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A Review on Future Challenges in the field of Plant Biotechnology

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Abstract -*Plant biotechnology has played a critical role in advancing human civilization. Plant domestication aided in increasing food production, allowing for the sustenance of populations in significant settlements. They provide the majority of calories in the human diet and are used as fodder for farm animals. They are also a good source of therapeutic drugs and industrial feedstocks and have recently been used to produce pharmaceutical proteins and biofuels. Nonetheless, there are numerous areas where plants can be improved through genetic manipulation, compelling reasons why this must be done. Genetically modified crops are agricultural plants that come under green biotechnology whose DNA is altered using genetic engineering techniques. The main goal, in most cases, is to introduce a new trait that does not occur naturally in the species. Biotechnology companies can help improve urban agriculture's nutrition and viability, thereby contributing to future food security. Plants produce various products in large-scale industrial processes, such as starch and cell wall material. The increase in atmospheric CO2 caused by the combustion of fossil fuels over the last century is well known, and biofuels can help slow the rise. Many biofuels are currently produced from sugars or oils extracted from plants that could be used for food or feed, so developing plants into second-generation biofuel feedstocks is critical to reversing this trend.*

Key Words: Biofuels, Green Technology, Agro-biotechnology, Genetic Engineering.

1. INTRODUCTION

Plant biotechnology is a set of techniques used to modify plants to meet specific needs or opportunities. It is common for multiple conditions and opportunities to coexist. A single crop, for example, may be necessary to provide sustainable food and healthy nutrition, environmental protection, and job and income opportunities. However, finding or developing suitable plants is a difficult task. Plant biotechnologies that aid in developing new varieties and traits include genetics and genomics, marker-assisted selection (MAS), and transgenic (genetic-engineered) crops. Researchers can use these biotechnologies to detect and map genes, discover their functions, select specific genes in genetic resources and breeding, and transfer genes for particular traits into plants. Agriculture was most likely. Humankind's most significant early success. It sparked the development of environmental changes, without which, for better or worse, we would not exist as a modern society. Humans have been doing this since the dawn of civilization.[1] Agriculture is constantly improving, with wheat being the first domestication recorded by historians 9,000 years ago. Agriculture has spread throughout human cultures, and "species manipulation" by early agriculturalists, as some refer to it, is the foundation of modern agriculture. In our lifetime, the application of genetic knowledge for crop improvement has resulted in unprecedented increases in agricultural productivity. It is widely acknowledged that global food shortages would be a much more severe problem today if plant breeding advances had not been made. [2] Plant biotechnology is the only option for improving micronutrients in crops that do not naturally contain them by engineering metabolic pathways. A specific GM biofortification can also be replicated across multiple target crops. Significant progress has been made in developing genetically modified (GM) biofortified plants. Many crops, including Golden Rice, have been genetically modified to be higher in vitamins, minerals, essential amino acids, and essential fatty acids. The same or similar strategies used to engineer pro-VitA in Golden Rice have also been used to successfully plan pro-VitA in other crops such as banana, cassava, potato, sorghum, soybean, and sweet potato. Reports are available for biofortified cereals, legumes, vegetables, oilseeds, fruits, and fodder crops. [3]

2. Green Biotechnology for the Environment

Green biotechnology uses plants and other photosynthetic organisms to improve crops or generate industrially applicable products in industries such as detergents, paper, biofuels, textiles, pharmaceutical substances, etc. The course covers plant cell molecular biology, emphasizing biotechnology in photosynthetic organisms. The biotechnologies presented in the system are based on functional genomics, proteomics, and plant breeding.[4] and quantitative genetics; genetically modified plants; phytoremediation; and the use of bioactive compounds. In 2009, 14 million farmers in 25 countries used genetically modified (GM) crops, the vast majority of whom were small-scale farmers in developing and emerging economies. Green biotechnology is economically beneficial, with annual global acreage increasing to 134 million hectares [5]. This is reflected in the increasing number of farmers who choose GM crops. GM seed is generally more expensive but saves money on pesticides, machinery, and labour. Green biotechnology entails using bacteria to help plants grow, developing pest-resistant grains, engineering plants to express pesticides, and so on. Green biotechnology encompasses the entire spectrum, from improved plant quality for animal feed or food to more advantageous and simplified cultivation (input-traits) and output-traits) To create and extract novel, non-plant content (molecular pharming). The goals of genetically modified plant breeding are similar to those of conventional plant breeding: on the one hand, quantitative (yield increase) and qualitative improvements (taste, colour of blooms, shelf-life, raw materials), and on the other, resistance to biotic (fungi, pests, viruses, bacteria, nematode worms) and abiotic (cold, heat, wet, drought, salt content). The plant can also be used as a "bioreactor" to produce enzymes, antibodies, recombinant proteins, or active pharmaceutical ingredients (molecular pharming). [6]

3. PLANT BIOTECHNOLOGY ENGINEERING

Plant biotechnology engineering is the deliberate and selective transfer of beneficial gene(s) from one organism to another to create new and improved crops. The American Plant Biologists Association submits statements supporting new technologies such as recombinant DNA technology, also known as "genetic engineering," which can supplement the tools needed to fight hunger and maintain a clean environment. [7] Genetic engineering to modify plants represents a significant advance in plant science. Plant biotechnology-derived modified crops are also expected to provide significant health benefits to people worldwide. One example is increasing the vitamin and mineral content of staple foods. The methods of gene transfer are as follows, Direct methods protoplast microinjection, protoplast electroporation, Agrobacterium-mediated transformation Agrobacterium tumefaciens Genetics and genomics, marker-assisted selection (MAS), and transgenic (GE) crops are examples of plant biotechnologies that aid in the development of new varieties and traits. Researchers can use these biotechnologies to detect and map genes, identify their functions, select specific genes in genetic resources and breeding, and transfer genes for specific traits into plants where needed. The COVID-19 pandemic has disrupted food supply chains significantly, increasing the demand for biotechnological solutions to achieve food security. Crops and vegetables provide a substantial source of food, materials, and medicine. Thus, there is excellent potential for genetically engineered crops with desirable traits such as increased biomass production and pathogen resistance while consuming fewer resources such as space and labour

4. Future Challenges in the Field of Plant Biotechnology

The advent of agriculture Civilized cultures arose 10,000 years ago following the domestication of suitable animals and plants because it was possible to provide surplus food and feed, allowing for additional activities in contrast to societies that relied on gathering and hunting. Agriculture has constantly been evolving; not only have plant cultivation practices improved productivity but the genetic material used has been gradually improved through breeding to sustain ever-growing populations. However, this linear increase in crop productivity is no longer meeting increased demand. Not only is farmland available per capita decreasing, but so are demands for renewable agricultural products, as traditionally petroleum-based industries rely more and more on biomass-derived products. The Grand Challenge in Plant Biotechnology thus consists first and foremost of increasing crop productivity by orders of magnitude, which has never been accomplished before, but also of improving plant quality to be optimal for its traditional uses, e.g., food and feed, but also of providing tailor-made biomaterials for a wide range of industrial applications, including the provision of energy for a variety of purposes, which can only be accomplished if the enabling technologies are developed. Plant biotechnology made its first contribution to crop productivity by developing crops resistant to broadband herbicides, which are frequently selected for plants, fifteen years ago. As fewer overall and environmentally questionable herbicides and more economically advantageous herbicides are used in such crop production systems, these technologies have proven to be extremely valuable, both ecologically and economically. The challenge remains in sustaining such production systems with crops resistant to broadband herbicides. It is expected that weed resistance to those herbicides will emerge after several growing seasons of continuous application of such broadband herbicides, and the crops' selective advantage will be lost. Using fatty acids, starch, and sucrose for biofuel production continually increases crop production demands. To avoid serious competition for resources needed to meet food and feed demands, alternative bio-based energy resources that do not compete for food and feed must be developed. These could be uncultivated plants or plants that produce more energy-dense biomaterials than carbohydrates or fatty acids, such as latex (polyterpenoids), which cannot be used for nutritional purposes. Latex (natural rubber) can only be obtained from the rubber tree, which only grows in tropical climates. [8] Finally, there is the ultimate challenge of genetically tailoring plant products to maximize their suitability as food, feed, fuel, materials, and pharmaceutical sources. Unless high-value compounds like pharmaceuticals are produced in plant systems other than crops, such as plant cell or tissue cultures, the ultimate challenge is understanding and influencing metabolism while maintaining crop productivity. To meet the challenges, a broad interdisciplinary approach must be taken in addition to the scientific and technological prerequisites. Multidisciplinary is required to transfer knowledge generated by model plants into crops or even highly environmentally specialized varieties. But it is also required to increase public acceptance and thus reduce regulatory restraints. Technologically, we will need to be able to generalize genetic manipulation of any plant species, as well as precisely engineer genomes beyond simply inserting trans-genes, introducing multiple traits simultaneously, and fully leveraging knowledge generated in any sub-discipline of Plant Science. [9]

Increased crop productivity in adverse environments

Managing herbicide tolerance

Managing resistance to pests

Managing resistance to diseases

5. FUTURE SCOPE IN PLANT BIOTECHNOLOGY

Plant biotechnology involves breeding plants to improve them for various reasons, such as increased yield and quality, heat and drought resistance, phytopathogen resistance, herbicide, and insect resistance, increased biomass for biofuel production, and improved nutritional quality. This chapter provides a brief history of breeding and the benefits and drawbacks of traditional techniques like molecular marker-assisted breeding and molecular farming. Tissue culture as a method of large-scale plant micropropagation and its advantages, as well as the future of genomic assisted molecular farming breeding programs based on high throughput sequencing platforms.[10]Some of the most existing issues faced in agricultural ecosystems could be solved by introducing transgenic crops with traits for insect pest resistance, herbicide tolerance, and resistance to viral diseases. The need for the adoption of plant biotechnological methods for improving food quantity and quality is increasingly being felt since the demands are not being fulfilled by traditional technologies alone. The increasing population pressures and rapid urbanization have resulted in a decrease in cultivable land. Hence, there is no alternative but to increase unit area productivity to meet the requirements. The advancement in science and applications of plant biotechnology are bound to influence agricultural productivity and food science and technology for the health and well-being of the human population in the time ahead.

6. DNA MARKERS IN PLANT TECHNOLOGY

Traditional breeding methods that use MAS and DNA markers can help improve plant characteristics. The creation of Quantitative Trait Loci (QTLs) mapping for crop plants allows for identifying DNA-trait associations (Collard and Mackill, 2008). Adopting these traditional crop improvement technologies is critical for improving food and nutritional security. Genomic and proteomic advances have already improved our understanding of the molecular basis of plant characteristics by combining molecular biology and bioinformatics tools. These are high-impact, agriculturally relevant areas for increasing plant productivity via the gene revolution. Concerns have been raised about the deterioration of the gene pool. Cryopreservation is used to support ex-situ and in situ gene banks. Tissue banks and tissue culture methods are both promising. Such initiatives would make international germplasm exchange for plant improvement easier. The use of wastelands for crop development resistant to extreme environmental conditions such as droughts, floods, frost, salinity, alkalinity, and so on is required for agricultural base enhancement. Value additions to age materials, global marketing strategies, efficient distribution systems, and the development of nutritionally superior, affordable, and convenient food products must all be prioritized. Biotechnological interventions to extend the shelf life of staple grains, fruits, and vegetables have been attempted. Increasing returns to growers and farmers will encourage induced farming by preventing post-harvest losses. [11]

7. CURRENT RESEARCH

Plant biotechnology has achieved significance in the recent past for increasing the quality and quantity of agricultural, horticultural, and ornamental plants and manipulating the plants for improved agronomic performance. Recent advances in genome sequencing will have far-reaching implications for agriculture in the future. Targeting a gene regulatory element enhances rice grain yield production.[12]CRISPR–Cas9-mediated chromosome engineering in Arabidopsis thaliana. Aegilops sharonensis genome-assisted identification of stem rust resistance gene Sr62.[13]PlantMWpIDB: a database for the plant proteomes' molecular weight and isoelectric points.[14]With Plant GARDEN, an online database that collects plant genomes, Japan's Kazusa DNA Research Institute leads an effort to collect and make them available to everyone. Improved understanding of all aspects of the transgenic/genetic engineering process to improve efficiency, precision, and the proper expression of the added genes or nucleic acid molecules. A broader range of functional and valuable characteristics, including complex characteristics.

8. CONCLUSIONS

Plant biotechnology, on the one hand, secures global food and plant production through its various tools while improving the nutritional value of food and plant products on the other. On the other hand, agriculture biotechnology ensures global ecological health by utilizing natural life forms. Green Biotechnology is thus expected to usher in a green revolution by promoting agricultural and plant development while safeguarding natural environmental health.

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