الكلية	العلوم
القسم	التقانات الاحيائية
المادة باللغة الانجليزية	Medicinal plants biotechnology
المادة باللغة العربية	تقانات النباتات الطبية الاحيائية
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عنوان المحاضرة باللغة الانجليزية	Plant Tissue Culture Techniques for Medicinal Plants
عنوان المحاضرة باللغة العربية	
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محتوى المحاضرة

Introduction

Plant tissue culture refers to the in vitro cultivation of plant cells, tissues, or organs under aseptic conditions on a nutrient medium. It plays a pivotal role in medicinal plant biotechnology for mass propagation, conservation, secondary metabolite production, and genetic improvement. Tissue culture techniques offer uniformity, rapid multiplication, and independence from seasonal constraints, making them vital for pharmaceutical and conservation purposes.

7.2 Principles of Plant Tissue Culture

7.2.1 Totipotency

The ability of a single plant cell to regenerate into a whole plant under appropriate conditions.

7.2.2 Aseptic Environment

Sterile conditions are necessary to prevent microbial contamination.

7.2.3 Culture Medium

A nutrient-rich medium (e.g., Murashige and Skoog [MS] medium) containing:

- Macronutrients and micronutrients
- Carbon source (e.g., sucrose)
- Vitamins and growth regulators (auxins, cytokinins)
- Gelling agent (agar)

7.3 Types of Tissue Culture Techniques

7.3.1 Micropropagation

- Clonal propagation of elite or endangered medicinal plants.
- Stages:
  - **Stage I**: Explant selection and establishment
  - **Stage II**: Shoot multiplication
  - **Stage III**: Rooting
  - **Stage IV**: Acclimatization

Examples:

- *Withania somnifera* (Ashwagandha)
- *Aloe vera*

7.3.2 Callus Culture

- Induction of unorganized, undifferentiated cell mass (callus) from explants.
- Source of somaclonal variation and precursor to cell suspension cultures.

7.3.3 Cell Suspension Culture

- Cells dispersed in a liquid medium; used for:
  - Large-scale biomass production
  - Secondary metabolite extraction

7.3.4 Organ Culture

- Culture of plant organs such as shoot tips, roots, or embryos.
- Useful for studying morphogenesis and organ-specific metabolite production.

7.3.5 Somatic Embryogenesis

- Development of embryos from somatic cells.
- Used for synthetic seed production and genetic transformation.

7.4 Applications in Medicinal Plant Biotechnology

7.4.1 Mass Propagation

- Rapid multiplication of high-yield or rare medicinal species.
- Uniform plantlets with desired traits.
- Examples: *Stevia rebaudiana*, *Bacopa monnieri*, *Centella asiatica*

7.4.2 Production of Secondary Metabolites

- In vitro cultures produce bioactive compounds independent of environmental variables.
- Optimization through elicitors, precursors, and bioreactor systems.
- Examples:
  - *Taxus spp.* – Taxol
  - *Catharanthus roseus* – Vinblastine and vincristine

7.4.3 Conservation of Endangered Species

- Preservation of threatened medicinal plants via in vitro banks.
- Cryopreservation of meristems and somatic embryos.

7.4.4 Germplasm Storage and Exchange

- Maintenance of genetic resources without seasonal limitation or large land areas.

7.5 Factors Affecting Tissue Culture Success

- **Explant Source and Type**: Young tissues often yield better results.
- **Growth Regulators**: Balance of auxins (e.g., IAA, NAA) and cytokinins (e.g., BAP, Kinetin) governs morphogenesis.
- **Media Composition**: MS, B5, or customized formulations.
- **Physical Conditions**: Temperature (22–27°C), light (16-h photoperiod), and humidity.

7.6 Bioreactor Systems for Large-Scale Culture

- Used for scaling up the production of biomass and secondary metabolites.
- Types:
  - Stirred-tank bioreactors
  - Air-lift bioreactors
  - Temporary immersion systems (TIS)

Advantages:

- Automated, sterile, and high-throughput
- Cost-effective for commercial applications

7.7 Somaclonal Variation and Genetic Stability

- Variations can arise during tissue culture.
- May lead to new chemotypes with enhanced metabolite profiles.
- Molecular markers (RAPD, SSR, AFLP) used for genetic fidelity assessment.

7.8 Genetic Transformation in Medicinal Plants

- Introduction of genes to enhance metabolite biosynthesis or stress resistance.
- Methods:
  - **Agrobacterium-mediated transformation**
  - **Particle bombardment (biolistics)**

Example:

- Overexpression of genes for artemisinin production in *Artemisia annua*.

7.9 Challenges and Limitations

- High cost of setup and operation
- Contamination risk
- Somaclonal variation affecting uniformity
- Need for skilled personnel

7.10 Summary

Plant tissue culture offers a powerful toolkit for the propagation, conservation, and metabolic engineering of medicinal plants. Techniques such as micropropagation, callus culture, and bioreactor-based production systems have transformed the landscape of medicinal plant biotechnology, enabling sustainable and high-quality supply chains. Despite challenges, advances in automation and molecular biology continue to enhance its application in research and industry.

Key Terms

- **Micropropagation**: In vitro propagation of plants through tissue culture.
- **Callus Culture**: Mass of undifferentiated plant cells grown in vitro.
- **Bioreactor**: Vessel for large-scale cultivation of cells or tissues under controlled conditions.
- **Somaclonal Variation**: Genetic variation among plants regenerated from tissue cultures.
- **Synthetic Seeds**: Encapsulated somatic embryos used for propagation and storage.

Review Questions

1. Describe the stages involved in micropropagation.
2. What are the advantages of using bioreactors in medicinal plant biotechnology?
3. Discuss how tissue culture can aid in the production of secondary metabolites.
4. What are the challenges associated with tissue culture of medicinal plants?
5. Explain the significance of somatic embryogenesis in conservation.

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