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THE FUTURE OF BIOTECHNOLOGY IN PAKISTAN

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ABSTRACT

From a human welfare standpoint, the greatest benefits of biotechnology will surely be derived from the adoption of improved Biotechnology procedures that may be defined as a technology based on biological systems – plants, animals and microbes or parts of it (cell, tissue, gene or DNA). Pakistan would have to focus on genetically modified and hybrid crops to tap true potential of agricultural productivity in the country in the shortest possible time through biotechnology.

Key Words: Modern biotechnology, Pakistan research institutes, Scope of biotechnology

INTRODUCTION

Biotechnology presents opportunities to greatly enhance the efficiency and productivity of biological pathways. Thus this new technology has great potential for transforming the genetic performance of specific qualities in plants, animals and humans including the alteration of growth or detection of diseases and unfavorable genetic traits. This is of tremendous value to agriculture, health, industry as well as conservation of biodiversity, and it is also important for translational commerce and trade.

Within the last 100 years, mankind has witnessed the rise of genetics as a scientific discipline (1900s), the discovery of DNA as the hereditary material (1944), the elucidation of the double helix structure of the DNA molecule (1953), the deciphering of the genetic code (1966), the ability to isolate genes (1973), and the application of DNA recombinant techniques (from 1980 onwards). The rapid advances

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in biotechnology make it rather difficult to analyze its future. Now when we talk about biotechnology we usually mean the technology derived primarily through the use of ‘recombinant DNA’. But recombinant DNA technology in principle although sounds to be simple (taking gene from one organism and putting into another) but in practice it is quite complex, tenacious, costly and challenging. Although the practice of biotechnology principles was very old, however the term ‘biotechnology got its due place after the principles of recombinant DNA technology or genetic engineering, coupled with tissue culture technique came into picture in the 1950s, and became popular in the 1960s. Biotechnology has considerable potential for promoting the efficiency of crop improvement, food production, and poverty reduction.

Scope

- Biotechnology has a wide scope ranging from diagnoses to treatment, agriculture to medicine, and from bioremediation to gene manipulation.
- Biotechnological industries are appearing as big share holders in local and global economy.
- As, this industry has flourished nation wide so, the employment opportunities in this industry has been increased a lot, which range from sales and marketing, to research and development, to manufacturing quality control and assurance.
- Biotechnology has devised such techniques and procedures which can provide the mankind with the safest, germ free and highly nutritious food, which is also resistant to pathogens, along with providing the shelter against the fetal diseases.

Background Information

Agriculture plays an important role in the national economy of Pakistan, where most of the rapidly increasing population resides in rural areas and depends on agriculture for subsistence. The importance and potential of biotechnology was realized as far back as 1959 when Pakistan's first Commission on Science and Technology emphasized the need for setting up research organizations in areas of vital importance to national development. Biotechnology has since been promoted in practically every science policy document. Pakistan's commitment to this field has been reflected in a separate allocation of the development budget to biotechnology in the Eighth and Ninth five year Plans.

Developing genetically modified (GM) crops to meet the requirement of increasing population in Pakistan, most of the activities have been on rice and cotton, which are among the top 5 crops of Pakistan. Biotic (virus/bacterial/insect) and a-biotic (salt) resistant and quality (male sterility) genes have already been incorporated in some crop plants. Despite acquiring capacity to produce transgenic plants, no GM crops, either produced locally or imported, have been released in the country. Pakistan could easily benefit from the biotechnological experiences of Asian countries; especially China and India, where conditions are similar and the agriculture sector is almost like that of Pakistan. Thus, the exchange of information and experiences is important among these nations. The major crops grown are wheat, rice, cotton, sugarcane, and maize. Gram and other pulses, oil seeds, and fodder crops are also grown in different parts of the country on sizeable areas. In Pakistan, the average yields of crops, despite rapid increase in the Green Revolution era, are still low compared to other countries. Hence Norman Bourlag (3) also suggested that new techniques in addition to conventional plant breeding are needed to boost yields of crops that feed the world. Nevertheless, such scientific advances in plant breeding led to 'green revolution', in 1970s which was also witnessed in Pakistan.

Desirable output traits might include prolonging shelf-life through vegetables that are more resistant to rotting and fungal infections, nutritionally superior foods, such as the vitamin A enriched ‘golden rice’ or tropical oils that are unsaturated, rust resistant food crops and agricultural products of medical value, such as edible vaccines (23).

Biotechnology has considerable potential for promoting the efficiency of crop improvement, food production, and poverty reduction, especially in developing countries like Pakistan. Agriculture biotechnology is helping today to provide people with more and better crops, food and holds even greater promise for the future. Green revolution farming methods are coming to an end with declining yields due to environmental and soil degradation, loss of seedling varieties and high input costs. So, many farmers around the world are turning to genetic engineered varieties (GE) to confront with new challenges. Many Asian countries including China, India, Indonesia, Malaysia, Philippines, Thailand, Pakistan and Vietnam are giving high priority to plant biotechnology research in the hope of addressing the pressing challenges related to improving productivity, farmers livelihoods, driving rural development, and meeting food security demands.

Biotechnology Research Institutes in Pakistan

Currently, there are 29 biotech centers/institutes in the country. However, few centers have appropriate physical facilities and trained manpower to develop genetically modified (GM) crops. In Pakistan, first plant tissue culture laboratory was established at National Agriculture Center, Islamabad in 1982. It is known to be the pioneer tissue culture facility providing laboratory in the country with emphasis on pre-basic virus-free potato seed and producing clones of other crops today, micro propagation and *in vitro* conservation are standard techniques in most important crops. At the beginning of the 1980s genetic engineering of plants remained a promise of the future, although gene transfer had already been achieved earlier in a bacterium. The first transgenic plant, a tobacco cultivar resistant to an antibiotic, was reported in 1983. The National Institute of Biotechnology and Genetic Engineering (NIBGE) is the country's major biotech research establishment, concentrating on research into plant, environmental, and medical biotechnology. NIBGE has produced some impressive results in a short time. Most recently scientists at the Institute have found a biotechnology-based solution which may help to eliminate PakiStan's recurring cotton leaf-curl virus (CLCV), which has been a recurringproblem NIBGE undertook a rewarding programme of reclaiming nearly 11 million acres of saline and sodic soils by biological methods. This technology developed by NIBGE has now been exploited by the International Atomic Energy Agency for initiating an integrated model project for eight countries. NIBGE is also researching the use of biotechnology to extract minerals and fossil fuels. It has developed methods to extract copper and uranium using bacteria. This technique has potential applications in the development of the Saindak mines in *Balochistan, Pakistan' biggest copper mining project.

The Centre for Advanced Molecular Biology (CAMB) was established in 1981 at Punjab University. During the past ten years the Centre has discovered forty-five new restriction enzymes which interfere with DNA replication. CAMB has also pioneered DNA based methods for the pre-natal diagnosis of Betathalassaemia. Methods for early detection of tuberculosis, hepatitis, and breast cancer have also been developed. In 1988 the status of the Centre was upgraded to a Centre of Excellence in Advanced Molecular Biology. In addition to the above mentioned organisations biotechnology is being taught at general as well as agricultural and medical universities.

Most of the activities have been on rice and cotton, which are among the top 5 crops of Pakistan. Biotic (virus/bacterial/insect) and abiotic (salt) resistant and quality (male sterility) genes have already been incorporated in some crop plants. Despite acquiring capacity to produce transgenic plants, there is not a single report available for the release of GM crops in the country. Pakistan is signatory to the World Trade Organization, Convention on Biological Diversity, and Cartagena protocols. Several legislations under the Agreement on Trade-Related Aspects of Intellectual Property Rights have been promulgated in the country. National Bio-safety Guidelines have been promulgated. The Plant Breeders Rights Act, Amendment in Seed Act-1976 and Geographical Indication for Goods is still passing through discussion, evaluation, and analysis phases.

Modern Biotechnology

Use of modern biotechnology started in Pakistan since 1985 when most of the crop improvement activities using modern biotechnology are focused on rice and cotton, which are among the top 5 crops of Pakistan. Brassica, chickpea, chilies, cucurbits, potato, sugarcane, tobacco, and tomato have recently been taken up. Among indigenously developed GM crops, cotton is at a fairly advanced stage of commercialization. Similarly, virus-resistant and salinity-tolerant GM cotton is at the field stage of evaluation. Following cotton is basmati rice, which has also been evaluated in the field for 2 years although not yet submitted for approval. Three other GM plants (sugarcane, potato, and tomato) are also in greenhouses at the field stage. Although transgenic plants of these crops have been obtained, field evaluation was hampered due to the delays in approval of biosafety guidelines. No GM crop has been approved for commercial cultivation so far in Pakistan under Pakistan Biosafety Rules (2005). National bio-safety rules by the Ministry of Environment (MOEnv) have now provided an opportunity to evaluate the GM crops for safe release into the environment and for commercial cultivation. Pakistan has made considerable progress in the research and development sector of agriculture biotechnology and has developed several GM crops. However, commercial release is hampered due to delays and weak capacity of regulatory bodies related to biosafety and IPR (Plant Breeders Rights). It is expected that the farmers of Pakistan will reap the benefits of legally released and indigenously developed biotech crops in the next 1-2 years.

Transgenic Crops

Tissue culture, developed in the 1950s, became popular in the 1960. Micropropogation and in vitro conservation are standard techniques in most important crops. The first transgenic plant, a tobacco cultivar resistant to an antibiotic, was reported in 1983. Transgenic crops with herbicide, virus or insect resistance have been released in past decades. Agriculture scientists stressed the need to promote transgenic crops in Pakistan, as the neighboring countries had adopted this technique and were obtaining manifold productivity.

Molecular Breeding

In the following decades, science made great studies in the elucidation of the molecular processes that underpin inheritance; genes, the unit of inheritance, were linked with proteins, DNA was shown to be the material of inheritance, the structure of DNA was resolved, DNA polymerase, ligases and restriction enzymes were discovered, recombinant DNA molecules were created and techniques for determining the nucleotide sequence of a DNA molecule were developed. Plant Scientists were quick to exploit the new tools for manipulating DNA molecules and also made the astounding discovery that a naturally occurring bacterium, *Agrobacterium tumefaciencs*, actually inserted a piece of its own DNA into that of a plant cell during its natural infection process. As a result by the mid -1980s everything was in place to allow foreign genes to be introduced in to crop plants and Scientists began to predict a second green revolution in which crop yield and quality would be improved dramatically using this new DNA recombinant technology.

All plant breedings involve the alteration of plant genes, whether it is through the crossing of different varieties, the introduction of a novel gene into the gene pool of a crop species, perhaps from wild relative. However the term genetic modifications was used solely to describe the new techniques of artificially inserting a single gene or small group of genes into the DNA of an organisms; organisms carrying foreign genes were termed genetically modified or GM.

Marker Assisted Selection

Dudley, (4) described that marker assisted selection (MAS) basically consists of identification of a tight linkage between genes controlling agronomic traits and molecular markers, and the use of these markers to improve lines or cultivars. In crop breeding MAS is a relatively recent concept aiming at the incorporation of desirable traits into elite germplasm, and is gaining significant support from its ability to accelerate plant breeding through precise transfer of genomic regions involved in the expression of target traits, and speeding the recovery of the recurrent parent genome. Langridge and Chalmers (13) discussed the crucial points in the process of identification of marker/trait associations, in particular defining the target, the choice of mapping population, construction of a linkage map, genotyping and phenotypic evaluations, and the importance of marker validation. DNA polymorphisms are valuable for several applications including genotyping, molecular mapping and marker-assisted selection. Associating a particular trait with a DNA polymorphism is especially valuable for breeding purposes. Recently, novel means of identifying abundant DNA polymorphisms have been developed that incorporate a microarray platform for high-throughput genotyping. These include diversity array technology (DArT™) (8) and subtracted diversity array (10) for DNA. Schaffer et al. (20) reviewed novel technologies, such as DNA chips that can be used for the analysis of global gene expression patterns in plants.

Molecular Markers

The general characteristics of the main generations of molecular markers and their applications have been extensively reviewed (6, 9, 13, 12, 19, 11). Restriction fragment length polymorphism (RFLP) and randomly amplified polymorphic DNA (RAPD) were the preferred types of markers for gene mapping and tagging in the early years of DNA marker applications (15, 22). Marker aided analysis based on PCR has become routine in plant genetic research and marker systems have shown their potential in plant breeding (16). Recent gene mapping studies have been dominated by simple sequence repeats (SSRs) owing to their highly polymorphic nature, abundance, co-dominant inheritance and reproducibility (19, 17). Newer approaches, based on single nucleotide polymorphism (SNP) is expected to be used increasingly (5) as this technique enables the development of markers within functionally relevant parts of the genome.

Pharming and Biotechnology

Pharming indicates a new kind of system to obtain medicines (1). Biotechnology has been used to engineer plants that contain a gene derived from human pathogen (21). An antigen protein encoded by this foreign DNA can accumulate in the resultant plant tissues. Results from pre-clinical trials showed that antigen proteins harvested from transgenic plants were able to keep the immunogenic properties. The ability of transgenic food crops to induce protective immunity in mice against cholera toxin has been recently demonstrated (2).

It is evident that several exciting technologies are being developed that will accelerate the already dizzying pace of progress in this field. The advances in plant genomics research in particular are resulting in an explosion of information that will yield new knowledge about plant biology at a rate that was unimaginable a decade ago. The challenge now is for plant biotechnologists to translate this knowledge into practical applications, especially those that directly benefit the ultimate end users, that is, the consumers. If this can be successfully accomplished then the continued rapid growth of plant biotechnology and of its revolutionary contributions to agriculture will be assured in Pakistan.

CONCLUSION

Biotechnology has revolutionized the field of biology and genetic engineering. Pakistan is on the threshold of entering into the arena. Joint programs of the Asian countries may help in accelerating development in the field of biotechnology which has great potentials for mitigating the suffering of the teeming millions of the region.

REFERENCES

Anderson, J. (1996) Feeding a hungrier world. *Phytopathology News*., Vol. 30, No. 6, pp. 90-91.
Arakaw, T., K.X. Chong, and W.H.R. Langridge. (1998) Efficacy of a food plant based oral cholera toxin B subunit vaccine. *Nature Biotechnology*., Vol. 16, pp. 292-297.

Borlaug, N.E. (1997) Feeding a world of 10 billion people; the miracle ahead. *Plant tissue culture and biotechnology.*, Vol. 3, pp. 119-127.

Dudley, J.W. (1993) Molecular markers in plant improvement: manipulation of genes affecting quantitative traits. *Crop Sci., Vol.* 33, pp. 660–668.

Edwards, K.J and R. Mogg. (2001) Plant genotyping by analysis of Single Nucleotide Polymorphisms In: Henry RJ(ed) Plant genotyping: DNA Fingerprinting of plants, CAB International, Chapter 1, pp 1–13.

Gupta, P.K., J.K. Roy and M. Prasad. (2001) Single nucleotide polymorphisms: a new paradigm for molecular marker technology and DNA polymorphism detection with emphasis on their use in plants. *Curr Sci.*,Vol. 80, pp. 524–535.

Gupta, P.K., R.K. Varshney, P.C. Sharma and B. Ramesh. (1999) Molecular markers and their applications in wheat breeding. *Plant Breed.*, Vol. 118, pp. 369–390.

Jaccoud, D.K., D. Peng and A. Kilian. (2001) Diversity arrays: a solid State technology for sequence information independent genotyping. *Nucleic Acids Res.*, Vol. 29, pp. 25.

Joshi, S.P., P.K. Ranjekar and V.S. Gupta. (1999) Molecular markers in plant Genome analysis. *Curr Sci., Vol.* 77, pp. 230–240.

Jayasinghe, R.S., T.E. Coram, J. Kaganovitch, C.C.L. Xue, C.G. Li and E.C.K. Pang. (2007) Construction and validation of a prototype microarray for efficient and high-throughput genotyping of angiosperms. *Plant Biotechnol J.*, Vol. 5, pp. 282-289.

Khlestkina, E.K and E.A. Salina. (2006) SNP markers: methods of analysis, ways Of development and comparison on an example of common wheat. *Russian J Genet., Vol.* 42: pp. 585–594.

Korzun, V and E. Ebmeyer. (2003) Molecular markers and their applications in wheat breeding. In: Pogna NE, Romano M, Pogna EA, Galterio G (eds) Proceedings of the 10th International Wheat Genetics Symposium, Istituto Sperimentrale per la Cerealicoltura, Rome, Italy, Vol 1, pp140–143.

Langridge, P and K. Chalmers. (2004) The principle: identification and application of molecular markers. In: Lörz H, Wenzel G (eds) Molecular marker systems in plant breeding and crop improvement. Biotechnology in agriculture and forestry, *Springer, Berlin Heidelberg.*, vol 55.pp 3–22.

Langridge, P.E., S. Lagudah,, T.A. Holton, A. Appels, P.J. Sharp and K.J. Chalmers. (2001) Trends in genetic and genome analyses in wheat: a review. *Aust J Agric Res.*, Vol.52, pp.1043– 1077.

Ma, Z.Q., B.S. Gill, M.E. Sorrells and S.D. Tanksley. (1993) RFLP markers linked to two Hessian #y resistance genes in wheat (*Triticum aestivum* L.) from ¹*riticum tauschii* (coss.) Schmal. *Theor Appl Genet.*, Vol. 85, pp. 750-754.

Paterson, A.H. (1996) Genome mapping in plants. Academic Press, Inc. and R. G. Landes Co; New York and Austin.

Prasad, M., R.K. Varshney, J.K. Roy, H.S. Balyan and P.K. Gupta. (2000) The use of microsatellites for detecting DNA polymorphism, genotype identiWcation and genetic diversity in wheat. *Theor Appl Genet.*, Vol. 100: pp. 584–592.

Röder, M.S., X.Q. Huang and M.W. Ganal. (2004) Wheat microsatellites: potential And implications. In: Lörz H, Wenzel (eds) Molecular marker systems in plant Breeding and crop improvement. Biotechnology in agriculture and forestry, vol 55. Springer, Berlin Heidelberg.,, pp 255–266.

Röder, M.S., Plaschke, J and S.U. Konig. (1995) Abundance, variability and chromosomal location of microsatellites in wheat. *Mol Gen Genet.*, Vol. 246, pp. 327–333.

Schaffer, R., J. Landgraf, M. Perez-Amador and E. Wisman, (2000) Monitoring genome-wide expression in plants. Curr Opin Biotechnol., 11, pp. 162–167.

Tacker, C.O., H.S. Mason, G. Losonky, J.D. Clements, M.M. Levine and C.J. Arntzen. (1998) Immunogenecity in humans of a recombinant bacterial antigen derived in a transgenic potato. *Nature medicine.*,Vol. 4, pp. 607-609.

Williams, K.J, J.M. Fisher and P. Langridge. (1994) Identification of RFLP markers linked to the cereal cyst nematode resistance gene (*Cre*) in wheat. *Theor Appl Genet.*, Vol. 89: pp. 927–930

Ye, X., S. Al-Babili, A. Kloti, J. Zhang, P. Lucca, P. Beyer and I. Potrykus. (2000) Engineering the provitamin A (beta-carotene) biosynthetic pathway into (carotenoid-free) rice endosperm. *Science.* 287 pp. 303–305.