Role of Tissue Culture in Modern Crop Improvement

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ABSTRACT

Plant tissue culture is an important biotechnology for rapid multiplication, production of disease-free planting material and improvement and conservation of crop plants. The process involves *in vitro* culture of plant cells, tissues or organs on suitable nutrient media and provides powerful techniques like micropropagation, somatic embryogenesis, embryo rescue, haploid production and *in vitro* selection for crop improvement. Plant tissue culture has been increasingly used for the regeneration of plants difficult to propagate by seed and for facilitating rapid multiplication schemes. Further, plant tissue culture techniques can be employed to support modern biotechnological approaches like genetic transformation and genome editing. Thus, despite challenges posed by contamination, browning and genotype specificity, tissue culture has great potential to supplement traditional breeding methods for the development of improved varieties with higher yield, disease resistance and climatic adaptation.

INTRODUCTION:

Modern agriculture is confronted with numerous challenges including rising populations, climate change, emerging diseases and the need for improved quality of food. Developing high yielding, disease resistant and environmentally resilient crop varieties is thus, a key priority in modern agriculture. Conventional plant breeding has played a significant role in crop improvement, but it is a

time-consuming process. Several plant tissue culture techniques have been developed that can supplement and accelerate crop improvement efforts.

Plant tissue culture refers to the laboratory-grown process of plant cells, tissues or organs on a nutrient medium under sterile conditions. It takes advantage of the fact that plant cells can be dedifferentiated and redifferentiated into complete plants under suitable conditions, a phenomenon called totipotency (George *et al*., 2008).

Role of Tissue Culture in Crop Improvement

1. **Rapid Multiplication and Healthy Planting Material Production**

One of the most common applications of tissue culture is micropropagation that allows rapid production of desired plants from a small amount of initial material. Large numbers of uniform plants can be obtained from a small number of mother plants in a relatively short time using micropropagation.

This method is particularly valuable for vegetatively propagated crops like banana, potato, and sugarcane. Moreover, tissue culture can facilitate the production of healthy planting material when disease-free mother plants and proper aseptic conditions are maintained throughout the culture process (Bhojwani & Dantu, 2013).

2. **Somatic Embryogenesis:** Somatic embryogenesis is another important method of vegetative propagation that involves developing embryos from somatic cells. This technique also helps in the production of large numbers of plants from a relatively small amount of initial material.

Somatic embryogenesis has been successfully used in crops such as banana, coffee and various woody plants. In addition, it can serve as an efficient system for regenerating plants for other biotechnological approaches such as genetic transformation (Guan *et al*., 2016).

3. **Supporting Plant Breeding:** Tissue culture techniques can be used to overcome many of the limitations of conventional plant breeding. For instance, embryo rescue can be employed to recover hybrid plants whose embryos do not normally develop following sexual reproduction. Embryo rescue involves transferring the embryo to an artificial nutrient medium where it continues to grow.

Another important tissue culture method is anther or microspore culture that can aid in the production of haploid plants. These plants can then be doubled to produce diploids with desirable traits. Compared to traditional breeding procedures, haploid production can lead to the rapid establishment of pure breeding lines by avoiding multiple generations of self-fertilization (Ferrie & Keller, 2007).

4. ***In Vitro* Selection:** Plant tissue culture can be used to select crop plants that are tolerant to abiotic stresses and resistant to pathogens. The process involves exposing plant cells or tissues to the stressor under investigation in vitro and identifying those cells or tissues that survive the challenge. The selected tissue can then be multiplied to obtain whole plants and further tested for superior performance.

For instance, tissue culture can be used to select salt-tolerant or disease-resistant crops. Nonetheless, it is important to remember that laboratory selection can only be used as an auxiliary tool because the plants obtained require greenhouse and field testing before they can be released as superior varieties.

5. **Conservation of Plant Genetic Resources:** Genetic diversity provides

valuable material for developing improved crop varieties. Traditional cultivars and wild plant relatives may possess useful traits such as stress tolerance, disease resistance and improved nutritional quality. Therefore, their conservation is important for future breeding programmes. Tissue-culture techniques offer useful approaches for maintaining such plant materials through in vitro conservation and cryopreservation, allowing valuable genetic resources to be banked for future crop improvement.

6. **Tissue Culture and Modern Biotechnology:** Modern biotechnology, including genetic transformation and genome editing, often requires tissue culture methods for the regeneration of transgenic plants. Transformation technology enables the introduction of specific genes into plants. Various tissue culture techniques such as microprojectile bombardment can be used to transform plant cells, tissues or organs. The transformed cells need to be cultured to regenerate whole plants. Similarly, genome editing techniques, such as CRISPR-Cas9 and TALEN also require tissue culture methods to create the desired mutations. Thus, when employed in combination with transformation and genome-editing techniques, plant tissue culture can be a powerful tool for crop improvement.

Challenges

Several challenges are associated with tissue culture, including the need for sophisticated laboratory equipment and the susceptibility of plant tissues to microbial contamination. Further, browning of tissues can occur due to the presence of polyphenol oxidase enzymes that can inhibit cell growth. Another challenge is the variation in response to tissue culture procedures among different plant species or varieties. For instance, some varieties may display apical dominance while others fail to form shoot initials.

In addition, plants regenerated from tissue culture may display somaclonal variation, which is a type of genetic variation that arises spontaneously in plant cells during tissue culture. This presents an opportunity for generating plant varieties with desirable traits. On the other hand, it can be problematic if uniform plants need to be produced. Therefore, careful evaluation of tissue-cultured plants is needed before large-scale multiplication (George *et al*., 2008).

CONCLUSION

Plant tissue culture is an invaluable biotechnology that complements conventional plant breeding methods. It provides opportunities for rapid multiplication of superior plants, embryo rescue, the production of disease-free planting material, conservation of valuable genetic resources and in vitro selection of stress-tolerant crop varieties. Further, tissue culture methods can support modern biotechnology approaches like genetic transformation and genome editing. Thus, despite the limitations of tissue culture, such as its genotype specificity and associated contamination problems, continued research can lead to improvements in tissue-culture techniques. The combined application of tissue culture and traditional plant breeding methods is critical for the development of improved food crops.

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