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A Review on Plant Tissue Culture

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Authors' contributions

This work was carried out in collaboration among all author. All authors read and approved the final manuscript.

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ABSTRACT

Plant tissue and cell culture involve the aseptic cultivation and propagation of plant cells, tissues, and organs in a meticulously controlled laboratory setting. This innovative method harnesses the potential of nutrient-rich media to efficiently replicate plant cells on a large scale, resulting in the rapid production of mature and disease-free plants. The cornerstone of commercial technology in this field is micropropagation, a process that achieves swift proliferation from minute plant cuttings, axillary buds, and, to a limited extent, from somatic embryos and cell clumps in suspension cultures and bioreactors. Micropropagation, a pivotal aspect of plant tissue and cell culture, holds immense value in generating high-quality and consistent planting materials. These materials find applications across diverse fields, including molecular genetic engineering, plant breeding, horticulture production, and environmental preservation. The process of micropopagation unfolds through several distinct stages, including propagation, subculture of explants for proliferation, shooting and rooting, and hardening. These stages collectively form a universal framework for large-scale multiplication of plants. This technique plays a critical role in overcoming the limitations of traditional

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plant propagation methods. By allowing for controlled and accelerated growth in a laboratory environment, plant tissue and cell culture contribute to the efficient production of disease-resistant and genetically uniform plant materials. This not only supports advancements in various scientific disciplines but also addresses practical needs in agriculture, horticulture, and environmental conservation. The continuous refinement and application of plant tissue and cell culture methods underscore their significance in meeting the growing demands for sustainable and high-quality plant materials across diverse sectors.

Keywords: Micropagation; environment; multiplication of plants.

1. INTRODUCTION

Tissue culture, also referred to as cell culture or in vitro cultivation, stands as a transformative field within biotechnology, wielding profound impacts across diverse industries, ranging from agriculture to medicine. This innovative technique allows for the regeneration of an entire plant from small tissue or plant cells placed in a suitable culture medium within a controlled environment. The resultant plantlets, known as tissue culture raised plants, are authentic replicas of the mother plant, showcasing identical characteristics. Numerous plant species have been successfully propagated through tissue culture, establishing it as a versatile and influential methodology in plant propagation. The inception of plant tissue culture traces back to the visionary work of German botanist Haberlandt in 1902. Regarded as the father of plant tissue culture, Haberlandt's pioneering experiments involved growing palisade tissue on Knop's salt solution with sucrose, leading to significant observations on cell growth [1]. Although plant tissue culture can be initiated from various parts of a plant, meristematic tissue is particularly crucial for micropropagation or direct shoot regeneration. To ensure successful culture initiation, the mother plant must be healthy, free from diseases and pests. Explants derived from shoot tips are preferred due to their juvenile nature, containing a higher proportion of actively dividing cells [2]. In addition to its applications in plant propagation, tissue culture plays a pivotal role in conservation efforts. Conservation, as defined by Usher [3], involves the wise use of Earth's resources, aiming to maintain genetic, species, and ecosystem diversity in their natural abundance. It is an essential strategy to counter the ongoing threats posed by human activities, such as residential and commercial development, overexploitation, pollution, and the introduction of exotic species. As the global human population approaches eight billion, concerns about the escalating rate of species extinction intensify, with humans being identified as the primary drivers of modern extinctions [4]. The use of tissue culture techniques contributes to the conservation of plant species, offering a means to propagate and safeguard endangered or threatened plants with genetic, ecological, or economic significance. This dual role of tissue culture, as a tool for both propagation and conservation, underscores its profound impact on shaping the trajectory of sustainable agriculture and biodiversity preservation.

2. STAGESOF TISSUE CULTURE PROCESS

1. Preparation of nutrient medium: A semi solid medium is prepared in double distilled water containing macro elements, micro elements, amino acids, vitamins, iron sources, carbon source like sucrose and phytohormones [5].

2. Establishment of Aseptic Culture: The starting material for the process is normally an actively growing shoot tip of axialary or terminal bud or shoot tip of plant. The process of tissue culture starts from the selection of mother plant having a same characteristic. The ex-plant is washed with water and then rinsed with disinfectant. The tissue is dipped in 10% of bleach solution for ten minutes for killing the micro-organism, fungal and bacterial organism [6].

3. Inoculation: it is carried out under aseptic conditions. In the process explants or micro shoots are transferred onto the sterilized nutrient medium.

4.Development of plant in growth room: after the inoculation of the plant tissue, the bottles are sealed and transferred red into growth room to trigger developmental process under diffused like (fluorescent light of 1000 – 2000 lux) at 25 +_ 2 o C and 50 to 60 % relative humidity. The cultures are observed daily for growth and any signs of infection/contamination. Cultures, that do not show good growth or infected, are discarded [7]

5. Hardening of micro plants: Due to very high humidity inside the culture vessels and artificial conditions of development, the plantlets re tender and are therefore are not ready for coping up with the field condition. The plants are removed from the sterile medium and covered with transparent sheet. After 10 to 15 days plant are transferred to greenhouse [8].

3. METHODS OF TISSUE CULTURE

Tissue culture can be broadly classified into two methods:

Suspension Culture: Cells are grown as a suspension in liquid media. This method is often used for the large-scale production of cells, such as in biopharmaceuticals [9].

Adherent Culture: Cells are attached to a solid surface like the bottom of a culture dish. This method is employed when studying cell behaviour, differentiation, and tissue formation [9].

Technique of tissue culture: Tissue culture involves the aseptic culture of cells or tissues in a controlled environment. The primary steps include:

Cell Isolation: Cells or tissues are extracted from a living organism and isolated.

Sterilization: Ensuring a contamination-free environment is crucial. Sterilized equipment and culture medium are used.

Cultivation: Cells or tissues are placed in a suitable culture medium with nutrients, hormones, and growth factors.

Incubation: Cultures are maintained in controlled conditions of temperature, humidity, and light.

Subculture: Periodic transfer of cells to fresh medium to prevent overgrowth and maintain viability [10].

4. PRINCIPLE OF TISSUE CULTURE

- The technique develops around the concept that a cell is totipotent and so has the capacity and ability to develop into whole organism [11].
- When given the necessary nutrients and plant hormones, single cells, plant without cell wall (protoplasts) and section of leaves, stems, or roots can be often be used to grow a new plant on a culture media.
- The controlled circumstances provide a growth and multiplication environment for the culture, including the right supply of nutrients, pH medium, suitable temperature and proper gaseous and liquid environment [12].

5. ADVANTAGES OF TISSUE CULTURE

- Disease free propagation – tissue culture allows for the propagation of plants that are free from disease, viruses, other pathogens. This is because the plant are grown in sterile environment, which prevent contamination by external factor [13].
- Rapid multiplication – tissue culture enables rapid multiplication of plants, making it possible to produce large no. of plants in short amount of time [14].
- Genetic modification – it can be use for genetic modification of plants, allowing for creation of new and improve plant varieties [15].
- Conservation of endangered species – It can be used to conservered endangered plant species, allowing for the propagation and preservation in controlled environment [16].

6. DISADVANTAGES Of TISSUE CULTURE

- Tissue culture is a powerful to for plant breeding and genetic improvement, but it also has some disadvantages. Some of these disadvantages include:
- High cost: - tissue culture requires specialized equipment and skilled personal and can be expensive [17].
- Limited genetic diversity: - clones generated by tissue culture are genetically identical to the parent plant, making them more susceptible to diseases, pest, and environmental stress. This lack of genetic diversity creates depends on a single crop and can also lead to monoculture that increase the risk of crop failure [18].
- Risk of contamination: - it requires a sterile laboratory environment to prevent microbial contamination of the medium [19].
- Adaptation defect: - tissue cultured plants may not adapt local condition in the same

way as wild plant, which can be a disadvantage if the plant cannot survive outside [20-22].

7. CONCLUSION

In conclusion, tissue culture has emerged as a revolutionary technique with far-reaching implications in diverse fields, particularly agriculture and conservation. Through meticulous in vitro cultivation, tissue culture facilitates the efficient regeneration of plants from small tissue or cells, offering numerous benefits, including rapid propagation, disease-free plantlets, and genetic uniformity. The method's versatility allows for the successful propagation of various plant species, making it a powerful tool in horticulture, molecular genetics, and environmental preservation. Rooted in the visionary work of Haberlandt, the father of plant tissue culture, this technique has evolved to become a cornerstone in the conservation of genetic, species, and ecosystem diversity. As humanity grapples with escalating environmental challenges, tissue culture not only plays a pivotal role in sustainable agriculture but also serves as a linchpin in the effort to preserve endangered or economically valuable plant species. In the face of an expanding global population and increasing threats to biodiversity, tissue culture stands as an invaluable ally in our collective endeavor to secure a sustainable and resilient future for the planet.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Bhojwani SS, Dantu PK. Plant tissue culture: an introductory text. India: Springer. 2013;318.
2. Tegen H, Mohammed W. The role of plant tissue culture to supply disease free planting materials of major horticultural crops in Ethiopia. Journal of Biology, Agriculture and Healthcare. 2016;6(1):122-129.
3. Usher MB. Biological management and conservation: Ecological theory, application and planning. Springer; 2013.
4. Wilson EO. Half-earth: our planet's fight for life. WW Norton & Company; 2016.
5. Cyr DR. 10 Seed substitutes from the laboratory. Seed Technology and Its Biological Basis. 2000;326.
6. Cutter EG. Recent experimental studies of the shoot apex and shoot morphogenesis. The Botanical Review. 1965;31:7-113.
7. Singh V. Micro-propagation through tissue culture. In Summer School. 2014;191.
8. Scherwinski-Pereira JE, Costa FHS, Camillo J, Silva DB, Alves RBN, Vieira RF. Tissue culture storage of Brazilian medicinal plants germplasm. In IV International Symposium on Breeding Research on Medicinal and Aromatic Plants-ISBMAP2009 860. 2009, June;211-214.
9. Trigiano RN, Gray DJ. (Eds.). Plant tissue culture concepts and laboratory exercises. CRC press; 1999.
10. Staba EJ. Plant tissue culture as a source of biochemicals; 1980.
11. Donnelly DJ Vidaver WE. Glossary of plant tissue culture. Belhaven Press; 1988.
12. Barz W, Reinhard E, Zenk MH. (Eds.). Plant Tissue Culture and Its Bio-technological Application: Proceedings of the First International Congress on Medicinal Plant Research, Section B, Held at the University of Munich, Germany September. Springer Science & Business Media. 2012;1976:6–10.
13. Cassells AC. Pathogen and biological contamination management in plant tissue culture: phytopathogens, vitro pathogens, and vitro pests. Plant Cell Culture Protocols. 2012;57-80.
14. García-Gonzáles R, Quiroz K, Carrasco B, Caligari P. Plant tissue culture: Current status, opportunities and challenges. International Journal of Agriculture and Natural Resources. 2010;37(3):5-30.
15. Kumar K, Gambhir G, Dass A, Tripathi AK, Singh A, Jha AK, Rakshit S. Genetically modified crops: current status and future prospects. Planta. 2020;251:1-27.
16. Manole-Paunescu A. Biotechnology for endangered plant conservation. Biotechnology and Biodiversity. 2014;181-202.
17. Sluis CJ. Integrating automation technologies with commercial micropropagation. Plant tissue culture engineering. 2008;231-251.
18. García-Gonzáles R, Quiroz K, Carrasco B, Caligari P. Plant tissue culture: Current status, opportunities and challenges.

International Journal of Agriculture and Natural Resources. 2010;37(3):5-30.
19. Kastrop PM, de Graaf-Miltenburg LA, Gutknecht DR, Weima SM. Microbial contamination of embryo cultures in an ART laboratory: sources and management. Human reproduction. 2007;22(8):2243-2248.
20. George EF, Hall MA, De Klerk GJ. (Eds.). Plant propagation by tissue culture: Volume 1. the background. Springer Science & Business Media; 2007;1.
21. Bhojwani SS, Razdan MK. Plant tissue culture: theory and practice. Elsevier; 1986.
22. Thomas CW. Bureaucratic landscapes: Interagency cooperation and the preservation of biodiversity. Mit Press; 2002.

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