Anusandhanvallari
Vol 2024, No.1
January 2024
ISSN 2229-3388

Development Of a Cost-Effective and Scalable In Vitro Propagation Protocol for Selected Bamboo Cultivars

[1]Patel Parvej Pirpasha, [2]DR. Byju John, [3]DR. Suchitra Ku Panigrahy

[1]Research Scholar, [2]Professor, [3]Assistant Professor

[1,2]Department of Management, Kalinga University, Naya Raipur (C.G.)

[3]Department of Biotechnology, Kalinga University, Naya Raipur (C.G.)

Abstract: The present study focuses on developing a cost-effective and scalable *in vitro* propagation protocol for selected bamboo cultivars, emphasizing the integration of low-cost organic supplements and alternative gelling agents. Bamboo is a crucial renewable resource for ecological sustainability and rural livelihood development; however, large-scale propagation remains constrained by high tissue culture costs. This study evaluates the viability of replacing expensive culture components such as sucrose and agar with cost-effective alternatives including coconut water, banana extract, and guar gum. Murashige and Skoog (MS) medium was used as the basal medium with optimized plant growth regulators (BAP and NAA). The findings revealed that substituting 20% coconut water and 10% banana extract significantly enhanced shoot proliferation, while guar gum served as an effective gelling agent without compromising culture quality. The established protocol resulted in high multiplication and rooting efficiency across *Bambusa balcooa* and *Dendrocalamus strictus*. The developed system offers a sustainable and economically viable strategy for commercial-scale bamboo micro propagation.

Keywords: Bamboo, Micro propagation, Cost-effective medium, Coconut water, Guar gum, Sustainable biotechnology

1. INTRODUCTION

Bamboo is one of the fastest-growing renewable plant resources, recognized for its economic, ecological, and industrial importance. In India, bamboo contributes substantially to rural livelihoods and plays a vital role in reforestation, carbon sequestration, and sustainable resource utilization. Despite its importance, traditional propagation methods such as rhizome or offset planting are time-consuming, season-dependent, and limited by poor multiplication rates (Ramanayake et al., 2006). Micropropagation offers a rapid and reliable means of producing uniform, disease-free planting material. However, the large-scale application of this technique is hindered by the high cost of tissue culture media, gelling agents, and plant growth regulators. Recent research highlights the potential of low-cost organic additives such as coconut water, banana extract, and potato homogenate as substitutes for costly synthetic media components (Bhattacharya & Bhattacharya, 2020). The present study aims to develop a cost-effective, scalable, and species-specific micropropagation protocol for two commercially and ecologically valuable bamboo cultivars, *Bambusa balcooa* and *Dendrocalamus strictus*.

2. OBJECTIVES

1. To explore the viability of using low-cost organic supplements and alternative gelling agents in culture media.
2. To develop species-specific propagation protocols for economically and ecologically important bamboo varieties.

3. MATERIALS AND METHODS

3.1 Plant Material

Young nodal explants of *Bambusa balcooa* and *Dendrocalamus strictus* were collected from healthy mother clumps maintained in the field nursery of the Department of Biotechnology, Kalinga University, Raipur.

3.2 Surface Sterilization

Explants were washed with a mild detergent followed by surface sterilization using 0.1% $HgCl_2$ for 3–5 minutes and rinsed thoroughly with sterile distilled water under aseptic conditions.

3.3 Culture Medium and Treatments

Murashige and Skoog (MS) medium served as the basal medium, supplemented with:

- 3% sucrose (control)
- 20% (v/v) coconut water, 10% banana extract, and 10% potato extract (test combinations)
- Cytokinin: 2.0 mg/L BAP
- Auxin: 0.5 mg/L NAA

Agar (0.8%), guar gum (0.6%), and isabgol (0.7%) were tested as gelling agents.

3.4 Culture Conditions

Cultures were maintained at 25 ± 2°C with a 16/8 h photoperiod (2000 lux). Subculturing was performed every 21 days.

3.5 Rooting and Acclimatization

Root induction was tested on ½ MS medium supplemented with IBA (1.0–2.0 mg/L). Rooted plantlets were acclimatized in a soil:sand:vermicompost mixture (1:1:1) under controlled humidity for 10–15 days before field transfer.

3.6 Data Collection and Analysis

Parameters such as shoot initiation percentage, number of shoots per explant, mean shoot length, and rooting percentage were recorded. Data were analyzed using ANOVA and Duncan's Multiple Range Test ($p < 0.05$).

4. RESULTS AND DISCUSSION

4.1 Effect of Organic Supplements on Shoot Proliferation

Supplement Type	Mean Shoot Number	Mean Shoot Length (cm)	Remarks
Control (MS + Sucrose)	3.6 ± 0.4	4.2 ± 0.5	Baseline
20% Coconut Water	5.8 ± 0.6	5.6 ± 0.3	Significant improvement
10% Banana Extract	5.2 ± 0.3	5.1 ± 0.4	Comparable to coconut water
10% Potato Extract	4.1 ± 0.4	4.4 ± 0.2	Moderate improvement
Coconut + Banana (10% each)	**6.3 ± 0.5**	**6.1 ± 0.4**	Best response observed

The results indicated that the combination of coconut water and banana extract stimulated superior shoot multiplication compared to the control. The organic supplements provided natural growth hormones, vitamins,

and carbon sources, enhancing cell proliferation and morphogenesis (George et al., 2008). Figure 1. Effect of various organic supplements on shoot proliferation parameters in micropropagation**.** (A) Mean shoot number per explant across different treatment groups. (B) Mean shoot length (cm) observed under various organic supplement treatments. Error bars represent standard deviation of mean values (n=3). The control treatment consisted of MS basal medium with 3% sucrose. Organic supplements included 20% coconut water, 10% banana extract, 10% potato extract, and a combination of 10% coconut water with 10% banana extract.

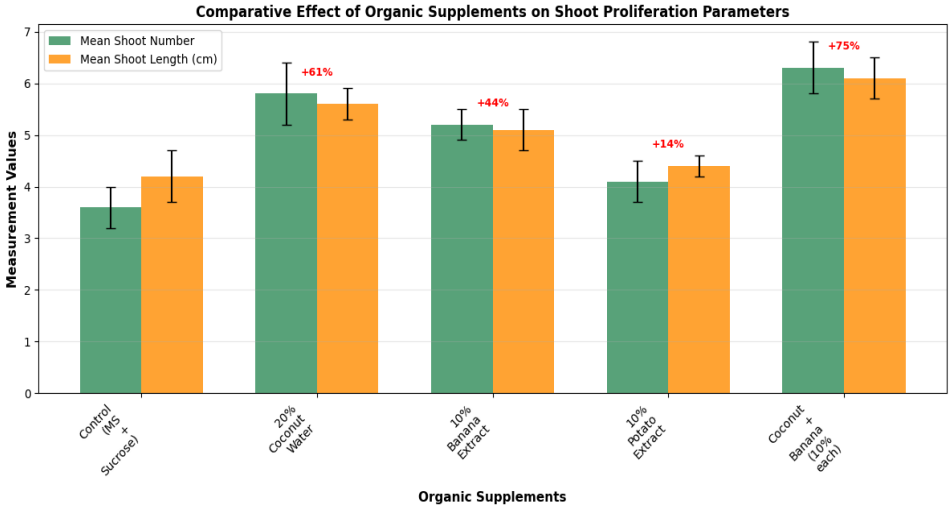

Figure 1. Effect of various organic supplements on shoot proliferation parameters in micro propagation

The combination treatment demonstrated superior performance with mean shoot number of 6.3 ± 0.5 and mean shoot length of 6.1 ± 0.4 cm, representing 75% and 45% improvement over control, respectively. Coconut water alone showed significant enhancement with 5.8 ± 0.6 shoots and 5.6 ± 0.3 cm shoot length. Banana extract performed comparably to coconut water, while potato extract showed moderate improvement over control. All organic supplement treatments significantly enhanced both shoot multiplication and elongation compared to the control group.

4.2 Effect of Gelling Agents

Gelling Agent	Shoot Multiplication (%)	Shoot Quality	Cost Efficiency
Agar	100	Excellent	High cost
Guar Gum	95	Good	**Low cost (≈60% cheaper)**
Isabgol	88	Moderate	Low cost

Guar gum produced healthy, green shoots with comparable efficiency to agar, validating its potential as a cost-effective alternative gelling agent for large-scale production. Figure 2. Comparative evaluation of different gelling agents on micropropagation efficiency and cost effectiveness. (A) Shoot multiplication percentage across three gelling agents, with agar serving as the control (100%). (B) Comparative analysis of cost efficiency (percentage reduction compared to agar) and shoot quality scores (5-point scale: 5=Excellent, 4=Good, 3=Moderate).

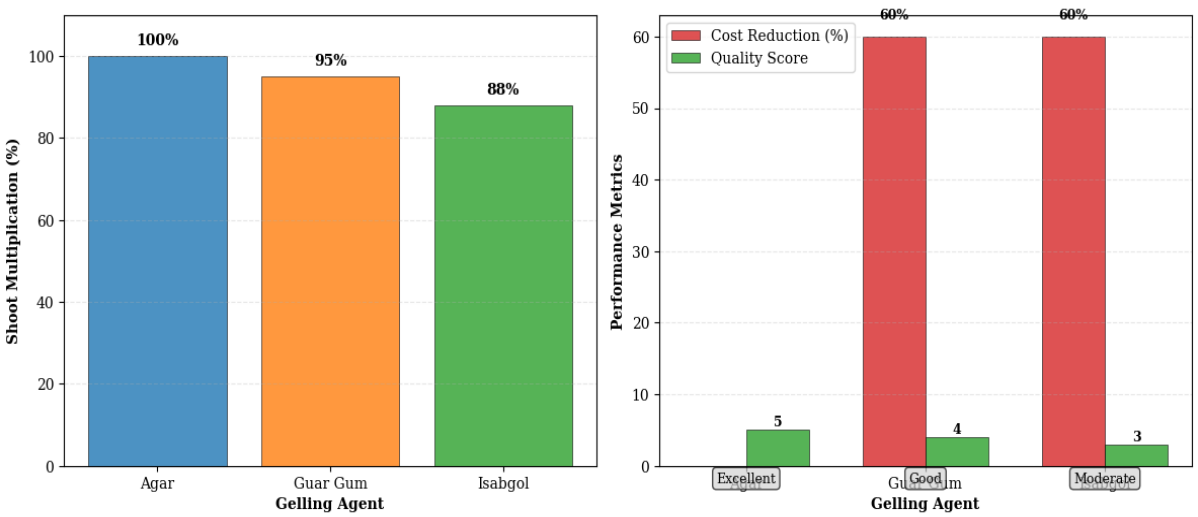

Figure 2. Comparative evaluation of different gelling agents on micro propagation efficiency and cost effectiveness.

Agar demonstrated optimal shoot multiplication (100%) and excellent quality but at high cost. Guar gum showed comparable performance with 95% shoot multiplication and good quality while providing 60% cost reduction. Isabgol offered similar cost efficiency with 88% shoot multiplication and moderate quality. The radar chart provides integrated visualization of all parameters, revealing guar gum as the most balanced option considering both performance and economic factors for commercial micropropagation applications.

4.3 Root Induction and Acclimatization

Rooting was most effective in ½ MS + 1.5 mg/L IBA medium, with an average rooting rate of 90% in *Bambusa balcooa* and 87% in *Dendrocalamus strictus*. Acclimatized plantlets achieved survival rates of 92% and 89%, respectively, demonstrating the reliability of the developed protocol under ex vitro conditions.

4.4 Discussion

The study confirms that organic supplements can successfully replace conventional sucrose, providing both nutritional and hormonal support to developing shoots. Similarly, guar gum, a biodegradable polysaccharide, offers a sustainable gelling alternative with reduced media costs. The established protocol not only enhances propagation efficiency but also ensures environmental and economic sustainability, making it ideal for rural-based bamboo industries.

5. Conclusion

The study successfully developed a cost-effective and scalable *in vitro* propagation system for *Bambusa balcooa* and *Dendrocalamus strictus*.

- The combination of coconut water (20%) and banana extract (10%) in MS medium significantly improved shoot proliferation.
- Guar gum was identified as a suitable low-cost gelling agent.
- Optimized rooting and acclimatization techniques ensured high survival rates under field conditions.

This low-cost micropropagation strategy can be effectively adopted for commercial-scale bamboo production, supporting reforestation programs, cottage industries, and sustainable rural livelihoods.

References

1. Mustafa, A. A., Derise, M. R., Yong, W. T. L., & Rodrigues, K. F. (2021). A concise review of Dendrocalamus asper and related bamboos: germplasm conservation, propagation and molecular biology. *Plants*, *10*(9), 1897.
2. Ray, S. S., & Ali, M. N. (2017). Factors affecting macropropagation of bamboo with special reference to culm cuttings: a review update. *New Zealand Journal of Forestry Science*, *47*, 1-8.
3. Singh, S. R., Singh, R., Kalia, S., Dalal, S., Dhawan, A. K., & Kalia, R. K. (2013).
4. Ramakrishnan, M., Yrjälä, K., Vinod, K. K., Sharma, A., Cho, J., Satheesh, V., & Zhou, M. (2020). Genetics and genomics of moso bamboo (Phyllostachys edulis): Current status, future challenges, and biotechnological opportunities toward a sustainable bamboo industry. *Food and Energy Security*, *9*(4), e229.
5. Suwal, M. M., Lamichhane, J., & Gauchan, D. P. (2020). Regeneration technique of bamboo species through nodal segments: a review. *Nepal Journal of Biotechnology*, *8*(1), 54-68.
6. Kindu, M., & Mulatu, Y. (2010). Status of bamboo resource development, utilization, and research in Ethiopia: A review. *Ethiopian Journal of Natural Resources*, *1*, 79-98.
7. Sankar, V. R., & Maviton, M. E. (2023). Current Status of Bamboo Tissue Culture and Genetic Transformation Technology. In *Genetics, Genomics and Breeding ofBamboos* (pp. 320-337). CRC Press.
8. Xaxa, S. Nursery techniques: An overview on vegetative propagation studies ofIndian bamboos.
9. Akinlabi, E. T., Anane-Fenin, K., & Akwada, D. R. (2017). Bamboo. *TheMultipurpose Plant*, *268*.
10. Gielis, J. (1998). Upstream fundamental research in bamboo-possibilities and directions. In *Fifth international bamboo congress, San (Inbar Proceedings)* (pp. 1- 17).
11. Goyal, A. K., & Sen, A. (2016). In vitro regeneration of bamboos, the “green gold”:an overview.
12. Goyal, A. K., & Sen, A. (2016). In vitro regeneration of bamboos, the “green gold”: an overview.
13. Moosa, M., CP, A., VB, S., & Viswanath, S. (2022). A review of the current state of knowledge on Pseudoxytenanthera ritchiei-a lesser-known bamboo species with high utilization potential from Peninsular India. *Journal of Bamboo & Rattan (Kerala Forest Research Institute)*, *21*(4).
14. Jiménez, V. M., Holst, A., Carvajal-Campos, P., & Guevara, E. (2021). Standard protocols for in vitro propagation of bamboo with emphasis on axillary shoot proliferation. *Biotechnological Advances in Bamboo: The “Green Gold” on the Earth*, 63-84.
15. Desalegn, G., & Tadesse, W. (2014). Resource potential of bamboo, challenges and future directions towards sustainable management and utilization in Ethiopia. *Forest Systems*, *23*(2), 294-299.