Biotechnological Tools for the Conservation of Biodiversity

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Abstract

Biodiversity is crucial for the functioning of ecosystems, and its conservation holds immense significance for both the environment and human well-being. In recent past ever increasing loss of biodiversity has posed a serious threat to the survival of fauna and flora present on this planet. Destruction of the habitat of plants and animals, introduction of exotic species, overexploitation of animals and plants, overpopulation of human and over consumption of natural resources are the root causes of biodiversity destruction. There is an urgent need for the conservation of biodiversity. Biotechnology offers new opportunity of conserving biodiversity. Biotechnology including tissue culture, micro-propagation, marker assisted breeding, conventional breeding, transgenic crops, and genomics, are all quite beneficial for conserving biodiversity in many ways.

At the same time, Biotechnology has been used to improve and enhance crop productivity, as well as to conserve and utilize the various aspects of biodiversity. The global concern of biodiversity preservation initiated either by in situ or ex situ methods. In situ methods protect fauna, flora and their natural habitat. On the other hand, ex situ methods involves preservation and maintenance of biodiversity outside their natural habitat. Classical methods of plant propagations have certain limitations in terms of rapid production of plant propagules and their long term conservation. So, the biotechnological methods such as plant cell culture, plant tissue culture, embryo culture, anther culture, etc. are quite applicable and useful techniques for ex situ conservation.

Key words: biodiversity, tissue culture, biotechnology, Ex-situ conservation

Introduction

Biodiversity is traditionally defined as the variety of life on Earth in all its forms. It comprises the number of species, their genetic variation and the interaction of these lifeforms within complex ecosystems. Biodiversity exists in three different levels; genes, species, and ecosystems in a given geographical area. Each of the components has its own composition, structure and function in environment. However, in recent years, increasing loss of biodiversity has posed a serious threat to the survival of fauna and flora present on this planet (1, 2).

Thus, Biotechnology offers new opportunity of conserving biodiversity. Biotechnology including tissue culture, micro-propagation, marker assisted breeding, conventional breeding, transgenic crops, and genomics, are all quite beneficial for conserving biodiversity in many ways. Moreover,

Biotechnology has been used to improve and enhance crop productivity, as well as to conserve and utilize the various aspects of biodiversity. The global concern of biodiversity preservation initiated either by in situ or ex situ methods. In situ methods protect fauna, flora and their natural habitat. On the other hand, ex situ methods involves preservation and maintenance of biodiversity outside their natural habitat. At the same time, Conventional methods of plant propagations have certain limitations in terms of rapid production of plant propagules and their long term conservation. Thus, biotechnological methods such as plant cell culture, plant tissue culture, embryo culture, anther culture, etc. are quite applicable and useful techniques for ex situ conservation(3-4).

Causes of biodiversity loss:

Main reasons for biodiversity loss are- Changes in land use (e.g. deforestation, intensive mono-culture, urbanisation), Direct exploitation such as hunting and over-fishing, Climate change, Pollution, Invasive alien species. Destruction of the habitat of plants and animals, introduction of exotic species, overexploitation of animals and plants, overpopulation of human and over consumption of natural resources are the root causes of biodiversity destruction. So, there is an urgent need for the conservation of biodiversity(5-7).

Nowadays, loss of specific species (extinction) or decreases in number of particular organisms (endangerment) are taking place in different parts of the world at a rapid speed. Domestic and wild animal species are undergoing a profound erosion process (8, 9).

Conservation of biodiversity through establishment of protected areas like National Park, Wild life sanctuary, Biosphere Reserves, Marine Reserves etc. are very effective in controlling the loss of biodiversity Although biotechnology is commonly thought of as recombinant DNA technology, it is used here in a broader term to include tissue culture, cryopreservation, plant micropropagation and animal regeneration from early embryos. Moreover, Biotechnology influences germplasm conservation in several ways. It provides alternatives in some cases to conserving whole organisms, it can assist with the exchange of germplasm, and the techniques of molecular biology can be applied to the problems of managing and using germplasm and influence results from the increased demand for germplasm and conservation services by the biotechnologists themselves (10-11).

Different modes of biodiversity conservation

In situ conservation focuses on preserving the genetic variation in the location it has been encountered originally i.e. in its natural habitats either in the wild or in traditional farming system. In situ conservation can be carried out at any level, in any country, without the need for special skills or technology. It can incorporate farmer and industry breeding as well as continued use of the resources.

Besides, ex situ involves conservation outside the native habitat and is generally used to safeguard populations in danger of destruction, replacement or deterioration. Approaches to ex situ conservation include methods like seed storage, field gene banks and botanical gardens.

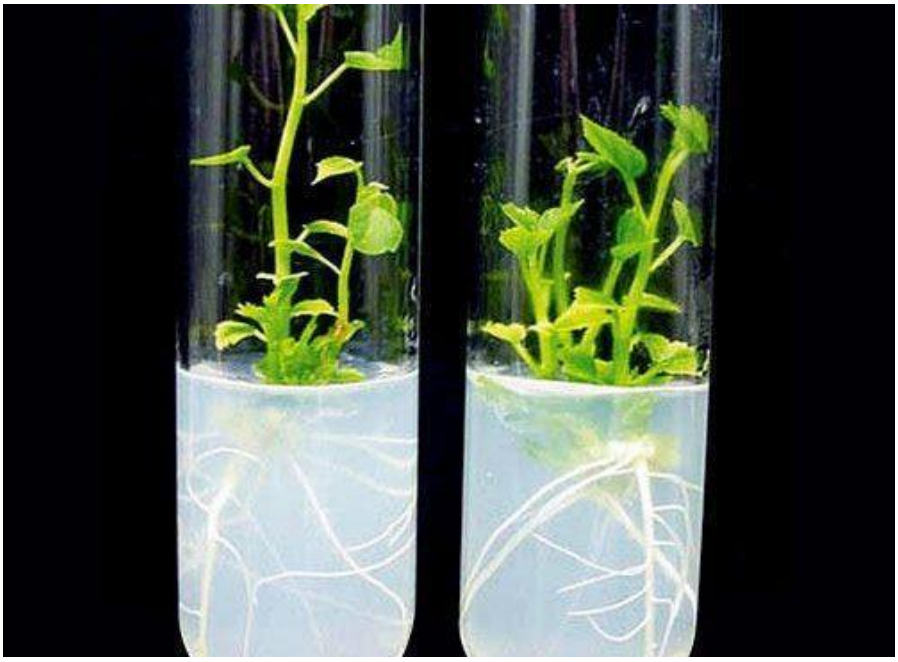
Biotechnological approach for biodiversity conservation.

Plant Tissue Culture (PTC) is a quick, independent and efficient in vitro technique to propagate plants under sterile micro environmental conditions. It is very effective method of cloning of plant material and to develop disease free clean plant stock for propagation. Any plant cell has the power of cellular totipotency to be differentiated into whole plant in the process of plant tissue culture. The main objective of PTC is the enhancement of plant production rate by quick regeneration of plants in the absence of seed or otherwise by using the seeds which have very low chances of germination. Tissue culture techniques can be applied in germplasm conservation of medicinally important plants those are of important source of pharmaceutical compounds. It can be applied for regenerating different clean disease -free stock of plants in the field of agriculture, horticulture, floriculture and pharmaceutical industry to enhance production. Rapid and mass propagation of plant species and their long- term germplasm storage can be achieved in a small space within short time period, with no damage to the existing population. using PTC methods. Tissue culture techniques are of great interest for collecting, multiplication and storage of plant germplasm and are very useful for conserving plant biodiversity, including

(a)genetic resources of recalcitrant seed and vegetatively propagated species; (b) rare and endangered plant species; and (c) biotechnology products, such as elite genotypes and genetically engineered material. Tissue culture systems allow propagating plant material with high multiplication rates in an aseptic environment (15-17).

(i) Micro-propagation

Micro-propagation helps in the production of virus free plants and is successful for those plant species which have difficulties in propagation using conventional methods. It is an in -situ conservation of plant species having special phenotypic characters by introduction of regenerated plantlets directly into its natural habitat. In a short period of time and limited space, it allows the production of numerous plant species. The selection of the explants is very important for the successful micro-propagation which decides the final fate of the developed plantlets via callus or without formation of calluses. micropropagation is rapid and has been adopted for commercialization of important plants such as banana, apple, pears, strawberry and many medicinal plants.(18-20).



Somatic embryogenesis and Organogenesis

The development of somatic embryo from a single or multicells is known as somatic embryogenesis. Plant genetic transformation and gene cloning depend on the plant tissue culture practices for their regeneration on suitable media. Plant propagation through somatic embryogenesis helps to obtain a large number of plants irrespective of seasons and provides several advantages over traditional methods. The main advantage of Somatic Embryogenesis is the production of numerous plantlets from a single cell which provides an option for their screening and evaluation. Biotechnological tools have an important contribution in the production of homozygous line from gametic embryogenesis. The de novo organ synthesis such as buds, roots and shoots from cultured tissues is called organogenesis. Plant mature cells have the capability to reverse their state of differentiation and produce new organs under cultured conditions. In vitro organogenesis, dedifferentiation and redifferentiation phases are commonly characterized. The balance of exogenous auxin and cytokinin in the medium is essential for de novo organogenesis. Thus, organogenesis entails the regulation of cell division, cell expansion, cell and tissue type differentiations, and patterning of the organ as a whole.

(iii) Cryopreservation

Cryopreservation is one of the biotechnological methods of ex situ plant conservation and applicable for long term storage of plant genetic material. Cryopreservation is extremely helpful method to conserve rare, endangered, threatened species. There are two types of cryopreservation protocols that basically differ in their physical mechanisms: classical cryopreservation procedures, in which cooling is performed in the presence of ice; and the procedures based on vitrification, in which cooling normally takes place without ice formation. Maintenance of cryogenic cultures in Liquid Nitrogen at -196°C or in the vapor phase of LN at -135°C is in such a way that the viability of stored tissues is retained following rewarming. Certain compounds like- DMSO (dimethyl sulfoxide), glycerol, ethylene, propylene, sucrose, mannose, glucose, praline, acetamide etc are added during the cryopreservation. These are called cryoprotectants and prevent the damage caused to cells (by freezing or thawing) by reducing the freezing point and super cooling point of water. Vitrification comprises treatment of samples with cryoprotective substances followed by dehydration with highly concentrated plant vitrification solutions (PVS), rapid cooling and rewarming, removal of cryoprotectants and recovery. This procedure has been developed for apices, cell suspensions and somatic embryos of different species. Cryopreservation of seeds is a very valuable strategy for the long-term conservation of tropical and subtropical forest species biodiversity, as it avoids problems related to embryo isolation and in vitro handling. The cryo preserved tissue has considered as safer, clean, disease- free genetic stock(12-14).

(iv) DNA Banks

DNA banking is also a potential method for the conservation of biological information by preserving the genomic DNA at low temperatures. The DNA isolation is easy and can be used extensively for the characterization and utilization of biodiversity. The implementation of such biotechnological tools on rare and endangered plant species may help in revival of their previous genes and their products which have been disappeared or inactivated in natural habitat. In gene banks, the plant and animal

materials are conserved and are available for breeding, reintroduction, research and other purposes. DNA banks maintain a library of the given DNA sample and provide vital information to the conservation scientists.

(v) Molecular marker technology

(a) Biochemical marker

Different variants of the same enzymes having identical or similar functions are known as isozymes. They are powerful tools for the study of genetic variability within and between populations of plants and animals. They are useful when several taxa, accessions and individuals are to be compared, to identify clones and to examine the clonal structure of various plant populations.

(b) Phytochemical markers

The discovery of phytochemicals from wild plant species is an achievement toward the eradication of the human diseases. With the advancement of modern techniques such as mass spectrometry (MS) and nuclear magnetic resonance spectrometry (NMR) combined with different separation techniques facilitated the identification and structural elucidation of these phytochemicals. These phytochemical analyses are valuable tools for taxonomic differentiation within species or for evaluating the effect of environmental factors. Variation in biosynthesis of these metabolites could be a result from both genetic and environmental factors, which play important roles in the development of phenotypic variations in plants.

(c) DNA Marker based techniques

DNA based markers either PCR based or non-PCR based. DNA markers assessed genetic diversity based on polymorphism. The polymorphism may be defined as simultaneous occurrence of multiple phenotypic forms of a trait attributable , restriction fragment length polymorphism (RFLP), random amplified polymorphic DNA (RAPD), amplified fragment length polymorphism (AFLP), sequence characterized amplified regions (SCAR), simple sequence repeat (SSR), inter simple sequence repeat(ISSR), Single nucleotide polymorphism (SNP) those are either PCR based or nonPCR based techniques.

(d) Gene Transformation

Genetic transformation is a powerful tool for enhancing the productivity of novel secondary metabolites of limited yield. Genetic transformation facilitates the growth of medicinal plants with multiple durable resistances to pests and diseases. Likewise, transgenes or marker-assisted selection may assist in the development of insect, pest, and drought, salinity resistant plants, which will be needed to fulfill the ever increasing world's need and save land for the conservation of biodiversity in natural habitats. These genetically transformed cultures can produce secondary metabolites in large amounts and can be a promising source for the constant and standardized production of

secondary metabolites. Production of potential pharmaceutical compounds using plant transformation strategies and transient expression system such as agro-infilteration and virus infection is known as molecular pharming or bio-pharming. Plants can act as factories for the biosynthesis of drugs or compounds which are very costly in the markets. There are various bio-products such as vaccine, antigen, antibody, therapeul and nutraceutical proteins, non-pharmaceutical plant derived proteins are being produced using molecular pharming.

Summary

The main objective of germplasm conservation is to maintain constant preservation of germplasm as it can be available at any time. Biotechnological approaches are imperative for rapid multiplication and conservation of the critical genotype of medicinal plants. These include in vitro propagation through tissue culture, Genetic transformation, Cryopreservation, DNA banks etc.

Biotechnological methods of biodiversity conservation offer many advantages to conventional procedures. Biotechnology be agricultural productivity and help in the preservation of biodiversity. Biotechnological methods of preservation have potential for long term storage.

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References:

1. Ahmad F, GopaL Raju L (2017) Assessment of threats to forest ecosystems using geospatial technology in Jharkhand state of India. Curr World Environ 12:11
2. Ahmad B, Khan H, Bashir S, Nisar M, Hassan M (2006) Inhibition activities of Colchicum luteum Baker on lipoxygenase and other enzymes. J Enzyme Inhib Med Chem 21:449-452.
3. Giam X, Bradshaw AJC, Tan TWH, Sodhi SN (2010) Future habitat loss and the conservation of plant biodiversity. Biological Conservation143: 1594-1602.
4. Engelmann F (2011) Use of biotechnologies for the conservation of plant biodiversity. In Vitro Cellular and Developmental Biology- Plant 47: 5–16.
5. Bhatt JR, Singh JS, Singh SP, Tripathi RS, Kohli RK (eds) (2012) Invasive alien plants. An ecological appraisal for the Indian Subcontinent. CABI, Wallingford.
6. Rai PK, Singh JS (2020) Invasive alien plant species: their impact on environment, ecosystem services and human health. Ecol Indic 111:106020.
7. Chaudhry P, Murtem G (2017) An ethno botanical note of the plant species used by local tribes for dwelling purposes in the Eastern Himalaya of India and some forest management related pressing issues. Ecol Quest 27:53–64.

8. Kanade R, John R (2018) Topographical influence on recent deforestation and degradation in the Sikkim Himalaya in India; implications for conservation of East Himalayan broadleaf forest. Appl Geogr 92:85–93.
9. Lanker U, Malik AR, Gupta NK, Butola JS (2010) Natural regeneration status of the endangered medicinal plant, Taxus baccata Hook. F. syn. T. wallichiana, in northwest Himalaya. Int J Biodivers Sci Ecosyst Serv Manage 6:20–27.
10. Thatheyus AJ (2006) Threats to Indian biodiversity. In: William SJ (ed) Biodiversity: life to our mother earth. Loyola College, Chennai, pp 217–230
11. Sharma DK, Sharma T (2013) Biotechnological approaches for biodiversity conservation.Indian Journal of Scientific Research 4: 183-186.
12. Pilatti FK, Aguiar T, Simões T, Benson EE and Viana AM (2013) In vitro and cryogenic preservation of plant biodiversity in Brazil. In Vitro Cellular and Developmental Biology-Plant 47: 82–98.
13. Lidder P, Sonnino A (2011) Current status of biotechnologies for the management of crop genetic resources. In: Lidder P, Sonnino A (Eds.) Biotechnologies for the management of genetic resources for food and agriculture, FAO, pp. 1-153.
14. Samejo MQ, Burdi DK, Bhanger MI, Talpur FN, Khan KM (2010) Identification of hydrocarbons from Abies pindrow leaves. Chem Nat Comp 46:132–134. https://doi.org/10.1007/s10600-010-9547-z
15. Shyaula SL (2011) Phytochemicals, traditional uses and processing of Aconitum species in Nepal. Nepal J Sci Tech 12:171–178.
16. Singh B, Ishar MPS, Sharma A, Arora R, Arora S (2015) Phytochemical and biological aspects of Rudraksha, the stony endocarp of Elaeocarpus ganitrus (Roxb.): a review. Isr J Plant Sci 62:265–276. https://doi.org/10.1080/07929978.2015.1020659
17. Singh N, Tewari A, Shah S (2020) Catkin maturation timing and seed germination in Betula utilis (D. Don) in the western Himalayan treeline area of Uttarakhand. J Adv Sci Res:11
18. Reed BM, Sarasan V, Kane M, Bunn E and Pence V.C (2011) Biodiversity conservation and conservation biotechnology tools. In Vitro Cellular and Developmental Biology-Plant 47: 1– 4.
19. Ashmore SE, Hamilton KN and Offord C.A (2011) Conservation technologies for safeguarding and restoring threatened flora: Case studies from Eastern Australia. In Vitro Cellular and Developmental Biology- Plant 47: 99–109.
20. Khan S, Al-Qurainy F and Nadeem M (2012) Biotechnological approaches for conservation and improvement of rare and endangered plants of Saudi Arabia. Saudi Journal of Biological Sciences 19: 1–11.