Biotechnology and biodiversity

Biotechnology is generally considered to be "any technique that uses living organisms to make or modify a product, to improve plants or animals, or to develop microorganisms for specific uses". Modern biotechnologies offer vast potential for improving the quality and increasing the productivity of agriculture, forestry and fisheries. Genes from plants, animals and microorganisms that flourish in the forests, fields and seas of the developing world are the strategic raw materials for the commercial development of new pharmaceutical, agricultural and industrial products. Whereas genetic wealth, especially in tropical areas such as rainforests, was once a relatively inaccessible trust fund, it is fast becoming a highly valuable currency.

Introduction of modern biotechnologies in the developing world is frequently compared to the Green Revolution. While the Green Revolution involved introducing new varieties of primarily wheat and rice in selected areas, biotechnology has the potential to affect all crops and tree species, as well as fish and livestock, in any corner of the globe. The Green Revolution was introduced to the Third World largely by international institutions, but the "Gene Revolution" is primarily in the hands of the private sector, with transnational corporations being the leading players. With few exceptions, scientific and technical capacity in the biosciences is centred in the industrialized world. As a consequence, biotechnology research, by and large, does not focus on the needs or interests of poor farmers in marginal areas of the world. Emerging biotechnologies have considerable potential to enhance food and agricultural production in the developing world, but they could also add to existing inequities by displacing traditional agricultural products, accelerating genetic erosion and introducing new environmental hazards.

MOLECULAR BIOLOGY is the most powerful tool of biotechnology. In the area known generally as genetic engineering, scientists can transfer genes between unrelated species endowing such "transgenic" plants, animals and microorganisms with properties that they could probably never have acquired in nature. As yet, only a handful of genetically engineered products are available commercially, but hundreds are in the pipeline.

Genetic engineers can design crop varieties containing natural insecticidal genes, fish with human growth hormones, and faster growing trees. It must be stressed, however, that genetic engineering consists essentially of mixing and matching genes from different species. It cannot create genetic material, replace lost material or eliminate the need to conserve living resources.

Molecular biology is important in characterizing and conserving biodiversity. For example, molecular markers can help establish the extent of diversity within a species and to identify genes of interest to breeders. Such techniques can also help establish priorities for conservation.

Biotechnology to protect biodiversity

Biotechnology already assists the conservation of plant and animal genetic resources through:

- new methods for collecting and storing genes (as seed and tissue culture);
- detection and elimination of diseases in gene bank collections;
- identification of useful genes;
- improved techniques for long-term storage;
- safer and more efficient distribution of germplasm to users.

(non vedo come questi punti possano essere a favore della biodiversità)

Tissue culture is just one example. The technique, which involves growing small pieces of plant tissue or individual cells in culture, provides a fast and efficient way of taking numerous cuttings from a single plant. In many cases, entire plants can be regenerated from a single cell because each cell contains all the necessary genetic information. After selecting a disease-free cutting, for example, scientists can mass-produce copies that are genetically identical. This is the basis of plant cloning, or micropropagation of plants.

In gene banks, tissue culture is now used routinely to preserve the genetic information of plants which have seeds that do not store well, are sterile or have poor germination rates. Plant cells maintained on a growth medium in a test-tube replace seeds or plants. Plants stored in this way include sweet potatoes, bananas and plantains, apples, cocoa and many tropical fruits.

Biodiversity: obstacle or…

Biotechnology contributes to conservation and the sustainable use of biodiversity, but several areas exist where modern biotechnology may hinder development or create serious hardship for rural communities.

Substitution. The economies of developing countries are threatened by biotechnology research that promises to eliminate or displace traditional export commodities, often a primary source of foreign exchange. Current research, for example, focuses on substitutes for tropical oils and fats — ranging from cocoa butter to castor oil. Biosynthesis in the laboratory of high-value ingredients such as vanilla, pyrethrum and rubber could ultimately transfer production out of farmers' fields and into industrial bioreactors. Without ample opportunity to plan and diversify, developing country farmers and their botanical exports may suffer massive displacement, wreaking havoc on already weak economies.

A new wave of genetic erosion?

Biotechnology may threaten the genetic diversity on which it depends. In the absence of conservation, commercial biotechnology may unleash a new era of genetic erosion. A commercial venture in Chile, for example, can propagate up to 10 million eucalyptus seedlings, all identical clones, in automated nurseries. Similarly, commercial semen and embryo transfer services for domestic animals raise concern about the displacement of traditional livestock breeds. Cloning could accelerate replacement or dilution of indigenous stock by imported breeds, leading to a loss of genetic diversity.

Biosafety. A related concern involves the ecological risks of introducing genetically engineered plants into centres of diversity. Transgenic varieties, a good number of them resistant to herbicides, have been produced in more than 40 crop plants. Gene flow to weeds from resistant plants could have far-reaching consequences. The resulting herbicide-tolerant weed could be difficult to control, harming future crop production as well as the surrounding ecosystem. Will biotechnology firms seeking to penetrate markets in developing countries take into account the risks posed in regions where wild and weedy relatives of major food and industrial crops are found? Will the developing countries have the capacity to monitor and assess the risks?

…**opportunity for development?**

Biotechnologists could develop new varieties and breeds adapted to low-input agriculture or harsh conditions, or improve processing. Biotechnology may help create markets by developing new industrial, medicinal and aromatic crops. Given their richness in biodiversity, several developing countries that have the capabilities, such as Brazil, China and India, could produce new high-value products based on local flora. The congenial agro-ecological settings and availability of relatively cheap labour should be conducive to large-scale production of new high-value crops, enabling such countries to maintain their comparative advantage in these commodities.

The use of biotechnology to develop biofertilizers and to detect and control pests and pathogens will be particularly helpful to poor farmers. Such technologies could also bring trading advantages by removing non-tariff barriers arising from the presence of pesticide residues or pest infestation in food commodities that otherwise have an export, and therefore income-generating, potential.

The fundamental question posed by biotechnology remains: Who will control the new technologies and benefit from them? FAO is trying to strengthen national capacities to exploit biotechnology for sustainable, low-input agriculture, and to encourage biotechnology research on products/commodities that are important to developing nations. It is also fostering the best uses of biotechnologies to identify and conserve genetic resources. Finally, FAO is developing a Code of Conduct that covers the issues raised above.

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.