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Botany

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Applications of Plant Cell and Tissue Culture

The following points highlight the top ten applications of plant cell and tissue culture. The applications are:

1. Clonal Propagation and Micro-Propagation

2. Biomass Energy

3. Secondary Metabolites

4. Genetic Variability

5. Somatic Embryogenesis and Synthetic Seed

6. Breaking Dormancy

7. Haploid Plants

8. Somatic Hybrids

9. Transgenic Plants

10. Germplasm Conservation.

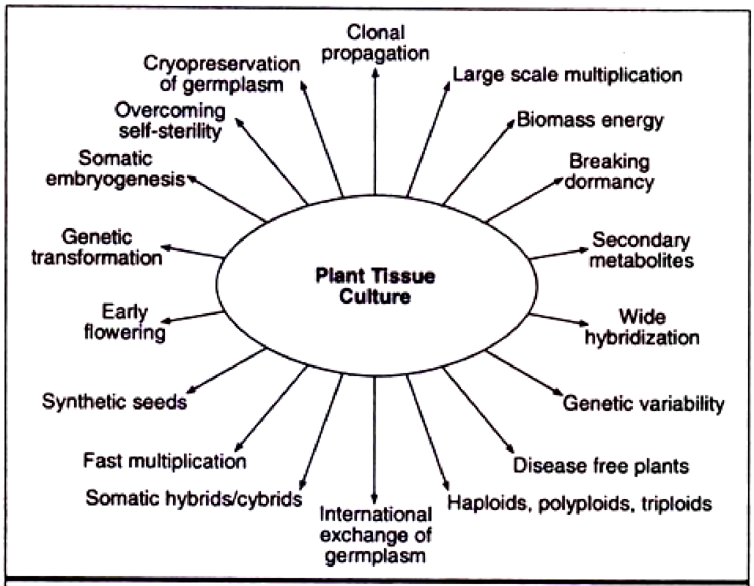

Fig. 16.6: Plant improvement through tissue culture technology

1. Clonal Propagation and Micro-Propagation:

Plant population derived from a single donor plant is called a clone and the multiplication of genetically identical copies of that cultivar is called clonal propagation which may be an useful tool to get a large population of plant species having desirable traits. Micro-propagation is achieved through multiplication of shoot tips or axillary buds cultured in vitro.

This technique is very much used in horticulture and silviculture—in the plants which have long seed dormancy, tree species, orchids and many fruit plants. This micro-propagation technique is also helpful for supplying the plant material throughout the year involving large scale multiplication i.e., grower and breeder gets a large number plant stocks irrespective of seasonal variation.

In tissue culture from a callus mass large numbers of shoot meristems can be regenerated within a very short time and space. As a result a large number of plantlets can be produced from such callus tissue. The most obvious advantage of this technique is the large scale production of plants of same genetic stock.

2. Biomass Energy:

In recent years, the interest has aroused in commercializing the in vitro propagation of forest trees. Micro-propagation has been successfully done in many trees of economic importance like *Acacia nilotica, Albizia lebbeck, Azadirachta indica, Butea monospermous, Dendrocalamus strictus, Shorea robusta, Tectona grandis and Cedrus deodara, Cryptomeria japonia, Picea smithiana, Pinus sylvestris.*

All these plant species are useful in forestry for biomass energy production. Development of automated procedure, plant delivery systems using somatic embryos and artificial seeds are also in progress.

3. Secondary Metabolites:

Production of many useful compounds like alkaloids (Codeine, Vincristine, Quinine, etc.), Steroids (Diosgenin), Glycosidic compounds (Digoxin) and many other essential oils (Jasmine), flavouring and colouring agents (saffron) can be done by plant cell culture. This aim can be achieved by selection of specific cells producing high amount of desired compounds and development of a suitable medium.

In general, secondary metabolites produced by plant cell cultures are rather small in amount but by clonal selection the particular high yielding clone of cells can be isolated. Sometimes the plant cell culture may provide the helpful way for more production of secondary metabolite by feeding the culture with inexpensive product precursors (biotransformation) or by manipulating their biosynthetic control mechanisms.

4. Genetic Variability:

The variability generated by the use of a tissue culture cycle has been termed as somaclonal variation by Larkin and Scowcroft. This genetic variability is due to cells of various ploidy levels and genetic constitution of the initial explant or also may be developed due to different cultural conditions.

The chromosomal instability in the cultured cells play an important role in polyploidization of cells and genetically variable plants can be raised.

Such kind of variations may show some useful characters such as resistance to a particular disease, herbicide resistance, stress tolerance, etc. and also some agronomical traits like tiller number, panicle size, flowering time, plant height, lodging resistance, yield, nutrient content and different kinds of morphological variations in leaf.

5. Somatic Embryogenesis and Synthetic Seed:

Direct or indirect somatic embryogenesis may be achieved from pro-embryonic cell of the direct explant or the embryoids developed within the callus tissue from induced embryogenic cells. The potential application of this technique is the mass production of adventitious embryos which ultimately develop into complete plantlet in maturing media.

These somatic embryos can be encapsulated with suitable nutrient containing alginate medium which are called artificial seeds or synthetic seeds. As the somatic embryos are derived from a single cell, this method is very much useful for production of disease free propagule. This artificial seed production is also desirable in case of asexually propagating plants.

Using embryo (zygotic) culture technique the seed dormancy period can be reduced or eliminated and the breeding cycle can be shortened in many of the plants like Malus sp, Ilex sp. and Telia americana etc. The life cycle of Iris was reduced from 2-3 years to less than one year. It was possible to obtain two generations of flowering in Rosa sp.

Embryo abortion in unsuccessful crosses may be recovered by culture of immature embryo of different hybrids.

7. Haploid Plants:

Haploid plants can be obtained through anther or pollen culture (androgenesis) or through ovaries or ovule culture (gynogenesis). The anther culture and haploid plant production has been attempted in many of the crop plants, where these haploids are of immense importance for production of homozygous diploid or polyploid lines by colchicine treatment within a very short period specially in case of fruit trees.

These androgenic haploids can also be used for production of different kinds of aneuploids like monosomic, nullisomic, trisomic, etc. and also for the induction of mutagenesis and doubling of those mutated lines. Many of the recessive traits can be made expressed in double haploids such as low glucosinolate content in Brassica, salt tolerance and disease resistance in rice, etc.

Generation of exclusively Y chromosome containing plant is possible also through haploid production as in case of Asparagus. The triploid or polyploid can also be produced by using protoplast fusion technique of this kind of androgenic haploids which may be used for different breeding programmes.

8. Somatic Hybrids:

Isolation and regeneration of plant from the protoplasts in vitro has opened up a new avenue in various fields of plant breeding and in plant biotechnology.

Somatic hybridisation, i.e., the asexual hybridisation using isolated somatic protoplasts is a new tool to make the wide hybridisation successful. Products of fusion between two protoplasts (heterokaryon) could be cultured to regenerate a new somatic hybrid plant of desired genotype.

This technique has been mainly used for introgressing many useful criteria from the wild genotype to cultivated crop variety. Success has been achieved obtaining somatic hybrid plants between sexually compatible and incompatible plants.

Production of cybrid, i.e., the fusion between two protoplasts—one partner with nucleus and another partner with cytoplasm, is also of immense importance in the plant breeding programme, mainly for production of male sterile line with the help of extra-nuclear genome.

9. Transgenic Plants:

The genetically modified (GM) plants, in which a functional foreign gene has been incorporated by biotechnological method, are called transgenic plants. A number of transgenic plants have been produced carrying genes for different traits like insect resistance, herbicide tolerance, delayed ripening, increased amino acid and vitamin content, improved oil quality, etc.

The different methods of introduction of foreign genes, direct (electroporation, microinjection or particle bombardment) or indirect (Agrobocterium mediated), have been applied either in plant tissue culture method such as embryogenic or organogenic plant development from different plant parts or in protoplast culture system.

The direct DNA uptake through protoplast is the most ideal method for production of transgenic plants. Any gene of interest that may be of eukaryotic or prokaryotic origin can be used for this purpose but should be expressed.

10. Germplasm Conservation:

Many of the important crop species produce recalcitrant seeds with early embryo degeneration. Also many of the plants are vulnerable to insects, pathogens and various climatic hazards. Maintenance of these plants are very difficult. Mainly the plant species which are endangered, rare and threatened with extinction are needed to be conserved by ex-situ method of germplasm conservation.

Plant tissue culture may be applied for this purpose. In vitro germplasm storage collection provides a cost effective alternative to growing plants under field conditions, nurseries or greenhouses.

Furthermore, the **cryopreservation o**f cells and tissue, revival of these tissue and regeneration of plants from tissue through tissue culture technique really effective in conservation biotechnology. Cryopreservation involves storage of cells, tissues, etc. at a very low temperature using liquid nitrogen.