produce them on the upper third of the culm (Sreejith and Chichaghare, 2022). Several factors influence the success of branch propagation, including cutting position, season of collection and the use of rooting hormones (Sreejith and Chichaghare, 2022; de Alwis and Ranasinghe, 2012).

Dendrocalamus giganteus is one of the fastest-growing and tallest bamboo species, reaching heights of 25–35 m and diameters of 15–30 cm (Abdul Khalil et al., 2012; Ramanayake and Yakandawala, 1998). Developing and exploring a simple propagation technique of the species for farmers is important for the scaling up of production of the species. One promising but underexplored option is the use of plastic covers to create microclimates that enhance rooting and shoot development in branch cuttings. Additionally, the use of manure for propagation has not yet been explored. Plastic covers may promote moisture retention, regulate temperature and reduce desiccation, which could create favourable conditions for root and shoot initiation. We examined the combined effects of plastic covers, manure application and cutting position on the growth and survival of *D. giganteus* branch cuttings under nursery conditions. The objectives of this research were 1) to evaluate the effect of plastic covers on the growth, survival and shoot development of *D. giganteus* branch cuttings under nursery conditions in different seasons; 2) to assess the influence of branch cutting position and season of cutting on the propagation success of *D. giganteus*, and 3) to investigate the potential of manure application combined with plastic cover on the propagation of *D. giganteus*. We hypothesized that: 1) Plastic covers would improve the survival and growth of *D. giganteus* branch cuttings; 2) basal branch cuttings harvested in December would exhibit higher success rates than those collected in April; and 3) manure application would enhance root and shoot development through nutrient enrichment.

2. Materials and methods

2.1. Plant material collection

Healthy and mature, more or less similar-sized branch cuttings were collected from *D. giganteus* at the Chano Mille nursery site, located in Arba Minch, Southern Ethiopia (Fig. 1). Two types of branch cuttings were used: (1) Basal branch cuttings, collected from the lower part of the branch close to the main culm, with each containing two nodes and two internodes and (2) middle (lateral) branch cuttings, collected from the middle portion of the same branch, also with two nodes and two internodes. The branch cuttings for the study were collected from 12 culms of similar size, all from plants established in 2005. The branch cuttings used to evaluate the impact of plastic covers were harvested in December 2022 and April 2023. The branch cuttings used to assess the impact of manure on bamboo propagation were harvested and prepared in May 2024. In all cases, the branches were carefully removed from the bamboo culm, packed and kept in a cooler fridge before being transported to Hawasa for the experiment, which was undertaken at the Finchawa Nursery. Soon after the arrival of the cuttings, they were planted in plastic pots at the nursery (Fig. 2).

2.2. Experimental design

The research comprised both observational and experimental analysis. Plastic pots with a diameter of 14 cm and a height of 16 cm were used. The branch cuttings were planted one per pot, with one node buried below the soil and the other exposed above the surface. Each cutting was inserted into the plastic pot at an angle of 45° (Fig. 2). The planted cuttings were kept under shade constructed from woven bamboo and watered twice daily, morning and evening, until the end of the study. A completely randomized design (CRD) was used. Survival and growth data were recorded for three months.

2.2.1. Observational method

The observational part of the study aimed to evaluate the effect of branch cutting position and season of collection on the propagation success of *D. giganteus*. For this purpose, plastic pots were filled with a growing medium composed of topsoil collected from the forest surface layer mixed with sand in a 2:1 ratio. The experiment was conducted during two distinct periods, December and April, to observe the influence of harvesting season. These observations provided information on how branch cutting position and season of branch cutting naturally affected survival, shoot initiation and root development. The number of branch cuttings used for the experiments in the nursery for the different seasons and branch positions is presented in Table 1.

2.2.2. Experimental methods

The experimental part of the study evaluated the effects of plastic covering and manure application on the propagation of *D. giganteus*. For the experimental study, the treatment applied along with their corresponding abbreviation is presented in Table 2. To evaluate the effect of cattle manure, pots were filled with a growing medium composed of local clay soil, cattle manure, and sand in a 2:1:1 ratio. For the treatments without manure, a growing medium of forest soil and sand in a 2:1 ratio was used. Only basal branch cuttings were used, as earlier observations showed poor success with middle branch cuttings. For the manure treatment, survival and growth data were recorded from May 22 – August 22, 2024. In the plastic cover (PC) treatments, individual cuttings were covered with transparent plastic bags tied at the bottom until bud initiation. Once buds began to grow, the bottom of the plastic

Fig. 1. *D. giganteus* at the Arba Minch nursery site (left) and the preparation of branch cuttings (right).

Fig. 2. Experimental setup showing *D. giganteus* basal branch cuttings in nursery conditions: (left) uncovered control treatment and (right) plastic-covered treatment.

Table 1
The number of cuttings used for each of the treatments during the experiment in the nursery.

Branch Position	Season	Plastic Cover	No Cover (Control)	Total per Season/ Position
Basal	December	48 cuttings	48 cuttings	96 cuttings
Basal	April	48 cuttings	48 cuttings	96 cuttings
Middle	December	48 cuttings	48 cuttings	96 cuttings
Middle	April	48 cuttings	48 cuttings	96 cuttings
Total		**192**	**192**	**384**

Table 2
Treatment applied for the study and their corresponding abbreviations.

No	Experimental Treatment	Abbreviation
1	Branch cuttings with plastic cover	PC
2	Branch cuttings without plastic cover	NPC
3	Branch cuttings with manure + plastic cover	MPC
4	Branch cuttings with manure + no plastic cover	MNPC
5	Branch cuttings with no manure + plastic cover	NMPC
6	Branch cuttings with no manure + no plastic cover	NMNPC

was untied and left for one week before removal to prevent suffocation of the emerging shoots.

2.3. Data collection

In the first experiment, which assessed the effect of plastic cover across different seasons, survival data were collected weekly for three months through visual observation, based on the initiation and growth of buds. Shoot development was used as the primary indicator of cutting survival. Cuttings were considered dead if all emerging shoots had died by the time of observation. At the end of the experiment, growth parameters were recorded, including shoot height, number of shoots and root development. For root data collection, the cuttings were carefully uprooted and the roots gently separated from the growing medium. For each propagated cutting, the length of five roots were measured from different positions around the root system: One from the centre-left, one from the centre-right, one from the centre-front, one from the centre-back, and one from the central part of the root mass. The average of these five measurements was then calculated and used for comparison of root parameters among treatments. Each shoot that developed from individual buds was measured separately. A standard ruler was used for both shoot height and root length measurements.

The dry root and shoot biomasses for the second experiment were collected by uprooting each of the surviving cuttings and carefully separating the roots from the soil. The newly growing shoots were separated from the branch cuttings. The roots and shoots were allowed to dry in an oven at a temperature of 60 °C for 16 h. After drying the roots and shoots from each cutting, their biomass was measured using an electronic balance.

2.4. Data analysis

The distribution of the data was assessed for normality using the Shapiro–Wilk test. As the data did not follow a normal distribution, a square root transformation was applied to satisfy the assumptions of the model prior to conducting ANOVA. Following transformation, the data met the normality assumption, and therefore a parametric test was employed for the statistical analysis. A statistical *t*-test and one-way ANOVA were also used for the analysis to determine significant differences between treatment groups. When there were significant differences, means were separated using least significant difference (LSD) tests at $p = 0.05$ level of significance. The statistical software program SigmaPlot 13 (Systat Software, Inc., San Jose, CA, USA) was used for data analysis and for the graphs. The survival percentage of the planted branch cuttings at different periods of counting and at the end of the experiment was also analysed using the following Eq. (1)

$$SP = \left[\frac{BCS}{TPC}\right] \times 100 \tag{1}$$

where SP = Survival percentage; BCS = Planted branch cuttings that has developed a shoot; and TPC = Total number of planted branches in the treatment.

3. Results

3.1. Survival, root and shoot development

The survival rates (as indicated by shoot growth) of basal and middle branch cuttings in April and December are presented in Fig. 3. The final survival rate result (based on the observation of roots and shoots) showed that basal branch cuttings collected in December and planted with PC and NPC (control) in the nursery resulted in survival rates of 61.2 % and 26 %, respectively (Fig. 3). The survival rate (based on their shoots) of the middle branch cuttings collected in December and planted in the PC and NPC treatments were 8 % and 2 %, respectively. However, at the end of the experiment, they had not developed roots and only had shoots. Similarly, the basal branch cuttings collected in April, and planted in the PC and NPC treatments, had survival rates (having both roots and shoots) of 42 % and 4.2 %, respectively. The middle branch cuttings collected in April and planted in the PC and NPC treatments

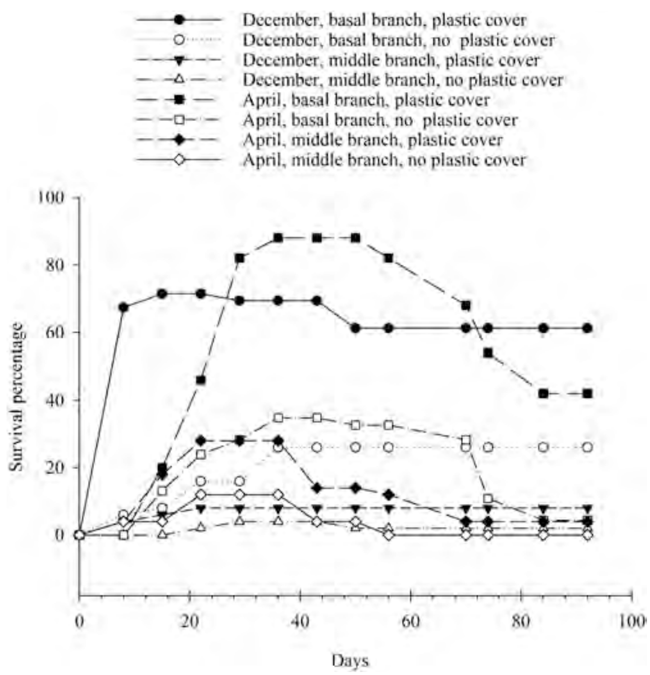

Fig. 3. The survival of basal branch cuttings and middle branch cuttings collected in December and April, evaluated over different time periods in the nursery based on shoot growth.

achieved a survival (based only shoot observation) of 4 % and 0 %, respectively. By the end of the experiment, none had developed roots.

The relative percentage of basal branch cuttings planted in the PC and NPC treatments, which were cut and planted in December and April, that developed one, two or three shoots is presented in Fig. 4. Most of the branch cuttings harvested in both December and April, and planted in the PC and NPC treatments, developed a single shoot (Fig. 4). Roots and shoots from basal branch cuttings collected in December are shown in Fig. 5. The mean shoot lengths of the December basal branch cuttings in the PC and NPC treatments were 23.5 cm and 21.3 cm, respectively (Fig. 4). There were no significant differences in the mean shoot lengths between the December branch cuttings that were planted either the PC or NPC treatments ($p = 0.54$, Fig. 6). The mean shoot lengths of the April basal branch cuttings planted in the PC and NPC treatments were 22.9 cm and 11.8 cm, respectively. The mean shoot lengths of the April basal branch cuttings planted in the two treatments were significantly different ($p = 0.04$, Fig. 6).

The mean root lengths of the basal branch cuttings planted in December in the PC and NPC treatments were 6.4 cm and 4.7 cm, respectively (Fig. 7). There were no significant differences in the mean

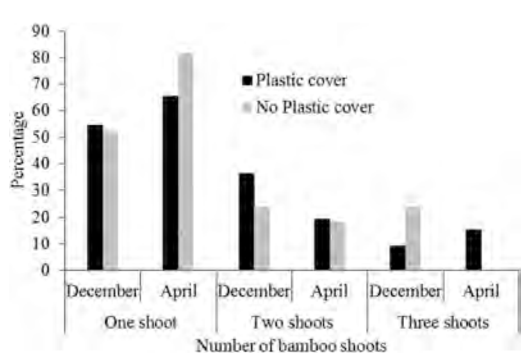

Fig. 4. The relative percentage of basal branch cuttings planted with a plastic cover (PC) and the control (NPC), which was collected in December and April and that developed one, two or three shoots by the end of the experiment.

root lengths of the basal branch cuttings planted in December in the PC and NPC treatments ($p = 0.098$, Fig. 7). The mean root lengths of the April basal branch cuttings in the PC and NPC treatments were 5.5 cm and 1 cm, respectively, with the difference being statistically significant ($p = 0.003$, Fig. 7).

3.2. *Effects of manure on the survival, growth, and biomass production of cuttings*

The mean survival percentage (evaluated by uprooting and visualizing the roots) of the basal branch cuttings in the MPC (manure and plastic cover) and NMPC (no manure, plastic cover) treatments were 37.5 % and 60 %, respectively. The mean survival percentage of the basal branch cuttings in the MNPC (manure, no plastic cover) and NMNPC (no manure, no plastic cover) treatments were 82.6 % and 76 %, respectively. Overall, the results of basal branch cuttings of *D. giganteus* in the nursery showed that the relative survival percentages were MNPC > NMNPC > NMPC > MPC. The growing shoots and roots planted in the MPC treatment are illustrated in Fig. 8.

The mean root lengths of basal branch cuttings were 36.8 cm, 28.6 cm, 32.5 cm and 36.1 cm for the MPC, NMPC, MNPC and NMNPC treatments, respectively. There were no significant differences in the mean root lengths among the different treatments (MPC, NMPC, MNPC and NMNPC) (Table 3). The mean dry root biomass of the basal branch cuttings of *D. giganteus* at the end of the experiment in the MNPC and NMPC treatments were the same, namely 2.6 g. The mean dry root biomass of the cuttings in the NMNPC treatment was 2.02 g, greater than the root biomass in the MPC treatment 1.9 g. However, the difference was not significant (Table 3, $p = 0.58$). The mean growing shoot lengths of the basal branch cuttings in the different treatments were 58.4 cm (NMPC), 51.4 cm (MNPC), 46.6 cm (NMNPC) and 44.9 cm (MPC). The differences were not significant ($p = 0.33$, Table 3). The mean dry leaf biomass for the treatments, 7.6 g (NMPC), 5.8 g (MNPC), 6.7 g (NMNPC) and 5.8 g (MPC), also showed no significant differences ($p = 0.12$, Table 3). The mean root-to-branch ratio results are presented in Fig. 9. The mean root to branch ratios in the MPC, MNPC, NMPC and NMNPC treatments were 0.29, 0.42, 0.31 and 0.27, respectively.

4. Discussion

We found that the survival rates of cuttings varied significantly depending on the season of collection, the position of the branch (basal branch cutting vs. middle branch cutting), and the use of plastic covers. Basal and mid-branch cuttings in the PC treatment achieved a relatively faster and higher percentage of shoot initiation and development compared with the control (Fig. 10). This may be associated with the temperature effect of the plastic, which could facilitate bud initiation. The survival of mid-branch cuttings harvested in both the December and April seasons was almost nil, and even those that developed smaller size shoots did not develop roots. This result for mid-branch cuttings contrasts with the findings of El-Keltawi and Abdel Rahman (2010) who found that the mid-branch cuttings in their study achieved a 40.3 % rooting ability. This difference may be associated with the growth hormone treatment: El-Keltawi and Abdel Rahman (2010) applied indole-3-butyric acid (IBA). Their experiment was also undertaken in a greenhouse, whereas our study was undertaken in an open nursery without any growth hormone treatments. Our results for the rooting of mid-branch cuttings corresponds with those of Kaushal et al. (2011), who found that even with the IBA treatment, *D. giganteus* mid-branch cuttings failed to produce roots. Pacris et al. (2024) found the survival of branch cuttings of *D. giganteus* grown in a nursery to be about 82.2–88.9 % when treated with Alpha Naphthalene Acetic Acid (ANAA), Gibberellic Acid (GA3) and Indole Acetic Acid (Auxin) after three months. This is higher than we found. The variation in the propagation success of *D. giganteus* in different studies may be associated with differences in the ages of the bamboo culms. Hamalton et al. (2022) found

Fig. 5. Propagated basal branch cuttings of *D. giganteus* in the nursery (left), developed roots and shoots (middle), and root systems of the propagated branch cuttings (right).

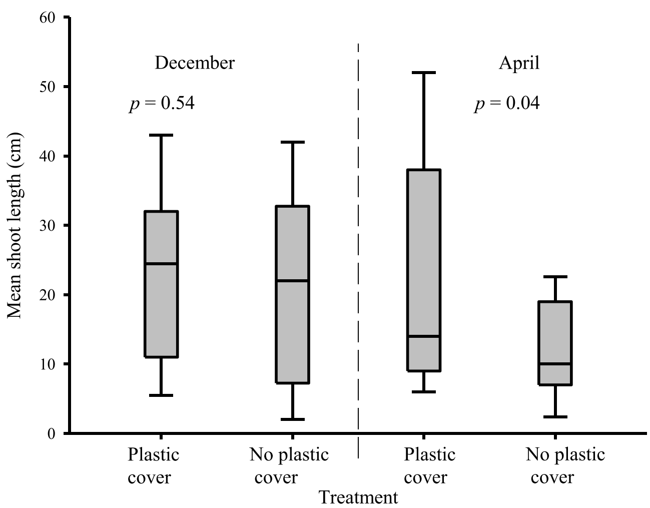

Fig. 6. Mean shoot lengths of the basal branches of *D. giganteus* planted in December and April with a plastic cover and without (the control) (PC and NPC treatments, respectively).

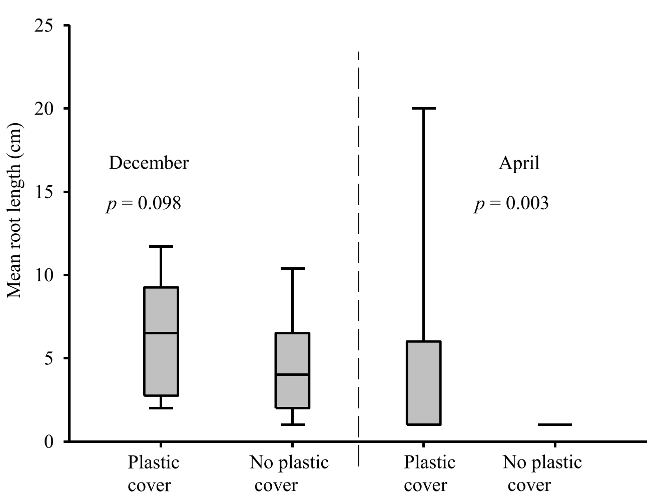

Fig. 7. Mean root lengths of the basal branch cuttings collected in December and April and planted in the PC and NPC treatments.

that 1–5-year-old culms were better source for the propagation of many species.

We found that the timing of the cuttings (December vs. April) was important, with basal branch cuttings harvested in December having a better survival percentage than those harvested in April. This was consistent in both the PC and NPC treatments. Many similar studies have found significant differences in the mean survival percentage of bamboo culm cuttings and branch cuttings taken at different seasons (Razvi et al., 2015; Gulabrao et al., 2012; Kaushal et al., 2011). Such differences in rooting ability may be associated with variations in the amount of carbohydrates and soil moisture, which may help in the regeneration of bamboo from cuttings. Zhan et al. (2022), working in the sub-tropical highlands of Kunming, China, considered that given the moisture, soluble sugar, starch and total non-structural carbohydrates (NSC) contents found in various bamboos, monopodial bamboo should be harvested in the cool dry season (e.g., January locally) for high production and future growth, and sympodial bamboo in the post rainy season (e.g., November locally). These seasonal based recommendations by Zhan et al. (2022) are specific to the climatic conditions of the sub-tropical highlands. In contrast, Ray and Ali (2017), working largely in monsoon regions such as India, showed that wet growing seasons are generally the best season for propagating many bamboo species due to higher carbohydrate availability and favourable climatic conditions. This shows that optimal times for bamboo propagation in different countries depend on local agro-climatic conditions.

The present study demonstrates that basal branch cuttings of *D. giganteus* can achieve a high rooting success rate (82.6 %) when grown in a substrate supplemented with manure, as confirmed by uprooting and visual inspection at the end of the trial. This result is comparable and even relatively higher than other similar studies that utilised growth hormones, suggesting that organic amendments such as manure can be a viable alternative to synthetic growth regulators. For instance, El-Keltawi and Abdel Rahman (2010) reported rooting rates of only 42.3–57.5 % with hormone-treated cuttings, while Bayani-Hardy and Reondres-Ermitanio (2022), Singh et al. (2016) (using *Dendrocalamus asper* (Schult. & Schult.f.) Backer), Kalanzi and Mwanja (2023) (using *D. giganteus*), Kaushal et al. (2011) (using *D. giganteus*) and Gulabrao et al. (2012) all relied on hormonal treatments to enhance rooting, but achieved a rooting success of less than 70 %. The relatively higher survival rate achieved with manure supplementation (82.6 %) points to an alternative option to facilitate the propagation of *D. giganteus* from branch cuttings when synthetic growth hormones are not available. The results indicate that manure application significantly increased the root-to-shoot ratio (RSR) in *D. giganteus* basal branch cuttings. The highest RSR value (0.42) was recorded in the basal branch cuttings in the MNPC treatment. This suggests that while manure can promote root development, a plastic covering over the branch cuttings (for humidity control) may not directly improve root growth and could even slightly reduce RSR (0.29 for MPC treatments relative to the MNPC.

Fig. 8. Basal branch cuttings of *D. giganteus* propagated with manure supplementation and a plastic cover (MPC) in the nursery (left), and their roots (right).

Table 3
The one-way ANOVA analysis result on the mean dry root biomass, mean shoot biomass, mean root length, and mean branch length under different treatments: manure with plastic cover (MPC), manure without plastic cover (MNMPC), no manure with plastic cover (NMPC), and no manure without plastic cover (NMNPC).

Parts of Seedlings	Manure + Plastic cover (MPC)	Manure + no Plastic cover (MNPC)	No Manure + Plastic cover (NMPC)	No manure + no Plastic cover (NMNPC)	*p*-value
Mean dry root biomass (gram)	1.9 (0.4)^{A}	2.643 (0.4)^{A}	2.61 (0.4)^{A}	2.02 (0.2)^{A}	0.38
Mean root length (cm)	36.8 (3.4)^{A}	32.5 (2.1)^{A}	28.6 (2.8)^{A}	36.1 (1.8)^{A}	0.09
Mean shoot biomass (gram)	5.8 (0.8)^{A}	6.2 (0.7)^{A}	7.6 (0.9)^{A}	6.7 (0.6)^{A}	0.47
Mean branch length (cm)	44.9 (3.4)^{A}	51.4 (3.8)^{A}	58.4 (6.2)^{A}	46.6 (2.6)^{A}	0.34

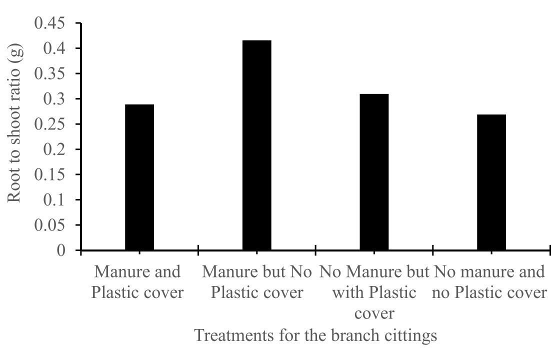

Fig. 9. The mean root to shoot (leaf and branch) biomass of *D. giganteus*.

The lower RSR in the NMPC (0.31), NMNPC (0.27) may indicate that nutrient availability is more important than plastic covering of the branch cuttings. The marginal benefit that we found for plastic alone (NMPC vs. NMNPC) may imply that a basal branch covering may aid survival indirectly by regulating the temperature but does not substitute for soil fertility. This may show that for *D. giganteus*, manure should be prioritised, while plastic covers used during the propagation of basal branch cuttings could support their survival.

Fig. 10. Successful propagation of basal branch cuttings of *D. giganteus* in the nursery.

5. Conclusions

We have demonstrated that *D. giganteus* basal branch cuttings exhibited relatively higher survival and rooting success when harvested in December (61.2 %) compared to April (42 %), and grown with a plastic cover (PC). The mid-branch cuttings performed poorly and only a few developed some small shoots and none developed roots. The treatment involving manure supplementation but no plastic cover (MNPC) had the highest survival rate (82.6 %), suggesting that organic amendments may be more effective than plastic covers alone in the propagation of *D. giganteus* from basal branch cuttings. Our findings illustrate the importance harvesting timing, branch cutting position, plastic covering of the branches during propagation and organic amendments in *D. giganteus*. They indicate that the possibility exists to propagate the species without applying the synthetic growth hormones that many rural people have difficulties accessing.

CRediT authorship contribution statement

Firew Tadesse: Writing – review & editing, Visualization, Validation, Data curation. **Shiferaw Alem:** Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Formal analysis, Conceptualization. **Hana Habrova:** Writing – review & editing, Validation, Supervision, Project administration, Funding acquisition.

Funding

This research was funded by Mendel University in Brno with contributions from the Czech Development Agency; Grant Number CzDA-ET-2023-053-DO-31120.

Declaration of Competing Interest

The authors declare no conflict of interest.

Acknowledgement

We gratefully acknowledge the support of all those who contributed to this research. Special thanks to Tesfaye Hankamo for his assistance with data collection, and to Wosenu Shewa for his help in preparing the culm cuttings.

Data availability

Data will be made available on request.

References

Abdul Khalil, H.P.S., Bhat, A.H.S., Jawaid, M., Zaidon, A., Hermawan, D., Hadi, Y.S., 2012. Bamboo fibre reinforced biocomposites: a review. Mater. Des. 42, 353–368. https://doi.org/10.1016/j.matdes.2012.06.015.

de Alwis, W.N.H., Ranasinghe, D.M.S.H.K., 2012. Vegetative propagation of *Dendrocalamus asper*, *D. giganteus* and *Bambusa vulgaris* by vegetative propagation. Proceedings of the 17th International Forestry and Environment Symposium. 2012, of the Department of Forestry and Environmental Science, University of Sri Jayewardenepura, Sri Lanka, p. 70.

Banik, R.L., 1995. A Manual for Vegetative Propagation of Bamboos. International Network for Bamboo and Rattan, New Delhi, India.

Bayani-Hardy, G., Reondres-Ermitanio, M., 2022. Survivability of three bamboo species (Giant bamboo- *Dendrocalamus giganteus*, Machiku bamboo- *Dendrocalamus latiflorus* and Spiny bamboo- *Bambusa blumeana*) as influence by the number of nodes. J. Biodivers. Environ. Sci. 21, 112–117.

Canavan, S., Richardson, D.M., Visser, V., Le Roux, J.J., Vorontsova, M.S., Wilson, J.R.U., 2017. The global distribution of bamboos: assessing correlates of introduction and invasion. AoB Plants 9, plw078. https://doi.org/10.1093/aobpla/plw078.

El-Keltawi, N.E.M., Abdel Rahman, S.S.A., 2010. Propagation of bamboo (*Dendrocalamus giganteus* Munro) through culm-branch cuttings in Egypt. Assiut J. Agric. Sci. 41 (1), 1–22. https://doi.org/10.21608/ajas.2010.267818.

FAO, 2007. World Bamboo Resources: A Thematic Study Prepared in the Framework of the Global Forest Resources Assessment 2005. FAO Forestry Paper 147. Food and Agriculture Organization, Rome, Italy.

Gebrehiwot, K., Teklay, W., Emiru, B., Sarah, T.B., 2016. Propagation potential of the lowland bamboo through seed and culm cuttings. J. Drylands 6, 513–518.

Gulabrao, Y.A., Kaushal, R., Tewari, S.K., Tomar, J.M.S., Chaturvedi, O.P., 2012. Seasonal effect on rooting behaviour of important bamboo species by culm cuttings. J. For. Res. 23, 441–445. https://doi.org/10.1007/s11676-012-0282-0.

Hamalton, T., Khannam, A., Bhuvaneshwari, M., Chandrakala, D., 2022. Vegetative propagation techniques for bamboo species: a review. Int. J. Agric. Environ. Biotechnol. 15, 101–107. https://doi.org/10.30954/0974-1712.01.2022.13.

Kalanzi, F., Mwanja, C.K., 2023. Effect of nodal cutting position and plant growth regulator on bud sprouting of *Dendrocalamus giganteus* Wall. ex Munro in Uganda. Adv. Bamboo Sci. 2, e100016. https://doi.org/10.1016/j.bamboo.2023.100016.

Kaushal, R., Gulabrao, Y.A., Tewari, S.K., Chaturvedi, S., Banik, R.L., 2011. Clonal propagation of important bamboo species through branch cuttings. Indian J. For. 34, 29–34. https://doi.org/10.54207/bsmps1000-2011-N6EN6N.

Lobovikov, M., Paudel, S., Piazza, M., Ren, H., Wu, J., 2007. World Bamboo Resources: A Thematic Study. FAO Forestry Paper 147. Food and Agriculture Organization, Rome, Italy.

Lou, Y., 2007. Comprehensive benefits of bamboo forests. In: Jiang, Z., Peng, Z. (Eds.), Bamboo and Rattan in the World. China Forestry Publishing House, Beijing, China.

Meredith, T.J., 2001. Bamboo for Gardens. Timber Press, Portland, USA.

Musau, Z., 2016. Bamboo: Africa's untapped potential. Afr. Renew. 30 (1), 22–25. https://doi.org/10.18356/d3c16c7c-en.

Ntirugulirwa, B., Asiimwe, T., Gapusi, J., Mutaganda, A., Nkuba, G., Ruzindana, A.N., Ntabana, D., Barnabé, B., Kahia, J., Gahakwa, D., 2013. Influence of bud position on mother stem and soaking duration on sprouting of bamboo cuttings. Rwanda J. 28, 3–10. https://doi.org/10.4314/rj.v28i1.1.

Ohrnberger, D., 1999. The Bamboos of the World: Annotated Nomenclature and Literature. Elsevier, Amsterdam, The Netherlands.

Pacris Jr., F.A., Asuncion, J.L., Baloloy, M.V., Ermitanio, M.R., 2024. The effect of different rooting hormones on the survival of three bamboo species of bamboo species giant bamboo-*Dendrocalamus giganteus*, machiku-*Dendrocalamus latiflorus*, and spiny bamboo-*Bambusa blumeana*. J. Biodivers. Environ. Sci. 25, 35–41.

Phillips, S., 1995. Poaceae (Gramineae). In: Phillips, S., Hedberg, I., Edwards, S. (Eds.), Flora of Ethiopia and Eritrea, vol. 7, Poaceae (Gramineae). Uppsala University, Uppsala.

Ramanayake, S.M.S.D., Yakandawala, K., 1998. Incidence of flowering, death and phenology of development in the giant bamboo (*Dendrocalamus giganteus* Wall. ex Munro). Ann. Bot. 82, 779–785. https://doi.org/10.1006/anbo.1998.0754.

Razvi, S., Bakshi, M., Nautiyal, S., Hakeem, K.R., 2015. Seasonal variation on rooting response of branch cuttings of *Dendrocalamus giganteus* Wallich ex Munro. J. Bamboo Ratt. 14, 11–25.

Ray, S.S., Ali, M.N., 2017. Factors affecting macropropagation of bamboo with special reference to culm cuttings: a review update. N. Z. J. For. Sci. 47, e17. https://doi.org/10.1186/s40490-017-0097-z.

Satapathy, G.K., Mohanty, T.L., Behera, M.C., Kar, R.K., 2020. Effect of age, position and type of cuttings on the performance of vegetative propagules in *Bambusa vulgaris* var. *Striata*. J. Pharmacogn. Phytochem. 9, 515–519.

Scurlock, J.M.O., Dayton, D.C., Hames, B., 2000. Bamboo: an overlooked biomass resource? Biomass Bioenergy 19 (4), 229–244. https://doi.org/10.1016/S0961-9534(00)00038-6.

Seethalakshmi, K.K., Jijeesh, C.M., Raveendran, V.P., 2008. Seed and seedling attributes of *Melocanna baccifera* and *Ochlandra travancorica*. J. Bamboo Ratt. 7, 101–108.

Singh, A.K., Gangopadhyay, S., Gupta, N., Roy, R.K., 2016. Nursery techniques in bamboo. Indian For. 142, 901–906.

Sreejith, M.M., Chichaghare, A.R., 2022. Macropropagation techniques in bamboos: a review. Agric. Rev. 46 (1), 102–108. https://doi.org/10.18805/Ag.R-2514.

Zhan, H., He, W., Li, M., Yu, L., Li, J., Wang, C., Wang, S., 2022. The dynamics of non-structural carbohydrates in different types of bamboo in response to their phenological variations: Implications for managing bamboo plantations. Forests 13, e1218. https://doi.org/10.3390/f13081218.