Application of biotechnology in natural resource management

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The untamed natural essence is known as natural resource. The sources can be categorized into renewable, flow and non-renewable sources. While renewable resources primarily involve living sources such as plant and animal forms and non-living resources like water and soil. Scientific and sensible use can lead to preservation of renewable resources. The basic characteristic of renewable resource is its sustainability. Flow resource includes wind, tide and sunlight (2007). The preservation of natural resource is of paramount importance for the sake of ecological balance and our ultimate survival in this planet. This planet holds a large amount of land and water resource. Human civilization is mainly concentrated in the huge land mass of this planet. We inhabit in this land mass and directly or indirectly exploit the natural resource of world.

Due to its geographical location, India is bestowed with rich natural resources arraying from dense stretches forestry to a number of water bodies. Many natural resources distributed across Indian landscapes are biological. With the formulation of the Third Five Year Plan, the stage has reached when, as a necessary condition of well-conceived long-term plans, a comprehensive view was taken by Government to study the extent and quality of the information available in respect of the country's main natural resources. Forest, fisheries fall in this category got special attention which requires proper exploitation (Vedam, 2000). The attainment of this objective involves the development of scientific methods for assessment of the nation's natural and human resources. Expanded demand for natural resources and materials has led to technological developments which have in part overcome limitations and thus increased the supply of resources. A strategy was developed to look at the management of natural resource in a coordinated manner and its investigation and utilization planned for long-term needs (Gilne, 2005). The extent to which resources have been studied and possibilities established ahead of needs is an important factor determining the rate at which the economy can grow. Our country is rich in plant biodiversity and its preservation is of utmost importance for sustainability of human civilization. Biotechnology and genetic engineering are the two technological tools that can be exploited for the management of renewable natural resources like plant and animal diversity.

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Biotechnology in managing the value of biology

In case of natural resource management the recent trend is the utilization of currently developed technologies. Biotechnology is a comparatively new one which in combination with other conventional eco-friendly techniques could be applied for landscape and natural resource management. Biotechnology is a system for application of different modern devices to living organisms or their derivatives for specific uses. In this connection another very widely used term needs mentioning *i.e.* genetic engineering. This term has a history of modifying biological organisms according to the need of humanity. In past biotechnology was used in the food processing and agricultural industries. After 1971, western scientific establishment developed laboratory-based techniques in biological research, such as recombinant DNA or tissue culture based processes, or horizontal gene transfer in plants using vectors to transfer DNA into a host organism. This technology is a comparatively new one combines the disciplines like genetics, molecular biology, biochemistry, embryology and cell biology (Maga, 2005). This technique has enormous potential for utilization in plant resource management. Its computational application or bioinformatics, drug production, pharmaco-genomics, gene therapy, and gene testing etc can lead to identification and utilization of a large amount of unexplored floral resource of India.

Green biotechnology is a comparatively new sector of biology which mainly deals with agriculture and the products of this area create considerable scope and debate on its environmental sustainability (Pasqual, 2007). Wild and stocked species are valuable as fodder plants and trout stocks for recreational fishing. Different biochemical and pharmaceutical resources fall in this category which has been traditionally valued by indigenous and non-indigenous contemporary practices. Ethno botany provides information about floral emblems and indigenous practices giving details of herbal medicinal and their economic importance. Though natural resource management is a vast area but in this article we will mainly deal with landscape and plant resource management with its prospects and drawbacks but the same techniques could be utilized for faunal management with some modifications.

Sources of biotechnology

Medicine and commercial pharmaceuticals are the focus area where the development of biotechnology first took place. Intense, well-funded research happens in this sector which is a far cry from NRM and landscapes. Agricultural biotechnology research, a product of dedicated effort and expense delivers a biotechnological invasion to a limited section of landscape and natural resource domain. The technologies involving molecular aspects of biology is a challenging domain of biology but still it sits outside the area of landscape and NRM. The great majority of the transgenic (genetically modified, GM) crops commercialized to date have been particularly targeted towards large-scale commercial farmers are contested for risks and benefits. But smallholder farmers in Asia and South Africa have been growing GM crops mainly for insect-resistant cotton for several years, while transgenic varieties of subsistence food crops, with traits such as drought-tolerance, are under development. There has been a recent surge of attention and funding to stimulate new scientific and technological solutions to GM crops throwing challenges to smallholder agriculturist, especially in Asia and Africa. Poorer farmers and consumers stand to be strongly affected positively or negatively – by such advances.

Emerging issues and scope of research related to NRM

Some important trends of biotechnology could be utilized for NRM. Exponential increase in genetic sequence data of growing number of organisms with agricultural and ecological interest, development of genomic and post genomic era, proteomics, bioinformatics, parallel processing, automation and miniaturization are the positively important technologies with great prospect creating positive endeavor in NRM research. Some of the interesting areas of biological research in relation to natural resource are discussed in the following paragraphs.

1. Biodiversity conservation

The conservation of biological diversity is a global priority in strategic conservation plans that are designed to engage public policy and concerns affecting local, regional and global scales of communities, ecosystems, and cultures. This country is rich in biodiversity reserves and biotechnology is efficiently used for germplasm conservation. A large number of germplasms of different cultivated and indigenous food, fodder, medicinal and fruit plants were recorded using conventional or biotechnological means. In this area without involving genetic engineering only marker-assisted-selection (MAS) can help us to germplasm conservation and screening (Shendure, 2004). In case of citrus (*Citrus reticulata* Blanco) the germplasms collected from its centre of origin i.e., north-eastern Himalayan region were characterized and recorded through the application of RAPD markers (Mondal, 1996). This approach is the beginning of citrus germplasm conservation through genetic means.

2. Agriculture and production

One of the important aspects of biotechnology is engineering the desired outcome into plants. In this method utilization of conventional marker can lead to beneficial utilization of the improvised trait. Crops sometimes contain genes that enable them to withstand biotic and abiotic stresses. In crop productivity drought and excessive salty soil are two important factors causing constraints. A plant gene, At-DBF2 isolated from thale cress, a tiny weed is able to withstand environmental stresses like salt, drought, cold and heat, far more than ordinary cells (Abdulla, 2002). In case of rice yellow mottle virus resistant races are available but are more susceptible to fungal infections. Food proteins may be modified for their nutritional qualities. Proteins in legumes and cereals could be transformed to provide the amino acids needed by human beings for a balanced diet. The example of this area is golden rice. About 85 million tons of wheat flour is used every year to bake bread. Maltogenic amylase is an enzyme which keeps the bread fresh and increases its longevity. Modern biotechnology aims in reducing the application of agrochemicals and increasing biological dependence. *Bacillus thuringiensis* (BT) is a soil bacterium that produces a protein with insecticidal qualities. Normally, this toxin appears as an inactive protoxin, which requires digestion by an insect to become effective. Some crop plants have been engineered to contain and express the genes for BT toxin, which they produce in its active form. BT toxin binds to the gut wall and as a result the insect stops feeding and later dies. BT corn is commercially available and used to control lepidopteran insects (Stahly 1984). Crops are genetically engineered for broad-spectrum herbicide tolerance. The introduction of herbicide tolerant crops reduces the number of herbicide active ingredients used for weed management. In 2001, herbicide tolerance deployed in soybean, corn and cotton accounted for 77% of the 626,000 square kilometers planted to transgenic crops. BT crops accounted for 15% ‘stacked genes’ for herbicide tolerance and insect resistance used in both cotton and corn accounted for 8%. Biotechnology could be used for some novel uses other than food. Oilseeds can be modified for fatty acids used for detergent industries, substitute fuels and petrochemicals called bio-fuels. Potatoes, tomatoes, rice, tobacco, rice, lettuce,

safflowers and other plants have been genetically-engineered to produce insulin and certain vaccines (Anonymous, 2001). Transgenic plants can be grown locally and cheaply. Home grown vaccines would also avoid logistic and economic problems and also contamination. In this case the identification of Cleaved Amplified Portion (CAPs) and their transformation into Sequence Characterized Amplified Region (SCAR) markers in case of polygenic traits deserves mentioning (Denby 2005). Most of the genetic characters associated with yield are controlled by a large number of genes, each of which has a minimal effect on the overall yield. In this field the finding of the highly associated gene provides optimal result.

3. Landscape management emphasizing forest resource

Recent biotechnological endeavors include application of some biological techniques in land resource management like conservation of forest assets, control of weed plants, waste land management etc. In case of population control reproductive efforts like daughter-less (sex-bias) technologies, sterile feral (reproductively compromised organisms), sterility of insects, chemical contraception, immunocontraception (with or without genetically modified infectious agents could be taken up (Alphey, 2002). Some lethal measures could be included like application of toxins, biochemically specified toxicity and biological control. In case of maintenance of population health use of vaccines, medicines, anti-parasitic application needs mentioning (Gilna, 2007). Endogenous, introduced or genetically selected organisms could be involved for bioremediation and restoration. Functional and adaptive genetics provides enormous information for landscape restoration. This includes monitoring of soil microbial gene activity, population level adaptive responses to stressors, determination of ecologically relevant genes or alleles, elucidation of biochemical paths. Pheromonal or semiochemical investigation can lead to development of probing techniques for chemical signaling. Biosensors and sentinel organisms can create future development in sensor technique.

Criticism on application of biotechnology in NRM

Agricultural biotechnology can increase herbicide usage and resultant super weed residues with herbicide resistance. This super weeds cause genetic contamination of non-GM crops which hurt organic and conventional farmers. The genetically modified crops may create health and ecological damage which remains a contentious issue into which research continues. It is important to balance this large array of biotechnological promise against some of the emerging and plausible questions that we face from biotechnological application in NRM domain (Gilna, 2007). The crops should be planted with necessary buffer zones and refuge areas to reduce the risk of evolution of 'Bt resistance' a part of 'GM resistance'. The planting of GM resistant Poplar in China may cause serious ecological disruption at a very basal level of the food-web by the damage done by a population of tree feeding insects. The domestication of novel, native species with the assistance of genetic modification or marker assisted breeding need to be clearly examined. Unintentional dispersion of some new genes from genetically modified organisms (GMOs) to natural environment through breeding with wild plants causes genetic pollution. Gene introgression can lead to such situation. An often cited example of genetic pollution is the reputed discovery of transgenes from GE maize in landraces of maize in Oaxaca, Mexico. A clear demonstration of the genotypes selected to produce important agronomical traits can 'genetically pollute' the wild population and cause damage to the natural resource of our country (Canter, 2005).

Future prospect of utilization of biotechnology for NRM

The current commercial development in agricultural biotechnology also opens an area to innovate technologies that deliver environmental benefits. Special consideration should be given to marker-assisted selection and breeding. Funding could be productively directed to the establishment of genetic databases for new and prospective domesticates (Angulo, 2001). Both new production systems for sustainable agriculture and management of landscape ecosystem services can lead to better management practice in connection to natural resource. Biotechnology could be developed to provide rich and novel information regarding genetic measurement of total biodiversity, genetic diversity, and biochemical assays of health status and parasite/pathogen loads, disease screening etc. Landscape and NRM-relevant biotechnology could open new provision for examination innovation and of current and modified intellectual properties. Lastly a consolidated and collaborative approach from all sectors of life sciences needs to be united with expertise in landscape and NRM problems for its holistic improvement.

REFERENCES

Abdulla S. 2002. "Drought Stress" *Nature*: Science Update; http://www.nature.com/ nsu.

Alphey L. 2002 Re-engineering the insect sterile technique. *Insect Biotech. Bioche*. **32**: 1243-47.

Angulo E. 2001 When DNA research menaces diversity. *Nature* **410**: 739.

Anonymous 2001. Agricultural Biotechnology, Poverty Reduction and Food Security. http://www.adb.org.

Canter P.H., Thomas, H. and Ernst E. 2005 Bringing medicinal plant into cultivation: opportunities and challenges for biotechnology. *Trends in Biotech.* **23**:180-185.

Chevre A.M., Eber F, Baranger A. and Renard M. 1997. Gene flow from transgenic crops. *Nature.* **389** :924.

Denby K. and Gehring C. 2005. Engineering drought and salinity tolerance in plants : lessons from genome-wide expression profiling in *Arabidopsis*. *Trends in Biotech.* **23**: 308-15.

Diamond V., Chakrabarty., 1980. 447 U.S.303 was a United States Supreme Court case dealing with whether genetically modified micro-organisms can be patented. *Patent Act of 1952*.

Gilna B. 2007. Biotechnology and its application in natural resource management in Australia. *Land and Water Department, Australia*. http://www.lwa.gov.au.

Jeremy R. 1998. The Biotech Century: Harnessing the Gene and Remaking the World, published by J P Tarcher, ISBN 0-87477-909-X.

Maga E.A. 2005. Genetically engineered livestock: closer than we think? *Trends In Biotech.* **23**: 533-35.

Mondal B. 2006. Studies on the genetic diversity of mandarin (Citrus reticulate Blanco) orange plant types collected from North Eastern Himalayan (NEH) region. M. Sc. Thesis Bidhan Chandra Krishi Viswavidyalaya, Mohanpur.

Pascual D.W. 2007. "Vaccines are for dinner". *Proc. Nat. Acad. Sci. USA* **104** : 10757–58.

Rhymer J.M. and Simberloff D. 1996 Extinction by hybridization and introgression. *Ann.l Rev. Ecol. Systematics* **27**: 83-109

Shendue, J., Mitra, R.D., Varma, C. and Church, G.M. 2004. Advanced sequencing technologies: methods and Goals. *Natures Rev. Genet.* **4**: 335-44.

Vedams E. 2000. *A Directory of Indian Government* Departments and institutions dealing with Natural Resources. New Delhi. Centre for Science and Environment. pp. 458.