Journal of Plant Biota

Review Article: 23 to 26
ISSN: 3048-4863
https://plant.researchfloor.org/

Plant Tissue Culture: Advancing Quality Material Production through Micro propagation, with Emphasis on Banana Cultivation

Sandeep Rout[1], Bharti Gupta[2], S. Kanaka[3*], A Purna Chandra Rao[4], P. Naganjaneyulu[4]

[1]*Faculty of Agriculture, Sri Sri University, Cuttack, Odisha, 754006, India*
[2]*Maharishi University of Information Technology, Dubagga, Lucknow (Uttar Pradesh) India*
[3]*Agrl. Economist, TNIAMP, MDPU, Chennai 5, India*
[4]*Qis College of engineering and technology Ongole, (Jawaharlal Nehru Technological University Kakinada, Kakinada), India*

Abstract

Plant tissue culture has emerged as a crucial technique in modern agriculture, particularly in the realm of micropropagation. This method offers a multitude of advantages, including the rapid production of disease-free and genetically uniform plant material. In the context of banana cultivation, tissue culture techniques have revolutionized the production of high-quality planting material, addressing various challenges faced by traditional propagation methods. This article explores the advancements in plant tissue culture, focusing on its application in banana cultivation. It examines the process of micropropagation, highlighting its role in enhancing the quality and quantity of banana yields. Additionally, the article discusses the significance of genetic uniformity and disease resistance in banana cultivation, both of which are facilitated by tissue culture techniques. Furthermore, it delves into the optimization of culture media and environmental conditions to maximize the efficiency of micropropagation. Through a comprehensive analysis of current research and practices, this article aims to provide insights into the role of plant tissue culture in advancing quality material production in banana cultivation.

Keywords: *Plant Tissue Culture, Micropropagation, Banana Cultivation, Disease Resistance, Genetic Uniformity, Sustainability*

Introduction

Bananas are among the most important fruit crops globally, providing vital nutrition and economic sustenance to millions of people. However, traditional methods of banana propagation, such as seed germination and sucker transplantation, often face limitations in terms of uniformity, disease resistance, and genetic variability. Plant tissue culture offers a promising alternative by allowing the rapid multiplication of disease-free, genetically uniform plantlets in a controlled environment [1].

The cultivation of bananas (*Musa* spp.) stands as one of the most vital sectors in global agriculture, contributing significantly to food security and economic development in various regions around the world. Bananas are not only a staple food for millions but also a crucial export commodity for many tropical countries. However, the traditional methods of banana propagation, primarily through suckers or seeds, are often plagued by challenges such as susceptibility to diseases, slow multiplication rates, and genetic variability among offspring. In recent decades, the application of plant tissue culture techniques has revolutionized banana cultivation by offering a reliable and efficient method for the mass production of high-quality planting material [2]. Plant tissue culture, commonly known as micropropagation, involves the aseptic culture of plant cells, tissues, or organs under controlled environmental conditions to produce clones of the parent plant. This technique has emerged as a cornerstone of modern agriculture, enabling the rapid multiplication of elite banana varieties while maintaining their genetic purity and vigor.

The adoption of tissue culture methods in banana propagation has ushered in a new era of productivity and sustainability in the banana industry. By bypassing the limitations of traditional propagation methods, tissue culture allows for the production of disease-free planting material, thereby mitigating the risk of devastating diseases such as Panama disease (Fusarium wilt) and Banana Bunchy Top Virus (BBTV) [3]. Moreover, tissue culture offers a solution to the challenge of genetic variability, ensuring uniformity and consistency in plant traits and fruit quality, the advancements in plant tissue culture techniques with a specific focus on their application in banana cultivation [4]. We delve into the principles of micro propagation and elucidate its role in enhancing the quality and quantity of banana yields. Furthermore, we examine the importance of genetic uniformity and disease resistance in banana cultivation and discuss how tissue culture methods contribute to achieving these objectives. Additionally, we explore the optimization of culture media formulations and environmental conditions to maximize the efficiency of micro propagation and ensure the successful establishment of tissue-cultured banana plants in the field.

Through a comprehensive review of current research findings and practical applications, this article aims to elucidate the significance of plant tissue culture in advancing the production of quality planting material for banana cultivation [5]. By understanding the principles and techniques involved in micro

28 February 2022: Received | 18 May 2022: Revised | 21 June 2022: Accepted | 17 June 2022: Available Online

Citation: Sandeep Rout, Bharti Gupta, S. Kanaka, A Purna Chandra Rao, P. Naganjaneyulu (2022). Plant Tissue Culture: Advancing Quality Material Production through Micro propagation, with Emphasis on Banana Cultivation. *Journal of Plant Biota.* **DOI: https://doi.org/10.51470/JPB.2022.1.1.23**

S. Kanaka | kanaka.s@tnau.ac.in

propagation, banana growers and researchers can harness the full potential of tissue culture to sustainably meet the growing demand for bananas while overcoming the challenges posed by pests, diseases, and environmental constraints [19-21].

Principles of Plant Tissue Culture

Plant tissue culture involves the aseptic culture of plant cells, tissues, or organs in a nutrient-rich medium supplemented with hormones and other growth regulators. The process typically consists of several stages, including explant preparation, sterilization, initiation, multiplication, rooting, and acclimatization. By carefully manipulating growth conditions and hormone concentrations, researchers can stimulate cell division, elongation, and differentiation, leading to the formation of whole plants from small tissue explants. Plant tissue culture is a sophisticated technique that involves the aseptic culture of plant cells, tissues, or organs in a controlled environment to produce clones of the parent plant. This method is based on the principles of totipotency, which suggest that every plant cell has the potential to regenerate into a whole plant under appropriate conditions [6].

The process of plant tissue culture typically involves several key steps.

1. Initiation: The process begins with the selection of suitable explant tissues, which can vary depending on the plant species and the desired objectives of the tissue culture. Explants may include shoot tips, leaf sections, stem segments, or embryo tissues. These explants are carefully excised from healthy donor plants and surface-sterilized to remove any contaminants [18].

2. Sterilization: Surface sterilization is a critical step in plant tissue culture to eliminate microbial contaminants that could jeopardize the success of the culture. Explants are typically treated with a combination of disinfectants such as bleach or alcohol, followed by rinsing with sterile water to remove residual sterilizing agents [17].

3. Establishment: Sterilized explants are then placed onto a nutrient-rich culture medium containing a precise combination of minerals, vitamins, sugars, and growth regulators. The composition of the culture medium can be tailored to promote the growth and development of specific tissues. Hormones such as auxins and cytokinins are often added to stimulate cell division and differentiation [16].

4. Multiplication: Once the explants are established on the culture medium, they undergo rapid cell division and proliferation, leading to the formation of callus tissue or adventitious shoots. These proliferating tissues can be sub-cultured onto fresh media to amplify the number of clones produced. Through successive rounds of sub-culturing, large quantities of identical plantlets can be generated from a single explant [15].

5. Rooting: In many cases, the regenerated shoots require induction of root formation to facilitate their acclimatization to soil after transplantation. Rooting hormones such as auxins are typically added to the culture medium to stimulate the development of roots on the regenerated shoots [14].

6. Acclimatization: Once roots have developed, the plantlets are transferred to soil or a suitable growing substrate in a controlled environment to acclimatize them to natural growing conditions. Gradual adjustment to ambient humidity, light intensity, and temperature helps minimize transplant shock and ensure the survival of tissue-cultured plants in the field [13].

The success of plant tissue culture depends on several factors, including the genetic characteristics of the donor plant, the choice of explant tissue, the formulation of the culture medium, and the maintenance of sterile conditions throughout the process [7]. Advances in tissue culture techniques have enabled the propagation of a wide range of plant species, including agronomically important crops, ornamental plants, and endangered species, for various purposes such as commercial production, genetic conservation, and research. By harnessing the principles of plant tissue culture, researchers and growers can achieve rapid and efficient multiplication of elite plant varieties while maintaining their genetic purity and integrity.

Advantages of Micro propagation in Banana Cultivation

Micro propagation offers several advantages in banana cultivation, revolutionizing traditional propagation methods. Firstly, it enables the rapid multiplication of elite banana varieties, ensuring a consistent supply of high-quality planting material. Secondly, micro propagation facilitates the production of disease-free banana plants, reducing the risk of devastating pathogens such as Fusarium wilt and Banana Bunchy Top Virus [8;12]. Additionally, micro propagated banana plants exhibit genetic uniformity, ensuring consistent growth and fruiting characteristics across the plantation. Furthermore, micro propagation allows for year-round production regardless of seasonal limitations, contributing to increased productivity and profitability for banana growers. Overall, the adoption of micro propagation techniques in banana cultivation enhances efficiency, sustainability, and resilience in the face of environmental and disease challenges.

Micro propagation offers several advantages over traditional methods of banana propagation.

1. Rapid Multiplication: Tissue culture enables the mass production of banana plantlets within a short period, significantly increasing the propagation rate compared to conventional techniques.

2. Disease Elimination: Through rigorous sterilization protocols, tissue culture techniques help eliminate pathogens and produce disease-free planting material, reducing the risk of infections and enhancing crop health.

3. Genetic Uniformity: Micropropagated plants are genetically identical to the parent plant, ensuring uniformity in growth, yield, and fruit quality, which is crucial for commercial banana production.

4. Enhanced Genetic Variability: Tissue culture also facilitates the conservation and propagation of rare or endangered banana varieties, preserving genetic diversity and promoting breeding efforts for improved traits.

Challenges and Considerations

Despite its numerous benefits, plant tissue culture presents certain challenges and considerations:

1. Cost and Infrastructure: Establishing and maintaining tissue culture laboratories require significant financial investment and technical expertise, limiting access to small-scale growers and resource-constrained regions.

2. Genetic Stability: Maintaining genetic stability and preventing somaclonal variations during long-term culture is essential to ensure the uniformity and performance of micropropagated plants.

3. Acclimatization and Field Performance: Transferring tissue-cultured plantlets to the field environment poses challenges related to acclimatization, stress tolerance, and field performance, requiring careful management and adaptation strategies.

Future Directions

As the demand for high-quality planting material continues to rise, the future of plant tissue culture in banana cultivation looks promising. Advances in biotechnology, genomics, and automation are expected to streamline production processes, reduce costs, and enhance the scalability and accessibility of tissue culture technologies. Moreover, ongoing research efforts in somatic embryogenesis, cryopreservation, and genetic transformation hold the potential to further improve the efficiency, versatility, and sustainability of micro propagation methods for bananas and other crops, the future of micro propagation in banana cultivation holds promising prospects for further advancements and innovations [9]. One key direction involves the integration of biotechnological tools such as molecular markers and genetic engineering to enhance the efficiency and precision of tissue culture techniques. By identifying molecular markers associated with desirable traits such as disease resistance, yield potential, and fruit quality, researchers can expedite the selection of superior banana genotypes for micro propagation, leading to the development of novel cultivars tailored to specific market demands and environmental conditions [10].

Moreover, the application of genetic engineering technologies offers opportunities to introduce beneficial traits into banana cultivars, including resistance to biotic and abiotic stresses, enhanced nutritional content, and improved post-harvest characteristics. Genetic modification techniques such as gene editing and transgenesis hold potential for addressing critical challenges facing banana production, such as emerging diseases, climate change, and post-harvest losses. Furthermore, there is a growing emphasis on the development of sustainable and cost-effective protocols for large-scale micro propagation of bananas, particularly in resource-limited regions. Efforts to optimize culture media formulations, streamline protocols, and reduce production costs are essential for promoting the widespread adoption of tissue culture techniques among smallholder farmers and agricultural communities [11].

In addition, the integration of automation and robotics into tissue culture facilities has the potential to revolutionize the scalability and efficiency of banana micro propagation. Automated systems for explant preparation, media dispensing, sub-culturing, and monitoring can significantly increase throughput while minimizing labor costs and human error, thereby making micro propagation more accessible and economically viable on a commercial scale. Furthermore, the exploration of alternative explant sources and culture techniques, such as embryogenesis and somatic embryogenesis, holds promise for overcoming challenges associated with genotype recalcitrance and limited availability of suitable donor tissues. By expanding the repertoire of tissue culture protocols and exploring innovative approaches, researchers can unlock the full potential of micro propagation for banana improvement and sustainable agriculture, the future of micro propagation in banana cultivation is characterized by ongoing research, innovation, and collaboration across disciplines. By harnessing the power of biotechnology, automation, and sustainable practices, micro propagation has the potential to play a transformative role in enhancing banana production, improving food security, and promoting economic development in banana-growing regions worldwide. Continued investment in research and technology transfer initiatives is essential to realize the full benefits of micro propagation for the banana industry and global agriculture in the years to come [12].

Conclusion

Plant tissue culture represents a powerful tool for advancing quality material production and addressing the challenges faced by modern agriculture, particularly in banana cultivation. By harnessing the principles of tissue culture and micro propagation, researchers and growers can achieve significant gains in productivity, sustainability, and resilience, ensuring a steady supply of high-quality bananas to meet the demands of a growing population and changing climate. In conclusion, plant tissue culture, particularly micro propagation, stands as a pivotal technology in the advancement of banana cultivation. This technique has revolutionized traditional propagation methods by offering numerous advantages, including rapid multiplication of elite varieties, production of disease-free planting material, genetic uniformity, and year-round availability of planting material. The adoption of micro propagation has significantly contributed to the sustainability, productivity, and resilience of banana production systems worldwide.

As highlighted throughout this article, the principles of tissue culture have empowered banana growers to overcome various challenges, including the spread of devastating diseases, limited availability of quality planting material, and genetic variability among offspring. By harnessing the potential of tissue culture techniques, growers can achieve higher yields, superior fruit quality, and enhanced resistance to biotic and abiotic stresses, the future of micropropagation in banana cultivation holds tremendous promise for further innovations and advancements. Integrating biotechnological tools, automation, and sustainable practices into tissue culture protocols can unlock new opportunities for improving efficiency, scalability, and accessibility of micro propagation technologies. Moreover, ongoing research efforts aimed at exploring alternative explant sources, enhancing genetic diversity, and developing novel cultivars are essential for addressing evolving challenges and opportunities in banana production. In essence, the journey towards sustainable banana cultivation relies on the continued collaboration, innovation, and knowledge exchange among researchers, growers, industry stakeholders, and policymakers. By embracing the principles of plant tissue culture and leveraging emerging technologies, the banana industry can navigate towards a future characterized by resilience, productivity, and prosperity for generations to come. Together, we can unlock the full potential of micro propagation to sustainably meet the growing demand for bananas while safeguarding the health of ecosystems and communities worldwide.

References

1. Suman, S. (2017). Plant tissue culture: A promising tool of quality material production with special reference to micropropagation of banana. *Biochemical & Cellular Archives*, *17*(1).

2. Singh, H. P., Uma, S., Selvarajan, R., & Karihaloo, J. L. (2011). Micro propagation for production of quality banana planting material in Asia-Pacific. *Asia-Pacific Consortium on Agricultural Biotechnology (APCoAB), New Delhi, India*, *92*.

3. Smith, M. K., & Drew, R. A. (1990). Current applications of tissue culture in plant propagation and improvement. *Functional Plant Biology*, *17*(3), 267-289.

4. Pandey, S., & Pandey, V. C. (2018, October). Plant tissue culture techniques and its achievements. In *Advanced Molecular Plant Breeding: Meeting the Challenge of Food Security* (pp. 329-366). CRC Press.

5. Pani, M., & Lukman, M. (2019). Leaf Rusts Diseas (Hemileia vastatrix B. et Br.) Existence in Organic and Inorganic Coffee Cultivation Land. Plant Science Archives

6. Jain, S., Sharma, R., Nidhi, N., Behera, S. D., Baksh, H., Sharma, R., & Kumar, V. (2023). Advancement in Tissue Culture Techniques for Fruit Crops. *International Journal of Environment and Climate Change*, *13*(11), 4396-4407.

7. Purohit, S. D., Teixeira da Silva, J. A., & Habibi, N. (2011). Current approaches for cheaper and better micropropagation technologies. *Int J Plant Dev Biol*, *5*, 1-36.

8. El-Sherif, N. A. (2019). Impact of plant tissue culture on agricultural sustainability. *Sustainability of Agricultural Environment in Egypt: Part II: Soil-Water-Plant Nexus*, 93-107.

9. Saraswathi, M. S., Uma, S., Kannan, G., Selvasumathi, M., Mustaffa, M. M., & Backiyarani, S. (2016). Cost-effective tissue culture media for large-scale propagation of three commercial banana (Musa spp.) varieties. *The Journal of Horticultural Science and Biotechnology*, *91*(1), 23-29.

10. Idoko, J. A., Osang, P. O., & Ijoyah, M. O. (2016). Evaluation of the agronomic characters of three sweet potato varieties for intercropping with soybean in Makurdi, Southern Guinea Savannah, Nigeria. Plant Science Archives

11. Idowu, P. E., Ibitoye, D. O., & Ademoyegun, O. T. (2009). Tissue culture as a plant production technique for horticultural crops. *African Journal of Biotechnology*, *8*(16).

12. Patil, S. M., Kumari, V. C., Sumana, K., Sujay, S., Tejaswini, M., Shirahatti, P. S., & Ramu, R. (2021). Sustainable development of plant tissue culture industry: The Indian scenario. *Journal of Applied Biology and Biotechnology*, *9*(2), 18-27.

13. Hamill, S. D. (2014, August). Processes, costs and traits of plants produced in tissue culture must be considered to develop effective crop production systems. In *XXIX International Horticultural Congress on Horticulture: Sustaining Lives, Livelihoods and Landscapes (IHC2014): 1113* (pp. 85-92).

14. Salam, M. A., Islam, M. R., Diba, S. F., & Hossain, M. M. (2019). Marker assisted foreground selection for identification of aromatic rice genotype to develop a modern aromatic line. Plant Science Archives

15. Rao, C. K. (2014). *Adoption of Tissue Culture in Horticulture: A Study of Banana-Growing Farmers from a South-Indian State*. Cambridge Scholars Publishing.

16. Sipen, P., Chubo, J. K., King, P. J., Huat, O. K., & Davey, M. R. (2011). Genetic improvement of banana using conventional and in vitro technologies. *Journal of Crop Improvement*, *25*(6), 697-727.

17. Kumar, T., Singh, R. S., Pal, A. K., & Kesari, R. (2016). Bio-technological advancement in banana (musa spp.) with perspective on value additiona review. *Progressive Research*, *11*(2), 139-149.

18. Navik, P., Kumar, D., Raghavendra, S., Padmavati, A., Shamim, M. D., & Srivastava, D. (2023). Tissue Culture Technology Intervention in Red Dacca and Cavendish Banana for Nutritive Value Enhancement Under Organic Farming in India. In *Transforming Organic Agri-Produce into Processed Food Products* (pp. 395-424). Apple Academic Press.

19. Islam, M. S., Rahman, M. M., & Paul, N. K. (2016). Arsenic-induced morphological variations and the role of phosphorus in alleviating arsenic toxicity in rice (Oryza sativa L.).Plant Science Archives

20. Staver, C., Van den Bergh, I., Karamura, E., Blomme, G., & Lescot, T. (2010). Targeting actions to improve the quality of farmer planting material in bananas and plantains-Building a national priority-setting framework. *Tree and Forestry Science and Biotechnology*, *4*(1), 1-10.

21. Balan, H. R., & Boyles, L. Z. (2016). Assessment of root knot nematode incidence as indicator of mangrove biodiversity in Lunao, Gingoog City. *Plant Science Archives*.