Pocket K No. 44

Biotechnology for Biodiversity

Biological diversity (biodiversity) is the variability among living organisms: within and between species and ecosystems. Biodiversity is considered as the foundation of agriculture being the source of all crops and livestock species that have been domesticated and bred since the beginning of agriculture approximately 10,000 years ago.[1] Crops like corn and wheat were inedible wild crops but through years of domestication, edible varieties have been made available as important commodities.

One of the tools used to enhance biodiversity is biotechnology.[2] Biotechnology covers a variety of techniques and applications that allow changes and improvements in living organisms to provide desirable products for man's use. Biotechnology is presently used for the conservation, evaluation, and utilization of biodiversity particularly for important crops.[3]

Biotech for Conservation

At present, loss of specific species, groups of species (extinction) or decrease in number of particular organisms (endangerment) are taking place in different parts of the world at a rapid pace. These losses are often manifestations of degradation or destruction in the ecosystem or habitat.[4] According to the Food and Agriculture Organization of the United Nations (FAO), it is estimated that about three-quarter of the genetic diversity in agricultural crops have been lost over the last century due to various reasons such as combination of different agricultural production systems and globalization.[5]

DNA Banks

More plant conservationists are turning to DNA technologies to have effective conservation strategies. The DNA bank is an efficient, simple and long-term method used in conserving genetic resource for biodiversity. Compared to traditional seed or field gene banks, DNA banks lessen the risk of exposing genetic information in natural surroundings. It only requires small sample size for storage and keeps the stable nature of DNA in cold storage. Since whole plants cannot be obtained from DNA, the stored genetic material must be introduced through genetic techniques.[6]

A number of DNA banks are present worldwide which include those managed by the International Rice Research Institute, South African National Biodiversity Institute, and National Institute of Agrobiological Sciences in Japan. Gene bank documentation has been enhanced with the advances in information technology, geographical information systems (GIS), and DNA marker technology. Information on DNA assessment of variation derived through these technologies help search for important genes.[7] Information from DNA collections are available online through biodiversity initiatives such as Global Biodiversity Information (www.gbif.net), Species 2000 (www.species2000.org), and Inter-American Biodiversity Network (www.ukbiodiversity.net).[8]

In vitro techniques are also valuable for conserving plant biodiversity.[9] Such techniques involve three basic steps: culture initiation, culture maintenance and multiplication, and storage. For medium-term storage (few months to few years), slow growth strategies are applied. For undefined time of storage, cryopreservation is applied.[10] In cryopreservation, plant tissues are processed to become artificial seeds and stored at very low temperatures to impede growth. Cryopreservation allows 20 percent increase in regeneration process compared to other conservation methods.[11]

Biotech for Evaluating Genetic Diversity

Germplasm refers to living tissues from which new plants can form. It can be a whole plant, or part of a plant such as leaf, stem, pollen, or even just a number of cells. A germplasm holds information on the genetic makeup of the species. Scientists evaluate the diversity of plant germplasms to find ways on how to develop new better yielding and high quality varieties that can resist diseases, constantly evolving pests, and environmental stresses.[12] Germplasm evaluation involves screening of germplasm in terms of physical, genetic, economic, biochemical, physiological, pathological, and entomological attributes.[13]

Molecular Markers

Molecular markers are used to map out the genetic base of crops and select favorable traits to come up with a better germplasm for growers. Molecular markers are short strings or sequence of nucleic acid which composes a DNA segment that are closely linked to specific genes in a chromosome. Thus, if the markers are present, then the specific gene of interest is also present.

Marker-assisted selection (MAS) such as single nucleotide polymorphisms (SNPs), is widely used in different agricultural research centers to design genotyping arrays with thousands of markers spread over the entire genome of the crops.[14]

After observing the desired traits in selected plants, these are then incorporated through modern or conventional breeding methods in existing crop varieties. Generated plants with the desired trait may be tested in the field for agronomic assessment and resistance screening against pests and diseases. Selected plants plants will be multiplied through tissue culture and other techniques.[7]

Recent advances in genomic, proteomic and metabolomic research offer unique opportunities for the search, identification, and commercial utilization of biological products and molecules in the pharmaceutical, nutraceutical, agricultural, and environmental sectors.[15]

DNA and Protein Profiling

To come up with effective conservation management programs for endangered crop varieties, it is important to evaluate their genetic relatedness and distances from other relatives. Such information could be derived through DNA profiling commonly conducted through electrophoresis.

Through this method, an individual organism is identified using unique characteristics of its DNA. DNA profiling depends on sections of the DNA that do not code for a protein. These areas contain repetitive sections of a sequence called short tandem repeats (STRs). Organisms inherit different numbers of repeated sequences from each parents and the variation in the number of repeats within an STR lead to DNA of different lengths. The targeted STR regions on the DNA are multiplied through polymerase chain reaction (PCR) and then separated by electrophoresis in a genetic analyzer. The analyzer is composed of a gel-filled capillary tube where DNA travels. When electric current is passed through the tube, the DNA fragments move through the gel tube by size (smallest travels first). The digital output of the analyzer is read and interpreted through a genotyping software.[16]

Proteins are involved in different important processes within the cell. The entire set of proteins in a cell is referred to as proteome, and the study concerned with how proteins work and assembled is called proteomics.[17] Proteomics is based on the end-products of gene activity: the protein patterns formed from unique genetic activities. Through two-dimensional acrylamide gel electrophoresis (2DE), complex mix of proteins is sorted in based on each protein’s specific combination of charge and molecular weight. These patterns are standard for protein discovery because the same proteins would migrate at the same points on the gel. The protein bands are developed in digital images and then analyzed in mass spectrometers.[18]

Biotech for Biodiversity Utilization

Most cultivated plant species have lost their inherent traits that came from their wild ancestors. These traits include resistance to harsh environmental conditions, adaptation to various soil and climate conditions, and resistance to pests and pathogens.[19] To utilize these important traits in cultivated varieties, scientists search for the genes that confer such important traits. They use conventional and modern biotechnology to create improved genetic variations of crops.

One of the most widely used traditional technique in plant breeding is hybridization or the crossing of parent lines (pure breeds of the same species) with desirable traits to come up with an improved line called hybrid. It takes advantage of heterosis or hybrid vigor, a phenomenon that brings out the superior qualities of the pure breeds through breeding. Desired traits can also be employed in plants through modern genetic modification techniques such as particle bombardment and *Agrobacterium tumefaciens*-mediated transformation.[20]

Biotech and Biodiversity for Benefit of All

Development of biotechnologies raised fears on loss of genetic resources on the part of farmers and developing countries. This called for public policy interventions that promote provision of public goods associated with agricultural biodiversity conservation and direct biotechnology development to meet the needs of the developing world.[20] One of the policies formed to answer this need is the *Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity* which was adopted at the 10th meeting of the Conference of Parties on October 29, 2010 in Nagoya, Japan. Through the Protocol, a legal framework is set for the biotechnology industry to manage access to genetic resources and provide fair and equal sharing of benefits.[21] The Protocol was acknowledged by the Biotechnology Industry Organization (BIO) as a helpful guideline to meet the common goal of conserving and sustaining biological diversity in all levels.[22]

A wide range of biotech products have shown that biotechnology has been highly profitable for farmers and the society especially in the fields of agriculture and medicine. Biotechnology applications offer opportunities to make substantial advances in our knowledge of the diversity of some of the most important crops.[23] Together with the traditional techniques, these applications lead us to more impact in plant genetic resources and biodiversity in general and in return meet the needs of the massively growing population and sustain life under rapidly changing climate.

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