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# APPLICATIONS OF BIOTECHNOLOGY IN AGRICULTURE- REVIEW ARTICLE

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**ABSTRACT**

Agricultural biotechnology plays a key role in research tools that scientists use to understand and manipulate the genetic makeup of organisms for use in agriculture: crops, livestock, forestry and fisheries. Biotechnology has vast application than genetic engineering; it also includes genomics and bioinformatics, markers-assisted selection, micro propagation, tissue culture, cloning, artificial insemination, embryo transfer and other technologies. However, genetic engineering, mainly in crop sector, is the area in which biotechnology is most directly affecting agriculture in developing countries and in which the most vital public concerns and policy issues have arisen. Therefore, this review report tries to touches all the aspect of biotechnology in the field of agriculture.

**Key word**: Biotechnology, Genetic engineering, Agriculture, Crop resistance, Livestock management.

## INTRODUCTION

Biotechnology is any technique that uses living organisms or substances from these organisms to make or modify a product for a practical purpose. Biotechnology can be applied to all genus of organisms from viruses and bacteria to plants and animals and it is becoming a major feature of modern medicine, agriculture and industry. Modern agricultural biotechnology includes a range of tools that scientists utilize to understand and manipulate the genetic make-up of organisms for use in the production or processing of agricultural products. Biotechnology is being used to address problems in all areas of agricultural production and processing. This includes plant breeding to raise and stabilize yields; to improve resistance to pests (James, 2002), diseases and abiotic stresses such as drought (Khan and Khan, 2010) and cold and soil acidity (Kole, 2011); and to enhance the nutritional content of foods such as potatoes and rice (Coghlan, 2003; Cordell *et al.*, 2009). Biotechnology is being used to buildup low-cost disease-free planting materials for crops such as, banana (Milu, 2008) and is creating new tools for the diagnosis and treatment of plant and animal diseases (Tanaka *et al.*, 2005). Biotechnology is being used to speed up breeding programs for plants, livestock and fish (Fu *et al.*, 2005) and to extend the range of traits that can be addressed. Animal feeds (James, 2002) and feeding practices are being changed by biotechnology to improve animal nutrition and to reduce environmental waste. Biotechnology is used in disease diagnostics and for the production of vaccines against animal diseases (Tanaka *et al.*, 2005), agricultural biotechnology is potentially the most powerful and the most beneficial for the poor. Cereal starch is used in many value-added starch-based biopolymers and starch-derived bio-fuels which are probable to be less harmful to the environment than those derived from petrochemicals (Thitisaksakul *et al.*, 2012). The goal of this entry, therefore, is to examine the many attempts of biotechnology in the field of agriculture to meet its growing and diverse end-uses (Thitisaksakul *et al.*, 2012).

**Related work on Biotechnology in Agriculture:** Modern biotechnology represents distinctive applications of science that can be used for the betterment of society through development of crops with improved nutritional quality, resistance to pests and diseases and reduced cost of production and vice versa. The following are given below:

**Micro propagation of disease free plants like Banana:** Banana is generally grown in developing countries where it is a source of food, employment and income. Microprapagation represents a means of regenerating disease- free banana plantlets from healthy tissues .It has all the advantages of being a relatively cheap and easily applied technology (Milu, 2008).

**Agriculture on acid soils: Improving Aluminum tolerance in Cereals:** To maintain the pH of soil, lime can be added to the soil to increase the pH. This treatment is costly and temporary. Improved cultivars that are tolerant of aluminum can be developed alternatively. Rye exhibits a fourfold increase in aluminum tolerance over wheat (Kole, 2011).

**Fortification of crops:** Certain crops are enriched with nutrients to reduce the malnutrition children in developing country. 'Protato' which is genetically engineered potato in India produces about one-third to one half more protein than usual, it also have substantial amounts of all the essential amino acids such as lysine and methionine Protein deficiency is wide spread in developing and under developing country. Potato is the staple and cheapest food of the poorest people (Coghlan, 2003). Similarly Golden rice has been genetically engineered to produce beta-carotene, the precursor to vitamin A. So, it can be used to recover the vision problem caused by Vitamin A (Ye *et al.*, 2000).

**DNA Markers used in Aqua culture:** A variety of approaches have been taken to build up genetic markers for aquaculture species. Dominantly-expressed markers have been used

widely in aquaculture studies. Amplified fragment length polymorphism (AFLP) markers provide a cost-effective alternative for species where DNA sequencing is not under way or when there are restricted resources for QTL mapping Dominant AFLP markers are preferred over random amplified polymorphic DNA (RAPD) markers because they are more reproducible both in other lines or populations and in other laboratories, and they can generate hundreds of markers (a single polymerase chain reaction commonly generates over ten markers) (McCullough *et al.*, 2008).

**Breeding and reproducing in Aquaculture:** Reproductive biotechnology in fisheries provides opportunities to increase growth rates and improve the management of farmed species and to limit the reproductive potential of genetically engineered species. Genetic engineering is an active area of research and development in aquaculture. The large size and hardy nature of many fish eggs allow them to be manipulated easily and make possible to gene transfer by direct injection of a foreign gene or by electroporation, in which an electric field assists gene transfer. Gene transfer in fish has generally involved genes that produce growth hormone and has been shown to increase growth rates dramatically in carp, salmon, tilapia and other species. In addition, a gene from the winter flounder that produces an antifreeze protein was put into salmon in the hope of extending the farming range of the fish. The gene did not produce enough of the protein to extend the salmon's range into colder waters, but it did allow the salmon to continue growing during cold months when non-transgenic salmon would not grow. These applications are still in the research and development stage, and no transgenic aquatic animals are currently available to the consumer (Fu *et al.*, 2005).

**Artificial insemination (AI) and Multiple Ovulation/ Embryo Transfer in Livestock:** Advancement in artificial insemination (AI) and multiple ovulation followed by embryo transfer (MOET) have already had a major impact on livestock improvement and development programs in developed countries and many developing countries because they trigger up the process of genetic improvement, reduce the risk of disease transmission and expand the number of animals that can be bred from superior parent (McCullough *et al.*, 2008).

**Genetically modified crops as animal feed:** Genetically modified crops, products derived from them and enzymes derived from genetically modified micro-organisms are widely used in animal feeds. Compound feeds are principally used for poultry, pigs and dairy cows and are formulated from a range of raw materials, including maize and other cereals and oilseeds such as soybeans and canola (James, 2002). There was no evidence about adverse effects in the animal fed the transgenic products for any of the measured parameters, such as nutrients composition, rumen fermentation, growth performance or carcass characteristics (MacKenzie and McLean, 2002).

**Pest and Herbicide Resistant Cultivars:** The common soil bacterium *Bacillus thuringiensis* (Bt) genes have been inserted to build up a particular protein in cotton crop. This protein is toxic to certain insects such as pink bollworm (*Pectinophora gossypiella)* and cotton boll worm (*Helicoverpa zea),* and is partially effective in controlling tobacco bud worm (*Helio thisvirescens)* and fall armyworm (*Spodoptera frugiperda)* (James, 2002). As a result Bt varieties have superior yield performance over a wide range of growing conditions (Fernandez-Cornejo *et al.*, 2000).

**Genetically engineered Herbicide-tolerant (HT) crops:** A gene from the soil bacterium *Agrobacterium tumefaciens,* is used in genetically engineered HT crops. It makes the recipient plant tolerant to the broad spectrum herbicide glyphosate. HT crops can reduce the production costs and help the weed management. An HT crop was developed under the name Roundup Ready (RR). RR soybeans were commercially released in 1996 (James, 2002). The yield of RR soybeans is same as of conventional soybeans, but reduce farming cost (Fernandez-Cornejo *et al.*, 2000).

**Genetically engineered Drought Resistant crops:** The techniques for gene transformation of crop plants have been applied for identification of gene responsible for drought resistance and their transfer. Mainly two approaches, namely targeted and short gun approach facilitate genetic engineering to obtain transgenic plants conferring drought resistance [9]. Similarly, RAJ cultivar of wheat is developed for the rain fed regions of Pakistan. For this purpose wheat material from international and local germplasm are screened by particular emphasis on drought tolerance and disease resistant. RAJ was evaluated for grain yield, diseases and drought resistance and other agronomic traits. This variety produced highest grain yield (Khan and Khan, 2010).

**Production of Biofuel by Agricultural waste:** Biofuel is a great substitution of fossil fuel. Many agricultural waste products are used for the production of biofuel. In India banana plant is used. As banana pseudo stem is commonly available to be used as lignocellulosic substrate. Banana pseudo stem is a source for bioethanol production. *Aspergillus ellipticus, Apergillus fumigates* and *Saccharomyces cerevisiae* are used in pretreatment saccharification of cellulosic substrate.

**Diagnostics and epidemiology:** Advanced biotechnology-based diagnostic tests make it possible to identify disease-causing agents and to monitor the impact of disease control programmes to a degree of precision not previously possible. Enzyme-linked immunosorbent assay (ELISA) tests have become the standard methodology for the diagnosis and surveillance of many animal and fish diseases worldwide, and the polymerase chain reaction (PCR) technique is especially helpful in diagnosing plant diseases and is proving increasingly so also for livestock and fish diseases (Cordell *et al.*, 2009).

**Vaccine development:** Genetically engineered vaccines are being developed to protect fish and livestock against pathogens and parasites. Recombinant vaccines can offer various advantages over conventional vaccines in terms of safety, specificity and stability. Today, quality improved

vaccines are available for example, Newcastle disease, classical swine fever and rinderpest. In addition to the technical improvements, advances in biotechnology will make vaccine production cheaper, and therefore improve supply and availability for smallholders (Cordell *et al.*, 2009).

**Animal nutrition:** Biotechnology has already resulted in animal nutrition aids such as enzymes, probiotics, single-cell proteins and antibiotic feed additives that are already widely used in intensive production systems worldwide to improve the availability of nutrients from feeds and the productivity of livestock and aquaculture. Gene-based technologies are being increasingly employed to improve animal nutrition, either through modifying the feeds to make them more digestible or through modifying the digestive and metabolic systems of animals to enable them to make better use of the available feeds. GMO crop is used as feed of animals without risk hazards (James, 2002). Similarly, the use of recombinant somatotropin, a hormone that results in increased milk production in dairy cows and accelerated growth and leaner carcasses in meat animals (Cordell *et al.*, 2009).

**Allergens and toxins:** Genetically modified products currently on the market have been tested for increased levels of known allergens and toxins and none has been found [6]. The use of genes from known allergenic sources in transformation experiments is discouraged and if a transformed product is found to pose an increased risk of allergenicity it should be discontinued.

**Use of bio-fertilizer:** Crops need balance nutrient from soil for proper growth as phosphate and nitrogen are major in utilization in metabolism. Biofertilizer made as crops seed coated with different organism as example *Penicillium bilaii* involve in dissociation of phosphate in soil so roots can easily absorbed and similar way associated with use of Rhizobium which is involve in nitrogen fixation. Biofertilizer reduce application of expensive chemical fertilizer and also ecologically suitable (Yang *et al.*, 2009).

**Improvement in floriculture:** Floriculture is associated with flower cultivation industry, biotechnology is playing key role in generation of new varieties as improve in color, scent, size and flower long life through gene manipulation technique. Basically three pigment as flavonoids, carotenoids and betalains are involved in flower color formation. Variation in flower color through gene manipulation technique concern with insertion of gene which modify metabolic path of flavonoids, as this path concern with colored anthocyanins and anthocyanidin 3-o-glucosides.Various genes regulate other factor which are involve in final color as anthocyanins and other pigment presence and their structurally modification and vacuolar pH (Tanaka *et al.*, 2005). Novel Blue – Violet flower color carnation and roses have been successfully. The color variation is obtained due to modification of F3/H and F3/5/H genes (Tanaka *et al.*, 2010).

**DISCUSSION**

Humans have been making use of biotechnology since they discovered farming. Its use extended from the planting of the seeds to the animal breeding. The agriculture sectors comprise establishment engaged is growing crops, raising animals, and harvesting fish and other animals from a farm, ranch, or their natural habitats. Agriculture is the backbone of the economy of any country. Agri products contribute in the GDP and gross income of the country. As the population of the world growing, the number of hungry people also increases ever before in human history. The gap between the rich and the poor is increasing both in North-South terms and within countries. Biotechnology play important role to feed the huge population. Biotechnology played a tremendous role in the development and improvement of agriculture sector that was totally unpredictable since last decades. Now it has become somehow a secure trade. Agriculture sector is still facing crisis such as environmental changes, over population, human destructive activities. Water is a basic need of all living, but our globe has not equally distributed water resources. Some areas of world are facing drought, and soil pH issues. Biotechnologist has built up such cultivars of crops which can easily with stand of such extreme conditions and produce high yield. New technologies is introduced to enhance the standards of the crop and animal farming such as micro propagation, marker assisted selection, artificial insemination and multiple ovulation embryo transfer. These are helpful to get desirable traits. Floriculture is improving day by day as production of new varieties in market. Insects-pests and diseases attacks were terrible threats in past decades especially in under developed countries. Pests and herbicides resistant crops are also introduced by gene manipulation, such cultivar give the economic benefits even at small scale farming level. Transgenic organisms also introduced in agric, animal and fish farming with high quality of traits. Plant and animal diseases are difficult to diagnose because the signs may be misleading or even entirely absent until serious damage has occurred. Advanced biotechnology-based diagnostic tests make it possible to identify disease-causing agents. ELISA tests have become the standard methodology for the diagnosis and surveillance of many animal and fish diseases worldwide, and PCR technique is especially useful in diagnosing plant diseases and is proving increasingly so also for livestock and fish diseases. Recombinant vaccines can offer various advantages over conventional vaccines in terms of safety, specificity and stability. Genetically modified Crop is used as fodder crop which helps to increase milk and meat production in animals and found to be safe in use. The most of the world population is starving and malnutrition. Bio-fortification has its strong implications in agriculture. There are certain crops which are fortified with nutrients to meet the daily intake requirements of growing infants. Such as golden rice provide vitamin A and potato gives high protein contents. Now, biotechnologist has developed crops which will require less nitrogen fertilizer and less water consumption, and will make plants resistant to cold and drought, also introduced bio-fertilizers. It will support the less involvement of resources and more environmental benefits.

As Biotech crops are obvious reducing energy and water consumption, reducing environmental impacts and helping farmers in providing a safe and plentiful food supply. A large percentage of the world's population lives in areas which have less soil nutrients and water. So farmers on these areas are getting less yields. Keeping in view such cultivars must be introduced that can with stand in harsh environment. As agriculture land is a constant, while population is increasing day by day. So, in future biotech researchers also need to improve the nutritional quality of food products to increase the caloric yield rather than crop yield, potentially meaning we will need. Next decades would also be great challenging for biotechnologists, as they try to develop more techniques to produce biofuel to overcome the depletion in fossil fuel reserves world widely.At last I would say that in coming future, it is the era of biotechnology in the field of agriculture and no one can deny on it.

**CONCLUSION**

Agriculture biotechnology applications are helpful in sustained food production. Biotechnology is a complement not an alternate for many areas of conventional agricultural research. It offers a variety of tools to improve our understanding and management of genetic resources for food and agriculture. As by reducing cost of production by reducing need of pesticide spray and fertilizer, development of new varieties that produce high yield and possess tolerance against abiotic stress. These transgenic crops can grow in wide range of environmental condition and possess more nutritional value, and also involve in production of vaccine and healthcare product for human population. Tissue culture technique, Micro propagation, DNA marker assisted technique are basic tools for transgenic varieties. These tools are already employed to breeding and conservation programs and to facilitating the diagnosis, treatment and prevention of plant and animal diseases. The application of biotechnology provides the researcher with new knowledge and tools that make the job more efficient and effective. The biotechnology also strikes the challenges of environment which affecting the agriculture directly or indirectly.

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