**GENETICALLY MODIFIED CROPS**

Pratyush Priyadarshan Pradhan, Rupesh Kar, Priyanshu Prasad Nath, Abhijit Anant Dehury, Goutam Nag, Avni Naik, Manash Ranjan Das, Abhilash Nayak, Barsa Rani Sahu, Ankita Ashok Kumar Nayak, Himansu Sekhar Nayak, Suprita Mohanty, Sushree Subarna Nayak

**Corresponding author:** pratyush2002pradhan@gmail.com

C.V. Raman Global University, Mahura, Janla, Odisha-752054

**Abstract:**

Global demand for food is increasing with the growing world population and decreasing arable land. Food and agricultural systems have to respond to several changes with increasing international competition, globalization and rising consumer demands for improved food quality, safety, health enhancement and convenience. Modern biotechnology involving the use of rDNA technology/genetic engineering emerged as a powerful tool for improving the quantity and quality of food supply. Available worldwide with aim of enhancing productivity, decreasing the use of certain agricultural chemicals, modifying the inherent properties of crops, improving the nutritional value or even increasing shelf life. Concerns about the potential risks associated with their impact to human health, environment and biological diversity.

**Keywords:** genetic engineering, shelf life, anti-sense, manipulation, Bacillus thuringiensis (Bt)

**Introduction:**

Genetically Modified Crops (GMCs), also known as genetically engineered crops, are a product of modern biotechnology, wherein the genetic material of plants is altered to introduce specific desirable traits. Since their commercialization in the mid-1990s, GMCs have sparked intense debate worldwide. This article delves into the advancements, benefits, concerns, and potential future implications of genetically modified crops.

Genetic modification or genetic engineering technology has benefited us in many ways:

• Mass production of GM technology based human insulin, vaccines, growth hormones and other drugs has greatly facilitated the availability and access to life saving pharmaceuticals.

• World over, the use of animal-based rennet for cheese production has been replaced to the extent of 80-90% by the enzyme chymosin produced by genetically modified microorganisms.

**History:**

10,000 years ago, humans began domestication using selective breeding. During 1700s farmers and scientists started cross breeding plants. In 1980s researchers develop the more precise and controllable methods of genetic engineering to create plants with desirable traits. The first genetically modified crop plant was produced in 1982, an antibiotic resistant tobacco plant.

 The first GM crop was produced in 1982, an antibiotic resistant tobacco plant.

 The first field trials occurred in France and the USA in 1986, when tobacco plants were engineered for herbicide resistance.

 The first genetically modified crop approved for sale in the U.S., in 1994, was the FlavrSavr tomato.

 In 1994, the EU approved tobacco engineered to be resistant to the herbicide bromoxynil, making it the first commercial GM crop marketed in Europe.

 In 1995, Bt maize (Ciba-Geigy), bromoxynil resistant cotton (Calgene), Bt cotton (Monsanto), glyphosate resistant soybeans (Monsanto), virus resistant squash (Asgrow), and additional delayed ripening tomatoes (DNAP, Zeneca/Peto, and Monsanto) were approved.

 In 2000, Vitamin A enriched golden rice was developed.

**The science behind Crop Genetic Modification:**

GM technology involves direct manipulation of DNA instead of using controlled pollination to alter the desired characteristics. Genetic modification is one the approaches to crop improvement, all of which aim at adding desirable genes and removing undesirable ones to produce better varieties. Conventional crop improvement involves selection and cross breeding using control pollination of better types available naturally or produced through breeding.

**Area and Production:**

In 2013, GM crops were planted in 27 countries; 19 were developing countries and 8 were developed countries. 18 million farmers grew GM crops; around 90% were smallholding farmers in developing countries. Between 1996 and 2015, the total surface area of land cultivated with GM crops increased by a factor of 100, from 17,000 km2 (4.2 million acres) to 1,797,000 km2 (444 million acres). 10% of the world's arable land was planted with GM crops in 2010. In the US, by 2014, 94% of the planted area of soybeans,96% of cotton and 93% of corn were genetically modified varieties. In 2014, GM crops were grown in 28 countries on an area of 181.5 million hectares. The global market value of these crops is estimated to be US$15.7 billion.

**Developing GM crops:**

Development of GM crops starts with the identification of gene of interest and isolating it from the host organism. The gene is incorporated into the DNA of crop plant using laboratory-based gene gun or agrobacterium approaches. The performance of the GM crop is tested under strict laboratory and field conditions.

**Methods:**

* **Gene guns (Biolistics):** "Shoot" (direct high energy particles or radiations) target genes into plant cells. It is the most common method. DNA is bound to tiny particles of gold or tungsten which are subsequently shot into plant tissue or single plant cells under high pressure. The accelerated particles penetrate both the cell wall and membranes. The DNA separates from the metal and is integrated into plant DNA inside the nucleus. This method has been applied successfully for many cultivated crops, especially monocots like wheat or maize, for which transformation using Agrobacterium tumefaciens has been less successful. The major disadvantage – serious damage can be done to the cellular tissue.
* **Agrobacterium-mediated transformation:** Agrobacterium tumefaciens is a bacterium that naturally transfers a part of its DNA (T-DNA) to plant cells, causing plant tumours. Scientists use this natural process to insert desired genes into the T-DNA of Agrobacterium, which then transfers the genes into the plant cells. This method is widely used for dicot plants.
* **Gene editing techniques:** Modern gene editing technologies, such as CRISPR-Cas9, allow precise modifications to a plant's DNA. CRISPR-Cas9 can target specific genes and either disable them or introduce new genetic material. This method enables more accurate and targeted changes compared to traditional genetic modification techniques.
* **RNA interference (RNAi):** RNAi is a process where small RNA molecules can be used to silence or regulate specific genes. By introducing specific RNA molecules into plants, scientists can control the expression of certain genes, resulting in desirable traits or resistance to pests and diseases.
* **Virus-mediated gene transfer:** Certain viruses can be modified to carry desired genes into plant cells. The virus infects the plant, delivering the desired genes into its genome. This method has been used to create virus-resistant crops.
* **Selectable marker genes:** To identify successfully transformed plants, scientists often include "marker genes" alongside the desired genes. These markers confer resistance to certain antibiotics or herbicides. When the plant is exposed to the corresponding antibiotic or herbicide, only the successfully transformed plants survive.

**Advancements in Genetically Modified Crops:**

The development of GMCs has been driven by the need to address various agricultural challenges, including increased demand for food production, climate change, pests, and diseases. Genetic modification allows scientists to introduce specific genes into crops, providing them with resistance to pests, improved nutritional content, and tolerance to environmental stresses, such as drought and extreme temperatures. As a result, GMCs have demonstrated higher yields and enhanced nutritional profiles compared to conventional crops in many instances.

**Statutory bodies on GM crop regulation:**

* **Recombinant DNA Advisory Committee (RDAC):** Monitors the developments in biotechnology at national and international levels.
* **Institutional Biosafety Committee (IBSC):** Approves low-risk experiments and ensures adherence to prescribed safety guidelines. Recommends high-risk experiments to Review Committee on Genetic Manipulation (RCGM) for approval.
* **Review Committee on Genetic Manipulation (RCGM):** Reviews all ongoing projects involving high-risk and controlled field experiments. Approves applications for generating research information on GM plants.
* **Genetic Engineering Appraisal Committee (GEAC):** Approves activities involving large-scale use of GMOs in research and production.
* **State Biotechnology Coordination Committee (SBCC):** Reviews the safety and control measures in various institutions handling GMOs. Acts as State level nodal agency to assess the damage, if any, due to release of GMOs and to take on-site control measures.
* **District Level Committee (DLC):** Inspects, investigates and reports to the SBCC or the GEAC about compliance or non-compliance of regulatory guidelines. Acts as nodal agency at District level to assess the damage, if any, due to release of GMOs and to take on site control measures

**Benefits of Genetically Modified Crops:**

* **Improved Crop Yields:** GMCs often exhibit increased resistance to pests and diseases, leading to better crop yields. This enhancement in productivity helps to meet the growing global demand for food and reduce food scarcity.
* **Enhanced Nutritional Content:** Genetic modification allows for the enrichment of crops with essential nutrients, such as vitamins and minerals. This biofortification can address malnutrition and nutrient deficiencies in vulnerable populations.
* **Reduced Environmental Impact:** By incorporating traits that protect against pests and diseases, GMCs may require fewer chemical pesticides and herbicides, thus reducing the environmental footprint of agriculture.
* **Increased Tolerance to Climate Change:** As climate change brings about more frequent extreme weather events, genetically modified crops with improved drought and heat tolerance have the potential to ensure stable food production under challenging conditions.

**Controversies Surrounding Genetically Modified Crops:**

* **Safety Concerns:** One of the primary criticisms of GMCs is their potential impact on human health. Critics argue that consuming genetically modified foods might have long-term health consequences, despite extensive safety assessments conducted by regulatory agencies.
* **Environmental Risks:** Opponents express concerns over the potential unintended consequences of releasing genetically modified organisms into the environment. Crossbreeding between GM crops and wild relatives could lead to hybridization, potentially affecting biodiversity.
* **Intellectual Property and Corporate Control:** A significant concern is the consolidation of seed companies and the patenting of genetically modified crops. This can result in a few companies controlling access to seeds and farmers becoming dependent on purchasing new seeds each season.
* **Potential for Unintended Effects:** The complex interactions between genes in an organism's genome raise concerns about possible unpredictable consequences of genetic modification that may not be immediately apparent.

**The Future of Genetically Modified Crops:**

The debate over GMCs is unlikely to subside in the near future. Advancements in biotechnology, such as gene editing technologies like CRISPR, present new possibilities for precision genome editing in crops. As the technology progresses, it will be essential to strike a balance between the potential benefits and risks to human health, the environment, and society at large.

* Focussed GM research agenda vis-a-vis agriculture development priorities
* Capacity building on GM research, development and regulation
* Increasing public awareness with reliable evidence-based information on GM crops and products
* Science based and consistent regulatory policy
* Simplified modules for risk assessment and management

**Conclusion:**

Genetically modified crops have revolutionized modern agriculture and offer promising solutions to address global food challenges. However, the ongoing debate over their safety, environmental impact, and potential economic consequences requires careful evaluation and informed decision-making. Striking the right balance between advancements and potential risks is vital to harness the full potential of genetically modified crops for sustainable and equitable agricultural development. As science and technology progress, society mus collectively navigate the path forward in using this powerful tool to ensure a prosperous future for agriculture and food security. The commercial applications of GM to horticultural crops lag far behind those of agronomic crops. In some respects, this is to be expected, since the majority of research and investment has been directed to commodities with the commercial value. For consumer and quality traits, however, many of the most interesting applications will be in horticultural crops (Clark et al., 2004).

**DECLARATIONS:**

**Author contribution statement:**

All the authors listed have significantly contributed to the development and the writing of this article.

**Data Availability Statement:**

No data was used for the research described in the article.

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