Plant Tissue Culture: Micro-propagation to genetic Transformation

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ABSTRACT

Tissue culture is one of the most important aspects of biotechnology. Application of biotechnology in agriculture has been widely demonstrated with the techniques of tissue culture. Plant tissue culture has several number of aspects including micro-propagation, somatic hybridization, somaclonal variation etc. with good application in the field of agriculture. Micropropagation is one of the most commercialized techniques in plant tissue culture. Micropropagation has been applied in various realms of agriculture. One of the most important application of biotechnology in the field of agriculture is plant tissue culture. Integration of plant tissue culture with the plant biotechnology has immense prospects and application. With the utility of plant tissue culture in the industries several metabolites and products with medicinal and cosmetic value has been produced. The basic concept of plant tissue culture along with its integration with genetic transformation has been discussed in this book chapter.

Keywords- Plant Tissue Culture, Micro-propagation, Plant Genetic Transformation, Biotechnology

INTRODUCTION

Plant tissue culture is the in-vitro uncontaminated culture of cells, tissues, organs or complete plantlets under regulated environmental and nutritional surroundings (Thorpe, 2007). The main objective behind this in vitro culture is production of true-to-type clones or for secondary metabolite production of bio-chemicals. Rapid multiplications of clones are obtained under controlled condition. Regulated environmental condition provide beneficial platform for the growth and multiplication of plant cells. Supply of proper nutrients, growth medium, and maintenance of adequate temperature is the basic requirement for the in vitro culturing of plant cells and tissues. The widest application of Plant Tissue culture technology is the rapid and large scale multiplication of plant cells and production of true-to-type genotypes. Globally, plant tissue culture technology is very important for industrial purpose because of its immense use in rapid multiplication of clones, meristem culture, crop improvement and production of secondary metabolites. Among all the technology in the plant tissue culture micropropagation s one of the most important and widest use application in the various fields. Micropropagation is rapid multiplication of very small plant tissues and cell under in vitro condition. This technology has immense potential toward production of elite quality and improved variants of genotypes with improved disease resistance and stress tolerance. This technique has been exploited commercially for the rapid multiplication of true-to-type improved genotypes. Microproapagtion technique has various benefits over conventional method of plant propagation via different method of propagation including seed, cutting etc. Even virus free plants can be rapidly produced through micropropgation technology with in a very less time. Plant genetic transformation has been obtained via plant tissue culture technique easily. This book chapter is mainly written to explain what is plant tissue culture and how this technology has been used to obtain plant genetic transformants. Various applications of micropropagation and role of tissue culture in plant genetic transformation is illustrated in this chapter.

I. TISSUE CULTURE TECHNOLOGY

Tissue culture is more than 30 years technology with widest applications in the fields of agriculture. This is a technique of culturing cells and tissue, in a favorable medium under laboratory condition for complete growth and development of plants (Adlak *et al*., 2019). Various types of tissue culture techniques include seed culture, embryo culture, callus culture, organ culture, protoplast culture, anther culture, pollen culture, single cell culture, suspension culture, somatic embryogenesis. This technology has prospects to bring silent revolution in the agriculture. Traditional breeding methods can be enhanced with the application of plant tissue culture technology. Timeline of developments in the tissue culture technology has been presented in **Table1**.

Table1: Key milestone developments in the tissue culture technology

Year	Scientist	Milestone developments
1902	G Haberlandt	Father of Plant Tissue Culture who gave the concept of totipotency.
1922	WJ Robbins	Root tips and stem tips were cultivated under sterile condition.
1934	PR White	Tomato root tips were grown in a liquid medium.
1929	F Laibach	Embryo culture.
1936	CD LaRue	The growth of plant embryos in culture.
1939	PR White	Callus culture was obtained in an artificial nutrient medium and also reported controlled differentiation in a plant cell *in-vitro*.
1941	J Van Overbeek, ME Conklin, AF Blakeslee	Cultured young datura embryos and reported essentiality of coconut milk for its growth and development.
1948	F Skoog and C Tsui	Callus culture of Tobacco stem segments *in vitro* and bud formation was obtained.
1957	F Skoog and CO Miller	Chemical regulation of organ formation in plant cells while culturing in vitro was reported.
1974	DS Letham	Reported cell division regulators in plant tissues.
1958	WH Muir, AC Hildebrandt, AJ Riker	Single cell isolation and growth *in vitro*.
1959	L Bergmann	Isolation and cloning of higher plant cell.
1952	G Morel and C Martin	Developed Meristem Culture.
1964	S Guha and SC Maheshwari	Anther culture of Datura through *in vitro* culture techniques.
1960	EC Cocking	Plant protoplast isolation.
1988	TA Thorpe	*In vitro* somatic embryogenesis
1987	WR Scowcroft	Somaclonal variation

A. Applications

Tissue culture technology is associated with wide range of application which is very much important in several biological fields. This technology has been applied to both plant and animal world. Genetically modified transgenic plants can be easily achieved with this technology (Espinosa-Leal *et al*., 2018). Plants with desired characteristics can be obtained vis culturing genetically modified plant cells *in vitro*. True-to-type genotypes or clones can be obtained easily with this technology. Tissue culture includes micropropagation, somatic embryogenesis, somatic hybridization, soma-clonal variation, anther culture, pollen culture etc. and all these technologies have widespread application in the field of biotechnology both for plant cell and animal cell. Plants without seeds, tubers or bulbs can be easily propagated with this technology (Kaur *et al*.,2019). Not only for production purpose this technology has immense application in conservation of biodiversity of plants and rare and endangered plant species.

B. Advantages

Tissue culture technology is associated with various advantages. The flow chart of benefits associated with these techniques has been documented in the **Figure1**.

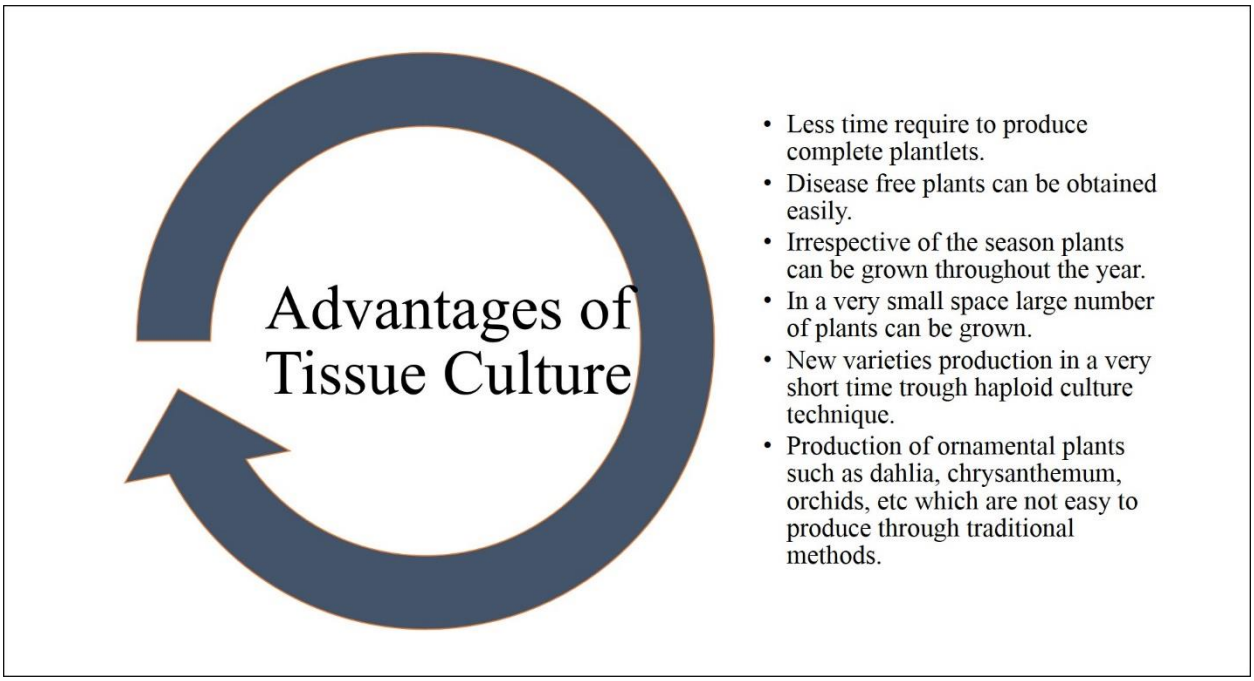
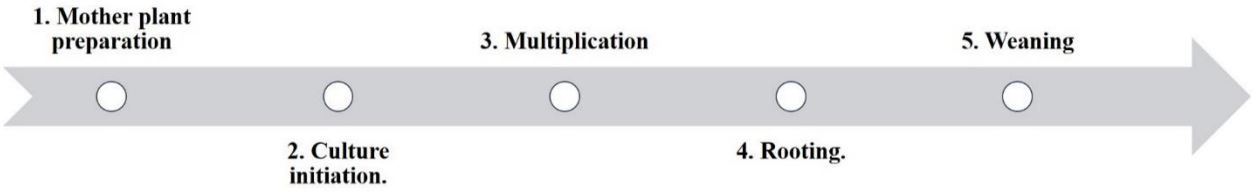


Figure1: Advantages of Tissue Culture Technique

II. Micro-propagation

Micropropagation is a rapid clonal propagation of plants *in vitro* under controlled condition using small pieces of plant cells (Lone *et al*., 2020). This technique is most widely used method in agriculture specially in horticulture. This technique is most widely used method in plant tissue culture for rapid production of plants. There are five stages in micropropagation-



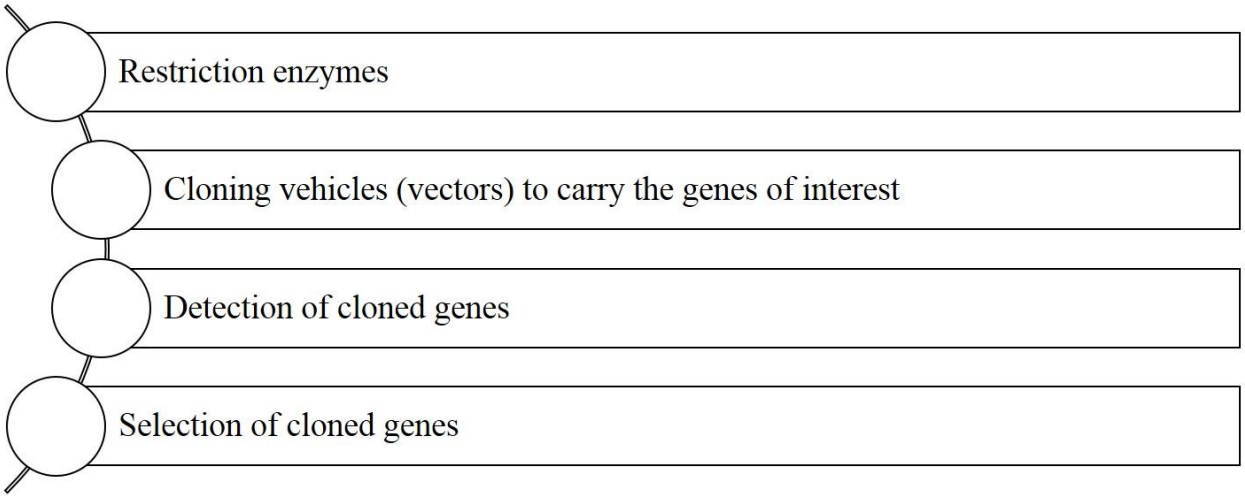
A. Application

Micropropagation is associated with plenty number of applications in the field of agriculture. Millions of clones can be produced in a very short time in compare to conventional method of plant propagation (Sivaji *et al*., 2020). It provides a very cost-effective platform to grow, store and maintenance of plants on a very large scale. Germplasm storage and conservation of endangered species can be achieved using this platform. Most of the plant species are difficult to grow on large scale using traditional method of propagation, in that case micropropagation is best technique and provide a better alternative platform for the rapid multiplication of plant species. Disease free plants can be obtained using this technique easily. Virus free plants can be obtained using meristem culture (Azad *et al*., 2020). There are plenty number of reports available for virus-free potato plans production. Clonal propagation on large scale in a very short time can be obtained easily using this platform.

III. PLANT GENETIC TRANSFORMATION

Transformation is the method of transferring genes from other organism to plant or animal cell to obtained transformed cells (Low *et al*., 2018). Genetic transformation is alteration of genome at gene level using transformation technique. Genetic transformation can be achieved using genetic engineering or recombinant DNA technology. Genetic engineering or recombinant DNA technology is all those tools and techniques which are applied to obtain genetically modified organism (Yalew *et al*., 2020). Gene is either removed from one organism or transferred in to another

organism, resultant is that e obtain transformants with genetically modified genome. The basic tools required for successful genetic engineering is-



Application of genetic engineering in various field is immense and has been summarize in **Figure2**.

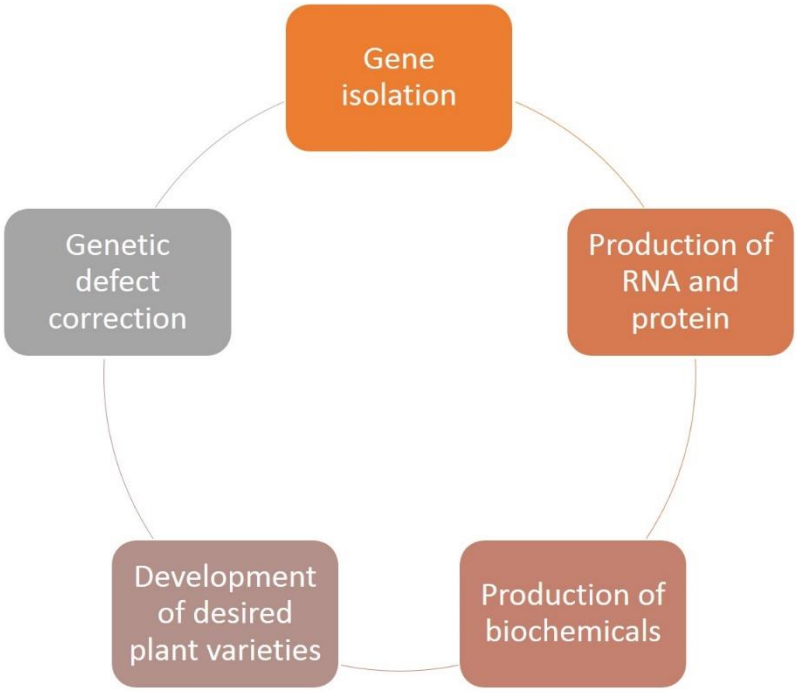


Figure2: Application of genetic engineering

A. Role of tissue culture in plant genetic transformation

One of the most novel facets of plant tissue culture is the plant genetic transformation. Plant genetic transformation provides the platform for the transfer of genes containing desirable attribute in to host plants and thus obtaining transgenic plants (Bidabadi *et al*., 2020). The approach has an extreme possibility of genetic improvement of numerous crop plants by coordinating with plant biotechnology and plant breeding. It has a favorable aspect toward the advent of agronomically valuable characters like enhanced yield, improved quality and increased resistance to insect, pest and disease. Genetic transformation can be achieved via direct mediated gene transfer methods or indirect mediated

gene transfer method. Indirect gene transfer method means vector dependent transformation and for this *Agrobacterium*-mediated genetic transformation is the most widely used method for the transgene expression in plant cells (Kavipriya *et al*., 2019). Now this genetic transformation can be easily achieved using plant tissue culture techniques.

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