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Original Article

Role of Biotechnology in Plant Science

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Introduction:

The goal of sustainable agriculture is to provide population with food and fiber while protecting the environment and maintaining natural systems. To build sustainable climate-resilient agriculture, social and economic equality must be combined with economic viability and a healthy environment. The word "sustainable" comes from the verb "sustain," which means to support, endure, and preserve. The goal of sustainable agricultural development is to provide long-term solutions for present and future generations in order to satisfy society's needs for food and fiber. Combining economic prosperity with a healthy environment is the main prerequisite for sustainable agriculture. to create climate-resilient agriculture while promoting social and economic equity. Sustainable agricultural scientists must employ multidisciplinary methods that integrate biology, engineering, chemistry, economics, and community development in order to achieve this goal. In terms of crop enhancement, biotechnology has shown great promise in terms of yield, biotic and abiotic resistance, and nutrient-rich crops. Biotechnology defined as a set of tools that uses loving organism (or parts of organisms) to make modify a product improve plants, trees, animals or develop microorganisms for specific uses.

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The 1990 Farm Bill (The Food, Agriculture, Conservation, and Trade (FACT) Act of 1990) defines sustainable agriculture as an integrated system of plant and animal production practices having a site-specific application that will, over the long term, fulfill the (a) food and fiber needs; (b) enhance environmental quality by judicial use of natural resources; (c) make the most efficient use of on-farm resources by integrating regenerative approaches; (d) improve farm economics;

and (e) enhance the quality of life for farmers and society as a whole (Rigby *et al*., 2001). 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. In order to increase crop productivity and resilience to different biotic and abiotic challenges, biotechnology is the technological application of biology. It mostly involves the transfer of genetic material containing a specific feature from one crop or organism to another (Hefferon, 2015). Numerous studies conducted on farms and small plots of land have shown that biotechnology intervention can enhance crop output, nutrient quality, and weed control while having no negative effects on the environment or ecosystem. Biotechnology has vast application than genetic engineering; it also includes genomics and bioinformatics. Biotechnology involves the use of approaches related to science to enhance the value of different kinds of living beings. More prospects and optimism for creating the second or third generation of biotechnological goods have been made possible by recent developments in OMICS methods, particularly CRISPR genome editing. Despite biotechnology's potential for sustainable agriculture, public opinion continues to be a barrier. To address people's questions and concerns, further outreach and extension are required. The widespread use of biotechnology in agriculture is hampered by the possible dangers of genetically modified organisms and the requirement to protect biodiversity.

Historical Perspective on the integration of Biotechnology in Plant Science:

India's agricultural biotechnology adventure started in the early 1980s, when traditional farming methods and cutting-edge scientific discoveries came together. At first, the emphasis was on comprehending crop genetics and applying traditional techniques to produce superior varieties. However, the scientific community in India soon realized that it was possible to directly alter the genetic composition of crops to produce desired features with the development of recombinant DNA technology (Saini *et al*., 2020). The establishment of the Department of Biotechnology (DBT) in 1986 under the Ministry of Science and Technology was a pivotal step towards institutionalizing biotech research and application in agriculture. The Green Revolution of the 1960s and 1970s had already set the stage by demonstrating the potential of scientific interventions in agriculture. The introduction of biotechnology was seen as the next logical step to further enhance crop yields, nutritional quality, and resistance to environmental stresses. India's engagement with agricultural biotechnology gained significant momentum in the late 1990s with the approval of Bt cotton, the first

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genetically modified crop in the country, which showcased the tangible benefits of biotech crops in terms of yield and pest resistance (Yukgehnaish *et al*., 2020).

Need of Biotechnology in Plant Science:

- Selection of desirable characteristics of plants and animals.
- Higher agricultural productivity.
- Disease and pest Resistance.
- Increase in Nutrition Value.
- Enhancements in crops and livestock.
- Enhancing traditional crossing of closely related species.
- Growth and development of the agricultural industry.

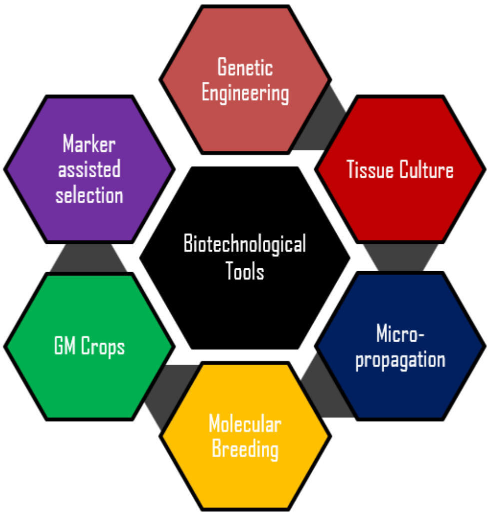

Fig. 1: Biotechnological Tools for crop improvement

Role of Biotechnology in different field of Plant Science:

Tissue Culture and Micro Propagation: Tissue culture is the cultivation of plant cells, tissues, or organs on specially formulated nutrient media. Under the right conditions, an entire plant can be regenerated from a single cell. There are several types of tissue depending on the part of the plant used. Micro propagation is a tissue culture method developed for the production of disease-free, high quality planting material and for rapid production of many uniform plants. Actively-dividing young cells (meri-stem) are placed in a special medium and treated with plant hormones to produce many similar sister plantlets.

Anther Culture: Anther culture is a tissue culture method used to develop improved varieties in a short time. Pollen within an anther contains half dose of the genome (haploid) which spontaneously double (diploid) during culture. In some species however, colchicine treatment is necessary to induce doubling. Doubling of the genome will allow the expression of recessive traits which were suppressed, masked or undetected in routine plant breeding.

Genetic Engineering and Gm Crops: The science of agricultural biotechnology has advanced significantly over the past 30 years as a result of growing knowledge about DNA, the molecular double-helix code that codes for genes. One of the recombinant DNA-based agricultural

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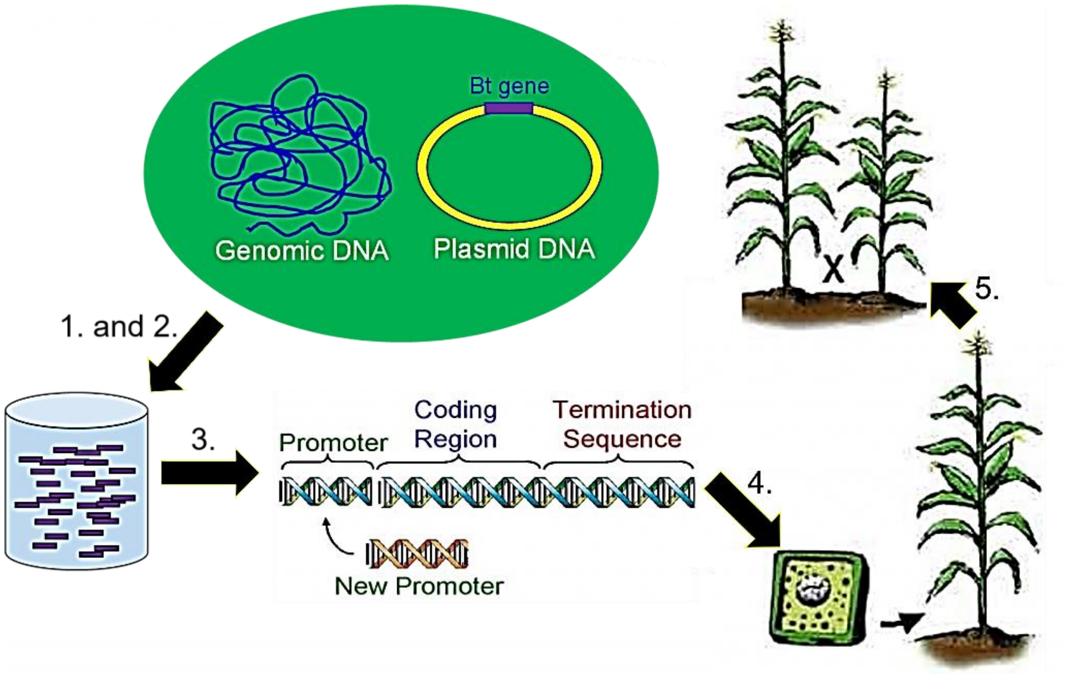
biotechnology technologies of today is genetic engineering. There have been two recent occurrences in the US. A genetically modified maize crop was found in human food that had been approved for animal consumption in the year 2000. In the second case, between 2001 and 2004, an unapproved genetically modified maize product was inadvertently distributed. (Herrera, 2005).



Pest Management: Three nematodous fungus, *Paecilomy ceslilacinus, Pochonia chlamydosporia* and *Plectosphaerella cucumerina*, were researched for suppressing potato cyst nematodes as part of integrated pest management (IPM) . The study was eventually completed, and it was shown that *P. Lilacinus*, when combined with several chosen fungicides and nematodes, had a high potential for suppressing potato cyst nematodes (Abbas *et al*., 2014).

Genome Editing: Genome editing (GE) technology opens a novel prospects for the specific modifications in agriculture crops for disease protection, pest control, defense against biotic/abiotic stresses, faster crop breeding and at the end maximum crop yield with less production cost (Appiano *et al.* 2015). . These advanced technologies help for the production of diverse range of value-added novel crop products to mitigate future challenges related to sustainability of agriculture. Genetic fingerprinting is a powerful tool in the field of plant science, to be used, for example, for correct germplasm identification. When linked to metabolomics and proteomics (fingerprinting techniques on the plant's metabolites or protein composition) has the potential to elucidate data on phenotypic variation, caused by growth conditions or environmental factors, and yield data on the genes involved in the pathways and enzymes involved in the synthesis of natural products (Terryn *et al*. 2006). The development of high throughput genome technologies in the past decade has permitted a range of possibilities to profile the epigenome of different organisms includ ing plants such as Arabidopsis. These novel techniques can be used with transcriptomics data, including the smRNA transcriptome, to provide an unprecedented level of information in the characterisation of genomic DNA methylation and histone modifications (Wang *et al.,* 2009).

Proteomics: The identification of chromosomal regions that cause variation in a trait has been made possible by modern technologies such as gene sequencing, microarray experiments, information on molecular markers, and the expression of genes and proteins within an organism's cells (Nimisha *et al.,* 2013). These tools can lead to far more accurate selection processes for genetic improvement. Proteins, their relationships and functions, and their subcellular location inside a tissue can all be identified using proteomic analyzes. This can be helpful in determining how proteins change during plant growth, particularly somaclonal variation. As a result, proteomics is being used more frequently in cellular, genetic, and physiological studies. Morel *et al.* (2012) found 100 significantly- and differentially-expressed proteins in somatic embryogenesis of *Pinus pinaster*. They were mainly involved in carbohydrate or lipid metabolism and genetic information processing. Many storage proteins were identified (vicillin-like, legumin-like, LEA proteins); some of them were observed from the beginning of maturation.

Molecular Breeding: The process of developing new crop varieties requires many steps and can take 10 to 25 years depending on the crop. Now, however, applications of agricultural biotechnology have considerably shortened the time it takes to bring them to market. It currently takes 7-10 years for new crop varieties to be developed. One of the tools, which make it easier and faster for scientists to select plant traits is called marker- assisted selection (MAS). The different traits and physical features of plants are encoded in the plant's genetic material, the deoxyribonucleic acid (DNA). The DNA occurs in pairs of chromosomes (strands of genetic material), one coming from each parent. The genes, which control the plant's characteristics, are specific segments of each chromosome. All of the plant's genes together make up its genome.

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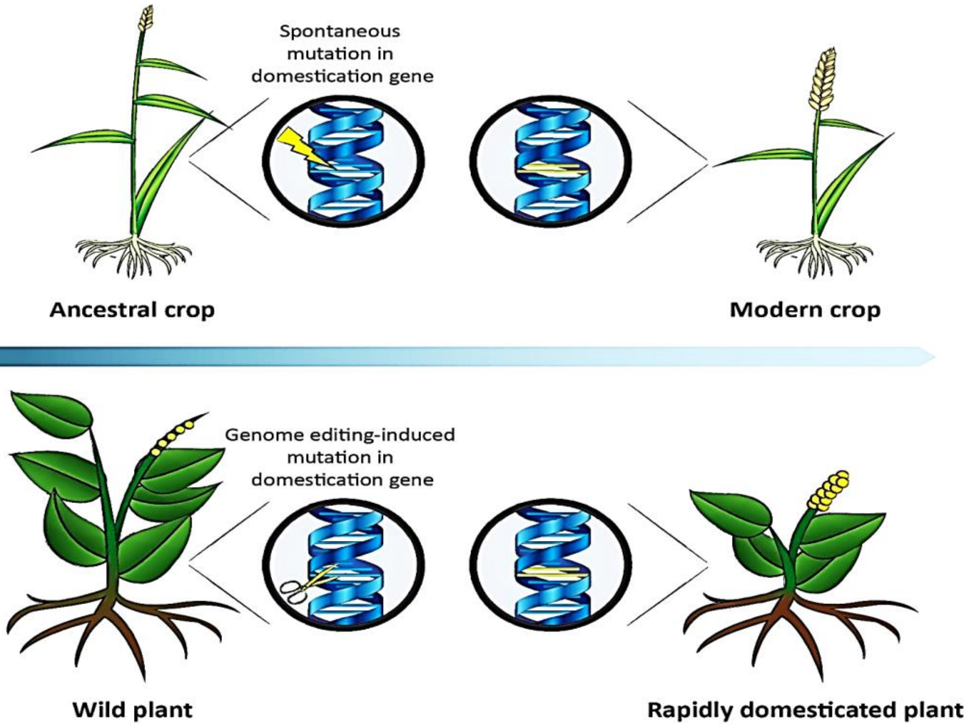

Biotechnology in Livestock: The primary technique for producing a sufficient supply of food for the growing global population is biotechnology. Technological miracles include gender pre-selection in animals and cloning gene mapping techniques. Another view of germplasm cryopreservation as a technical gift is this one. It is said that the twenty-first century would be remembered as the century of molecular genetic markers and genomic selection. Methane production in cattle is made possible by biotechnology, and genetic selection increases milk production.

Biotechnology in Livestock waste: With a growing global population, rising demand for edible oils and animal fats has driven up costs due to poor supply and limited application in the field of bio fuel, particularly in developing nations. The amount of biodiesel generated from various crop and animal waste feedstock's utilizing biotechnology processes. Enzyme-based biofuel synthesis is employed in biotechnology. It is favoured over chemical-based biofuel manufacturing.

Conclusion:

The plant science sector has undergone a revolution thanks to biotechnology, which has also greatly benefited consumers and farmers. It entails the modification of living things in order to develop novel goods, procedures, and methods to deal with diverse agricultural problems. Improved crop varieties that are well-adapted to various environments and resistant to biotic and abiotic challenges are among the most notable effects of biotechnology on agriculture. Agriculture biotechnology applications are helpful in sustained food production. Biotechnology is a complement not alternate for many areas of conventional agricultural research.

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