IJFANS INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 11,S Iss 3, Dec 2022

Overview of the Research on Plant Tissue Culture

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Abstract

Cells, tissues, and organs of plants are grown in aseptic solid or liquid media. Commercial micro propagation is used to quickly multiply system cuts, axillary buds, somatic embryos, cell clumps in suspension cultures, and bioreactors. Agriculture, horticulture, forestry, and breeding are all fields that use plant tissue culture. Applied biotechnology is used for mass propagation, getting rid of viruses, making secondary metabolites, and cloning plants in a lab. Some endangered plant species have been saved by freezing them for a long time and letting them grow slowly for a short or medium amount of time. These methods are better than other ways to save plant species with seeds that are resistant or dormant.

Keywords: Germplasm; Embryo culture; Protoplast fusion; Micropropagation

Introduction

Tissue culture is a way to make clones of plants by growing cells, tissues, organs, or whole plants in a clean environment with strict dietary and environmental rules. The clones have the same genotype that was chosen. Conditions that are controlled help the culture grow and spread. A proper nutrition supply, pH-balanced environment, temperature, and gaseous and

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liquid environment are required. Industrial plant propagation uses plant tissue culture. Plant tissue culture methods are used to make more plants, get rid of diseases, improve plants, make secondary metabolites, and do research. Tissue explants can lead to the growth of tens of thousands of new plants. Under controlled conditions, a single explant can make thousands of plants in a short amount of time and space, no matter the season or weather. Micropropagation has been used to grow and protect rare, endangered, and vulnerable species because it makes new plants quickly and doesn't need a lot of space or plants [1].

The history of plant tissue culture

Cell discoveries and theories are used in plant tissue culture. Schleiden and Schwann said that the cell is the building block of life in 1838. Scientists thought that since each cell was independent, they could grow back into full plants under the right conditions. In 1902, Gottlieb Haberlandt, a German scientist, tried to grow palisade cells from leaves in a salt solution with sucrose. Without dividing for a month, the cells grew and stored starch. He pioneered plant tissue culture despite his failure [2].

Plant tissue culture basics

In a clean, controlled environment, plant cell culture makes tissues and organs from synthetic media. The strategy relies on the fact that plant cells are totipotent, which means they can express their whole genome when they divide. For plant regeneration, the ability of plant cells to become any kind of cell is just as important as their ability to change metabolism, growth, and development [3]. Plant tissue culture medium has all the nutrients a plant needs. The bulk of the medium is made up of macronutrients, micronutrients, vitamins, other organic substances, plant growth regulators, a carbon source, and, if the medium is solid, a few gelling agents. Murashige and Skoog medium is often used to help plants grow roots in a lab (MS medium). The pH of the medium affects how plants grow and how growth regulators work. The new range is 5.4–5.8. The medium for growing things can be solid or liquid. The response of the first explant is affected by the plant hormones and nitrogen in the medium[4].

Agriculture/tissue culture

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Plant tissue culture is a new way to grow plants to meet demand all over the world. This affects agriculture and other industries. Because of what it has done for agricultural sciences, it is an important part of modern agriculture. Biotechnology is being used in agriculture at a rate that has never been seen before [5]. Through tissue culture, plants with the same genes and no diseases can be made and grown in large numbers. Somaclonal variation can be caused by cell and tissue culture. Tissue culture may be able to give new stable genotypes more genetic diversity. Gene transfer using biotechnology, mass micropropagation, and in vitro regeneration in tree species have all worked. In vitro culture of mature and/or immature zygotic embryos can bring back inter-genus crossings that don't make seeds that can grow. Using genetic engineering, farmers can make crops that are resistant to pests and have high yields [6].

Germplasm conservation

Cells and organs may be saved from extinction by growing them in a lab. As plant species go extinct and national floral legacies are threatened, germplasm conservation is becoming more important around the world [7]. When clones are saved instead of seeds, tissue culture can keep vegetative tissues and genetic information. It can also keep plants from dying from biotic or abiotic stress. Gene banks can't store sterile plants or "recalcitrant" seeds, but in vitro methods can.

Embryo culture

In embryo culture, embryos are grown from seeds and ovules in a nutrient-rich medium. In embryo culture, the plant grows directly from the embryo or indirectly from a callus, and then it grows branches and roots. The process makes seeds sprout, checks to see if the seeds will grow, and makes haploid plants and rare species. Growing removed embryos shortens the time it takes for plants to reproduce and makes seeds less likely to stay dormant. Hybrids between different types of jatropha have been made and used successfully for mass production [8]. Somatic embryogenesis and plant regeneration are used to quickly clone and improve certain individuals with the help of Jucara Palm embryo cultures. The same is true for endangered species. Recently, *Khaya grandifoliola* was grown in a lab by using embryos from ripe seeds to make more plants. The plant is valuable because it has wood and medicine.

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This method is used in forestry to keep good people when it's hard to pick them out and improve the natural population [9].

Genetic transformation

Genetic transformation is the newest way to work with plant cells and tissues. It moves genes with the properties that are wanted into host plants and then grows back transgenic plants. By using this method in plant biotechnology and breeding programmes, the genes of many crop plants can be changed for the better. It gives farmers a chance to add traits like higher yield, better quality, and resistance to pests and diseases. Both vector-mediated (indirect gene transfer) and vector-less (direct gene transfer) methods can be used to change the genes of plants. The most common method for plant gene expression that depends on a vector is agrobacterium-mediated genetic transformation. Through root explant genetic transformation, plants got traits that help them grow. Virus-based vectors make it possible to make recombinant proteins on an industrial scale by giving plant cells a way to express proteins quickly and in a stable way. Particle bombardment was used to transfer direct DNA to the tips of mature shoots that grew from Jatropha seeds. This method reduces the amount of dangerous chemicals in seeds, so they can be used in many industries. Today, plants that are resistant to diseases or viruses are made by changing their genes. Transgenic potato plants that are resistant to PVY were made by scientists. Using the multi-auto-transformation (MAT) vector approach, transgenic *Petunia hybrida* plants without markers were made. *Botrytis cinerea*, which causes grey mould, didn't hurt the plants [10].

Combined protoplasts

Somatic hybridization, which creates hybrids between different species and different genera, is important for plant breeding and agricultural progress. The process is to combine protoplasts with genomes from two species, pick somatic hybrid cells, and grow hybrid plants. The process of protoplast fusion is becoming more important in crop growth because it can transfer genes from one species to another to pass on traits that are good for the plant. Electrofusing protoplasts of ditch reed and rice made somatic hybrids that could handle salt. By reducing sexual incompatibility, in vitro protoplast fusing makes it possible for unique hybrid plants to grow. Horticulture uses it to make hybrids that are resistant to disease and

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produce fruit. When citrus protoplasts were put together with closely related citrinae species, the result was a plant that could grow. Brassicaceae intergeneric hybrids are the best example of how somatic hybridization can happen in important crops. Somatic hybrid plants have been made by using two wheat protoplasts as recipients and *Haynaldia villosa* protoplasts as fusion donors. This was done to deal with chromosomal loss and less regeneration. It also gives genes that make wheat better [11].

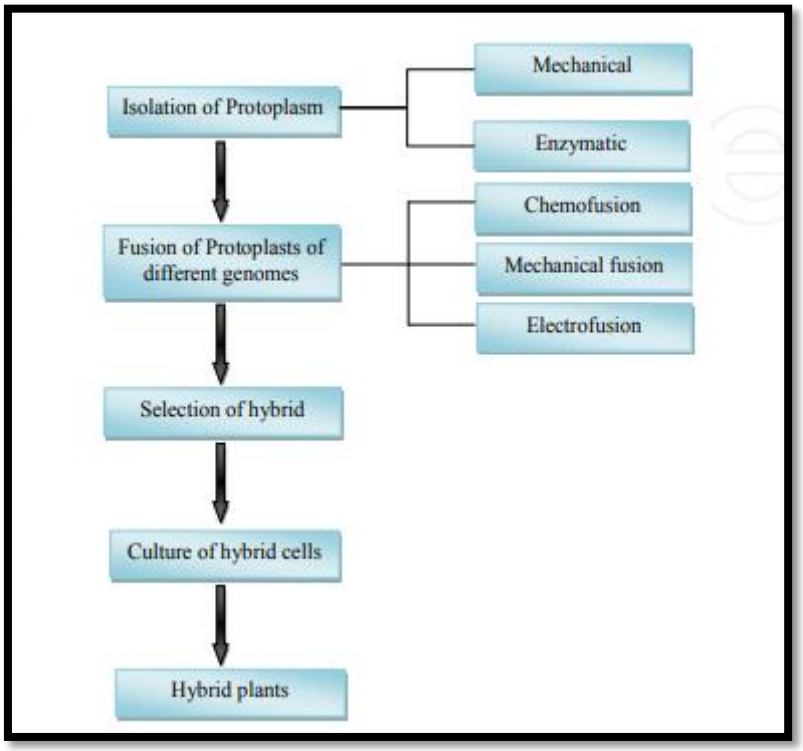

Fig:1 Protoplast fusion makes a hybrid plant

Making a haplotype

With tissue culture techniques, protoplast, anther, and microspore cultures can be used to make homozygous plants quickly. Chromosomal doubling can be used to make homozygous diploids, which are sterile plants with only one set of chromosomes. By doubling a plant's chromosomes to make it fertile again, double haploids could be turned into new pure breeding cultivars. Androgenesis is the process by which immature pollen cells turn into haploid plants without fertilisation. Pollen grains were used by Sudherson et al. to make haploid plants of Sturt's desert pea [12]. Haploidy technology has changed plant breeding by

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speeding up the development of inbred lines and getting rid of seed dormancy and non-viable embryos. This technology is used to make haploid plants that are more resistant to both biotic and abiotic stresses. By adding genes for traits that were wanted when the wheat was still haploid and then copying the chromosomes, drought-resistant wheat was made.

Current and future plant tissue culture

In the last few decades, plant cell biotechnology has grown into a new age of biotechnology that focuses on secondary plant products. Molecular biology and genetic engineering were used to make new and better agricultural products in the second half of the 20th century. These products are now in high demand in many economies around the world. These would not have been possible without tissue culture technologies for transferring genetic material into plant cells. Transgenic plants are a potential technique to manufacture proteins, antibodies, and vaccines [13]. Fermentation-based manufacturing costs more than transgenic plants. "Plantibodies," which are vaccines or antibodies made by plants, are amazing because plants don't have to be checked for viruses and bacterial toxins. Transgenic plants were used by 13.3 million farmers in 2008, up from 11 million in 2007.

Plant tissue cultures

Micropropagation

Explants are taken from a healthy mother plant to start the micropropagation process. You can take out a leaf, bud, apical meristem, or a root. Figure 2 shows the parts of the procedure.

Step 1:Get the donor plant ready

Bring any plant tissue into a lab. To avoid contamination and get the best results, the mother plant should be grown in a lab under the best possible conditions [14].

Step: 2 Initial stages

At this stage, sterilized explants are put in a medium that gives them food. Use both fungicides and bactericides at the same time. Items depend on where they come from. Surface-sterilize explants with chemical solutions to get rid of contaminants without hurting plant cells. Most disinfectants are made of mercury chloride (HgCl2), salt, calcium, and

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ethanol. Depending on the method of propagation, the growth chamber either lets light in or keeps the lights off [15].

Step: 3 Multiplication

During this phase, propagules are made. With repeated subcultures, propagules grow until there are as many plants as you want [16].

Step: 4 Rooting stage

There may be rooting in the medium used to grow the explants. But it may be necessary to change the medium, which may include nutrients and growth regulators, to help the plant grow roots and strong roots.

Step: 5 Acclimatization

In vitro plants that were weaned and toughened from low to high humidity and light intensity, the rate of hardening increases. Then, the plants are put in a greenhouse on a suitable base, such as sand, peat, compost, etc., until they are ready to go outside [17].

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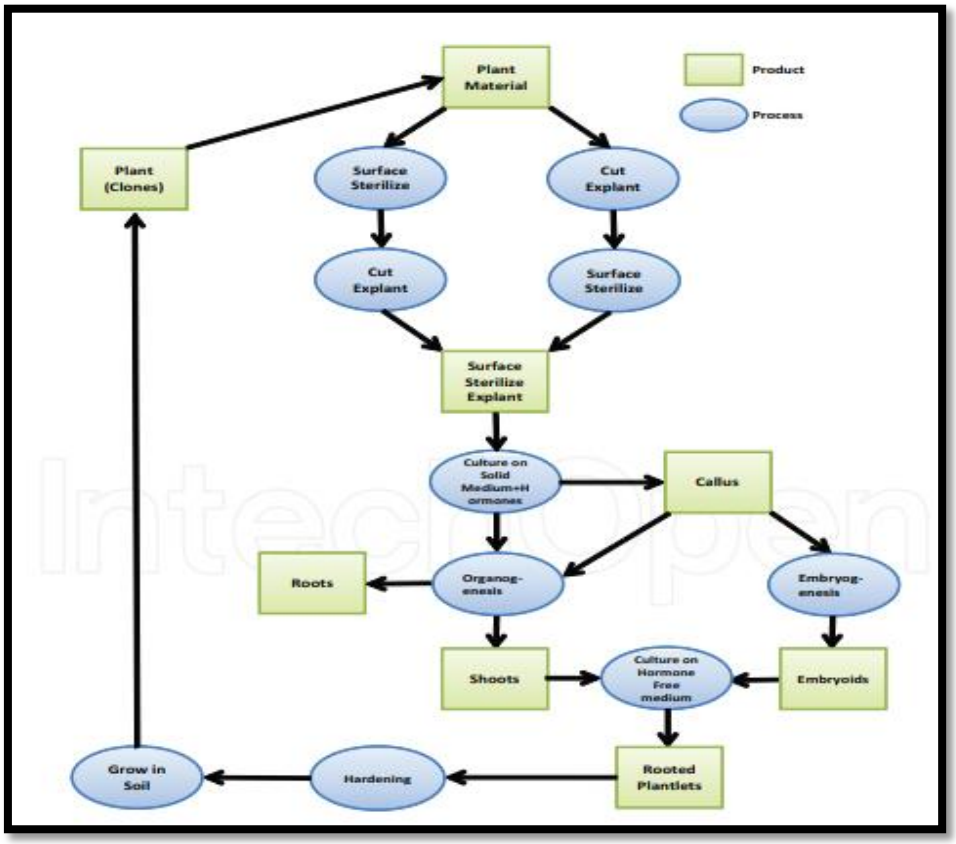

Fig: 2 Depicts tissue culture experiment flow

Organogenesis/somatic embryogenesis

Somatic embryogenesis is used for long-term clonal propagation and regrowing plants in a lab. Somatic cells turn into embryos that have grown and changed. Somatic embryos don't need to be fertilized by zygotes to grow into plants. Somatic embryogenesis can be set off by transplants or calluses. To make more embryos, zygotic segments from the seed, leaf, or stem are used to start somatic embryogenesis. Before planting, mature embryos are grown in a lab for germination and plantlet development [18].

Organogenesis

Through organogenesis, roots, branches, and leaves are made. These organs may come from the meristem or groups of undifferentiated cells (callus). In organogenesis, calluses and adventitious meristems change into organs by changing the plant's growth hormones when it

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is growing well. Skoog and Muller found that tobacco callus that had a high ratio of cytokinin to auxin could grow new roots and shoots [19].

Medicines made from tissue cultures

Plant cell and tissue cultures make it possible to make good secondary metabolites in a controlled way. To make therapeutic secondary metabolites, whole plant systems, microbial cell cultures, and animal cell cultures are used in plant cell cultures [20]. In the search for alternatives to medicines made from plants, biotechnological methods, especially plant tissue cultures, show promise as an addition to traditional agriculture for making bioactive plant metabolites in factories. Microbiologists and plant scientists from all over the world have spent the last ten years studying the biosynthetic potential of different cell cultures.

Civilizations with deep roots

In the last twenty years, the Agrobacterium rhizogenes-based hairy root system has become a popular way for plant roots to make secondary metabolites. Root cultures, in particular, may help make more secondary metabolites[21]. Different cultures have put a lot of attention on changing (hairy) roots. Hairy root disease is caused by *Agrobacterium rhizogenes*. Neoplastic roots that have been infected by *A. rhizogenes* grow quickly, stay genetically stable, and don't need hormones to grow. In biotechnology, hairy roots can be used to make plant secondary metabolites because they are hardy and produce a lot [22,23]. Root cultures that have been changed genetically may make secondary metabolites like full plants [25,26].

Conclusion

The most potential is in plant tissue culture. Covered topics include freezing valuable germplasm, breeding plants to make them more nutritious, including trees, and micropropagating ornamental and forest trees. All biotechnological ways to change traits genetic engineering, haploid induction, and somaclonal variation need a good in-vitro plant regeneration system. Micropropagation is the only way to quickly make uniform, disease-free planting material [24]. Farmers and people who run nurseries that sell high-quality fruit, ornamental, forest, and vegetable plants have new opportunities. The plant makes things all year. Plant cell culture has come a long way. Transgenic plants might be the best thing that

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came out of plant cell culture. Countries that lose crops because of disease or changes in the weather might benefit from faster multiplication. Most of the time, field genebanks lose genetic resources. Field genebanks are getting help from slow-growth in vitro storage and cryopreservation. If they can, they can use field genebanks to build a secure replica collection. They give genetic resources to future generations that can be used to easily change genes or do traditional breeding. So, it affects the growth and production of agriculture.

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