ISSN: 2457-0761

JBC-APRF-3(4):1-1, 2019

JOURNAL OF BIODIVERSITY AND CONSERVATION

Biodiversity loss: Ecological issues and mitigation through plant Biotechnology

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ARTICLE INFO

Article History

Received: 2 September 2019

Received in revised form: 2 October 2019

Accepted: 2 November 2019

Keywords: Biotechnology, Biodiversity, Anthropogenic activities

ABSTRACT

Anthropogenic activities are responsible for global biodiversity loss. The ecological issues could be the key to understand the mitigation measures & biotechnological approaches could be fruitful way to mitigate the biodiversity loss. The present study highlights the importance of biotechnology.

INTRODUCTION

BIODIVERSITY

Biodiversity represents the variety and variability of life: between the species and the ecosystems. Multifariousness provides the premise for ecosystems and their services upon which all living organisms as a unit is dependent. It touches both upon native environments on land and sea as well as agricultural and other man made surroundings. 3.5 billion years of evolution has resulted in the biodiversity that we observe today. Biodiversity in India is ideally quite spectacular with a rich heritage of 91,200 species of animals and 45,500 species of plants, making it one of the 12 mega diversity countries in the world. Reportedly, two biodiversity hotspots are found in India: The Eastern Himalayas and The Western Ghats.

Agricultural Biodiversity

The biodiversity that includes all the components relevant to food and agriculture is referred to as Agro biodiversity. Agricultural biodiversity is central to sustainable food systems and sustainable diets. Crop diversity is vital for providing beginning material for breeding. However, the genetic diversity found in agriculture biodiversity (monoculture) is less broader than the genetic diversity observed in plants and animals living in the wild (multicultural). This points out to the importance of wild, untamed species in agricultural breeding programs. Nevertheless, if monoculture is not looked after, it spontaneously turns to multi culture diverse system. It is seen that diversity in plant increases the ability to withstand perturbation. So, mixtures of varieties of crops could offer higher yield and be more resistant to pests and diseases than monocultures.

Convention on Biological Diversity

The continuous loss of biodiversity has not only imposed threats to all creatures but also disturbed several ecologically balanced systems. It has been estimated that one third of the global plant species are threatened at different levels according to International Union of Conservation of Nature (IUCN) (IUCN 2013).To cease biodiversity loss, the international community developed the Convention on Biological Diversity (CBD) prior to the Rio Earth Summit in 1992. The CBD has become one of the world's most vital multilateral environmental agreements and a key tool for sustainable development. About 196 member-states and over 6,000 participants have been meeting for quite 25 years to deliberate and come up with policies to protect biodiversity.

Threats to Biodiversity

CBD stratified the priority of threats to global biodiversity in the following manner:

Habitat loss: The biggest threat to biodiversity is habitat destruction. The one species that is globally expanding in numbers are humans. This has increased the spread of cities accompanying with the expansion of agriculture. The requirement for food is anticipated to double in the next Thirty years particularly in the less developed countries. The tropical humid forests are the main hotspots of biodiversity. Burning and selective logging can disrupt the balance in the biodiversity.(Braun et al, 2020)In this current scenario, undertaking of effective as well as productive agricultural land uses has raised a global challenge of conserving biodiversity (Tscharntka et al. 2012).

Introduction of exotic species: According to Sukopp & Sukopp (1993), one in ten imported plants may spread in a modest way and that one in a hundred may turn into a nuisance weed. These foreign plants become a threat to the native ones as being extremely competitive and often by lacking local predators like insects and birds. In line with the World Conservation Union (IUCN), habitat loss followed by Invasive Alien Species (IAS), has been a serious explanation for extinction of native species. According to Lowe, the harm caused by invasive species has been estimated to be £1 trillion per annum – close to 5% of global GDP (Lowe et al. 2000).

Flood, drought, salinization, climate changes: These are combinely become the third cause for diversity loss. Another cause may well be thanks to several years of Man-wild conflicts. This has increased the extinction rates about 1000 times than before.

Ecological issues

The threats to biodiversity have posed many issues on the environmental basis. Some of the major issues are pollution of land, air and water, land degradation, ozone depletion, climate changes, loss of natural and cultural resources. This has ultimately damaged the habitats of plants and animals including humans. Consequently, it has resulted in warfare, genocide, starvation, diseases epidemics and pandemics and collapse of society. Humanity has made unprecedented collected effort and brings about sustainability. This cannot demolish ecological issues from the root but can reduce its effect. These issues are addressed at a regional, national or international level by government organizations. The United Nations Environment Programme is the largest international agency, set up in 1972, that coordinates the UN's environmental activities and helps the developing countries to implement environmentally sound policies and practices.

Conservation of Biodiversity

As the conservation of biodiversity is a global concern, several strategies have been adopted in understanding and conserving plant diversity throughout the world. Both *ex situ* and *in situ* methods of biodiversity conservation are equally important. They are applied for the conservation of Red Listed Plants (IUCN 2013) In situ involves the natural presence of ecosystems, species and habitats; and preserve it. Whereas ex-situ conservation involves the up-keep of living samples outside the natural resources e.g. botanical gardens, gene banks, seed banks, etc. Although it's typically believed that biotechnology has adverse effects on biodiversity, however indeed, biotechnology offers new means of improving biodiversity. It is currently well recognized that an applicable conservation strategy for a specific genotype requires combining approach of *ex situ* and *in situ* techniques in line with the need of the program.

The power of Biotechnology

Biotechnology is a set tools and techniques used to modify living tissue for the production of food, drink, medicine or for other benefits to the human being, or other animal species. (Olomolo et al. 2019). The history of biotechnology is deep frozen in time ranging from the domestication of untamed plants and animals to the actual selection of the best (Pathak et al. 2014). It was shown by both Karembu and Campa that biotechnology depends on biodiversity that provides the genes and traits that support human upheaval. Different biotechnological methods like several molecular marker techniques starting from biochemical, physiological and DNA based marker has helped to conserve analyses and detect genetic diversity of rare and endangered species. Genetic variability is the main perquisite of the survival of any plant species in their natural habitat, so study of genetic diversity in conserved germplasm is important and application of different biotechnological processes, especially in vitro culture and molecular biology particularly transgenic technology are playing a promising role. This has also led to the production of a new category of cell lines with special attributes and genetically transformed material (Pathak et al. 2014).A protocol popularly known as "The Cartagena Protocol on Biosafety" was developed as a result of this very terribly relevant reason that the world community appreciated the potential positive impact of biotechnology in the conservation of biodiversity (Braun et al. 2002)

Biotechnology has pushed us from green revolution to gene revolution. Let's discuss some of its techniques.

1. **Plant tissue Culture** is an effective method of cloning plant materials

and producing clean plant stocks. Since every cell of the plant body has the power of totipotency to divide to a whole new plant, any part of the plant body can be used as a tool to conserve it for next generations. PTC has paved way for increasing the rate of plant productions by their quick regeneration. It has been really helpful in case of plants that do not produce seeds until certain age, storage of parts that can be vegetatively propagated and seeds which have low capabilities of germination. Different techniques in PTC could supply bound benefits over traditional strategies of propagation for assembly, proliferation, preservation and storage of plant genetic resources (Bunn et al. 2007). Fischer pointed out PTC can be applied in the regeneration of clean disease free stocks of plants in the area of agriculture, floriculture, horticulture and pharmaceutical industry (Fischer et al. 2004). 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 harm to the existing population using PTC techniques (Pathak et al. 2014)

2. **Molecular Marker Technology** involves the gene or a DNA sequence with known location on specific fragment that can be used to identify an individual species. A genetic variability among the germplasm can be easily determined either by using biomolecular markers or by using DNA based markers such as 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), those are either PCR based or non PCR based techniques (Glaszmann et al. 1987; Khan et al. 2012). A variety of applications of this technology is found in the field of phylogenetic studies , trait identification and mapping, DNA fingerprinting, genetic diagnostics, study of genome, gene tagging, identifying location in QTL's, and Marker assisted selections. For instance, in 1998, the plant breeding team at the School of Engineering of Orihuela (EPSO), part of the Miguel Hernández University (UMH) in Elche, initiated a tomato breeding program. Marker-assisted selection and backcrossing were used to simultaneously introduce three genes (*Tm-2a*, *Ty-1*, and *Sw-5*) that confer resistance to relevant viruses, such as tomato mosaic virus (ToMV), tomato yellow curl virus (TYLCV), and tomato spotted wilt virus (TSWV), to traditional varieties of local tomatoes, specifically the "Muchamiel" and the "De la pera" types (Carbonell et al. 2018)

3. **Invitro production of secondary metabolites** Various methods like biotransformation (a substrate is chemically converted to different product via living cell culture), plant cell immobilization (cell ceases to grow and accumulates metabolites), genetic transformation and elicitors (organic/inorganic agents in PTC trigger rapid production of

Secondary metabolites) have become valuable for the production of secondary metabolites of interest. Pharmaceutical products of interest like Morphine and Codeine, Taxol, Ginsenosides, Berberine, Diosgenin, Vinblastine and Vincristine have been successfully produced. Thus, there is economical production of certain chemicals that cannot be done by chemical methods.

4. **Growth Restriction in Cell Culture** The frequency of subculture can be reduced by using different slow growth inducing situations such as alternation of growth regulators, modification of salt and sugar concentrations, addition of osmotically active compounds and sometimes change in external factors (Temperature, humidity, etc.) (Bunn et al. 2007; Reed &Chang 1997) The slow growth strategy is routinely used in medium-term conservation of many species both from tropical and temperate regions as well as endangered species.
5. **Cryopreservation** is the preservation of living cells, tissues organs and microorganisms at ultralow temperature (usually that of liquid nitrogen, -196 °C). All the metabolic processes and cell divisions are stopped by the use of liquid nitrogen. As a result, the cells do not undergo any genetic changes while storage. Cryopreservation is very suitable method to conserve rare, endangered, threatened plant species (Zhao et al. 2008) Cryopreservation of shoot tips is also being applied to eradicate systemic plant pathogens, a process termed "Cryotherapy". Till today, severe pathogens have been eradicated in sweet potato (*Ipomoea batatas*) banana (*Musa* spp.), raspberry (*Rubusidaeus*), grapevine (*Vitisvinifera*), potato (*Solanum tuberosum*) and *Citrus* spp., *Prunus* spp. using Cryotherapy. These pathogens include 9 viruses (sweet potato feathery mottle virus, sweet potato chlorotic stunt virus ,banana streak virus, grapevine virus A, raspberry bushy dwarf virus, cucumber mosaic virus, plum pox virus, potato virus Y and potato leaf roll virus) (Cruz-Cruz et al. 2013)It may be well integrated as an additional insurance policy for storing plant biodiversity.
6. **Plant DNA Bank** helps in the maintenance of a higher genetic diversity of a particular genetic stock. The International Plant Genetic Resources Institute (IPGRI) and the Consultative Group on International Agricultural Research (CGIAR) Centers like the International Center for Agricultural Research in the Dry Areas (ICARDA) are involved in the conservation of rare and vulnerable plant species by maintaining in *vitro* DNA bank.(Reed et al. 2004; ICARDA 2014).Since there is a chance of genetic erosion during the storage condition, regular examination of tissue culture derived plants must be done to identify any morphological changes or to spot any soma clonal variations. It is very important to select and preserve desirable soma clonal that can be a vital source of genetic variability (Pence et al. 2002).
7. **Genetic Engineering** Wild species are extremely rich resources of

useful genes not available in the cultivated gene pool. The genetic base has to be widened to cope with challenges different plants have to face. Genetic engineering has been put forward to conserve the agricultural biodiversity cytogenetically that ultimately allow for the incorporation into the crop with the wild gene of our interest. Chromosome engineering has been successfully applied to introduce into wheat genes/QTL for resistance to biotic and abiotic stresses, quality attributes, and even yield-related traits (Ceoloni et al. 2017)

The smart approaches – "Nanobiotechnology"

Nano biotechnical approaches have enabled engineering and development of smart plant sensors which translates plant chemical signals associated with stress or resources deficiencies into digital information that can be monitored by various electronic devices. This has helped in the study of signal molecules, enabled fine tuning resource use by interacting with agricultural devices thereby improving plant growth and crop yield. It has applications ranging from development of technology in laboratory to chemical phenotype for urban farming. Recently, this technique has been used to deliver DNA plasmids into plant cells using high aspect ratio nanomaterial without any chemical or mechanical aid (Giraldo et al. 2019)

CONCLUSION

Biodiversity is the basis for every one of us to thrive. It has been the fundamental nurturing system for all the creatures present till date. The extent of its exploitation has catered threats to our future. Since tomorrow never comes, today is the day itself we should start conserving it. The nature needs space from mankind for its own protection. The multidisciplinary approach to biotechnology has resulted in a new and unique interdisciplinary area in which molecular biology, different branches of engineering, electronics etc. have played a pivotal role in conservation of modern biotechnology within reach of the common man. From application point of view, like the twin strands of DNA double helix, biotechnology and conservation are joining forces with technological explosion that will dwarf what will be possible by either one of them.

Though biotechnological methods offer many advantages to conventional procedures, yet it has various social consequences that should be taken care of. The generation, adaptation and adaptation of these biotechnical tools require a consistent level of financial and human resources and appropriate policies need to be in place. Meeting the projected in global demand for food and biodiversity conservation in this century requires interdisciplinary and convergent approaches to boost sustainability. If human race has to survive on this planet, we need to reorganize our ability to act and think on a global scale with more responsibility.

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