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Genetic Modification–It's Evolution and Application in Agriculture

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Introduction

Genetic modification is a method that includes inserting DNA into the genome of an organism. In order to create a GM plant, new DNA is introduced into plant cells. The phrase genetic modification (GM) refers to the transfer of genes across species by a variety of laboratory procedures such as cloning genes, splicing DNA segments together, and inserting genes into cells. Collectively, these techniques are known as recombinant DNA technology. Genetically modified crops (GMCs, GM crops, or biotech crops) are agricultural plants whose DNA has been altered using genetic engineering techniques. The simple addition, deletion, or alteration of a single feature in an organism to produce a desired change is referred to as genetic engineering. Most of the time, the goal is to give a new characteristic to the plant that does not exist naturally in the species.

Genetic modification in plants is often concerned with improving their ability to survive in peculiar harsh environments, to provide greater resistance to pests and diseases, to improve nutritional qualities, and to create tolerance to certain herbicides. GM plants have also been developed to produce compounds of potential industrial use. The most common GM plants that have been developed and commercialised so far are GM maize, soybean, oilseed rape and cotton that have been modified to provide resistance to certain insect pests and tolerance to herbicides.

In India, the only approved GM crop till date is Bt. Cotton which has been developed by introducing a gene from a soil bacteria *Bacillus thuringiensis* var. *Kurstaki* to check the attack of lepidopteran pests including moths and butterflies. The gene produces a protein which is toxic to the larvae paralyzingits digestive system and the insect dies of starvation.

Historical developments in the area of GM

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

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- The first field trial occurred in France and the USA in 1986, when tobacco plants were engineered for herbicide resistance.
- In 1987, Plant Genetic Systems (Ghent, Belgium), founded by Marc Van Montagu and Jeff Schell, was the first company to genetically engineer insect resistant(tobacco) plants by incorporating genes that produced insecticidal proteins from*Bacillus thuringiensis* (Bt.).
- 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 (CibaGeigy), bromoxynil resistant cotton (Calgene), Bt cotton (Monsanto), glyphosate resistant soybeans (Monsanto), virus resistant squash (Asgrow), and additional delayed ripening tomatoes (DNAP, Zeneca/Peto, andMonsanto) were approved.
- In 2000, Vitamin A enriched golden rice was developed.
- In 2013, the leaders of the three research teams that first applied genetic engineering to crops, Robert Fraley, Marc Van Montagu and MaryDell Chilton were awarded the World Food Prize for improving the "quality, quantity or availability" of food in the world.

Recent Scenario on GM Crops

GM crops were planted in 28 countries in 2015, covering 179.7 million hectares, or more than 10% of the world's arable land. The major producers are the United States, Brazil, and Argentina. In 2018, the United States had the greatest area of genetically modified crops in the world, with 75 million hectares, followed by Brazil with little over 51.3 million hectares.

The top GM crop grown in 2015 was soybean (92.1 M ha), followed by maize (53.6 M ha), then cotton (24 M ha) and oilseed rape (canola) (8.5 M ha). This represents 83 per cent of the world production of soybean, and 75 per cent of production of cotton. GM crops made up 29 per cent of the world's maize produce, and almost a quarter of the world's oilseed rape that year. Furthermore, the area to GM crops raised from 1.7 million hectares in

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1996 to 191.7 million hectares in 2018, with an increasing proportion grown by developing countries including India. (ISAAA, 2018)

Applications of Genetic modification

This technique can be utilised in the development of various traits in the crop plants. Some of the examples of application of genetic modification are listed here:

1. Development of herbicide, insect and virus resistance plant
    - Herbicide tolerance
    - Insecticide resistance
    - Virus resistance
2. Modification of plant nutritional content. Example – Golden rice
3. Synthesis of edible vaccines
4. Delayed ripening
5. Production of bioplastics, etc.

Herbicide tolerance

Resistance to a herbicide called Roundup (or glyphosate) in soybeans was the first GM trait to gain widespread acceptance. Herbicide-tolerant crop types are also available, which are grown without the use of genetic modification. The resistance to these types of broad herbicide – which would usually kill both weeds and crops – means that efficient weed control is possible because the herbicide can be applied while the crop is growing, without damaging the crop. In the absence of herbicide-tolerant crops, a variety of herbicides may be required to eradicate all weeds prior to sowing the crop. Herbicide-tolerant crops also have the advantage of being able to be grown in weedy fields since weeds may be managed using herbicide, minimising the requirement for ploughing and thereby lowering soil erosion. Demerits are that the farmer must purchase a special herbicide to match the herbicide-tolerant crop, and this form of management goes against efforts to lessen agriculture's dependency on chemical inputs.

Insect resistance

The bacterium *Bacillus thuringiensis* (Bt.) produces a group of proteins known as the Bt toxin, which are toxic for certain insects, but do not harm beneficial insects or other animals. *Bacillus thuringiensis* is used as an insecticide spray in organic farming. Genes for several Bt toxins have been introduced into many crops by GM. For instance, over 90% of

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the cotton planted in the USA, India, China, Australia and South Africa are GM varieties containing Bttoxin genes. Over the last 20 years, it is estimated that the application of 4,50,000 tons of insecticide has been avoided due to the use of Bt toxin genes in crops.

Virus resistance

GM has also been employed to help Hawaii's papaya sector recover after the papaya ringspot virus nearly wiped out the state's plantations in the 1990s. Although there is no natural resistance to this virus in papaya types, resistant papaya strains have been developed by generating a gene from the virus itself. In recent years, 77% of Hawaiian papaya growers have planted GM papaya.

Positive Impacts of GM crops

- Agricultural performance (yields) is improved with less labour and cost input.
- Reduced usage of pesticides and herbicides
- Ability to grow crops in uncongenial environments (e.g., conditions of drought, soil salinity, extremes of temperature, consequences of global warming, etc.).
- Improved sensory attributes of food (e.g., flavour, texture, etc.).
- Removal of allergens or toxic components, such as the research in USA to produce anonallergenic GM peanut (University of Arkansas) and a nonallergenic GM prawn (Tulane University) and in Japan, to produce a GM non-allergenic rice.
- Improved processing qualities result in less waste and lower consumer food costs.

Negative Impacts of GM crops

Environment:

In the case of crops with modified insecticidal capabilities, unintended environmental consequences include harm to non-target and beneficial species, as well as the emergence of new strains of resistant pests. Furthermore, there is worry that pollen from genetically modified herbicide-resistant crops might reach wild, weedy relations of the crop, resulting in the creation of so-called super weeds.

Health:

There is currently no proof that genetically modified foods are hazardous. There are, however, no definite assurances. GM crops have unintended health consequences such as allergies, antibiotic resistance, nutritional deficiency, and toxicity.

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Conclusion

Genetic modification is a topic of much debate and tension, very prevalent in some parts of the world and banned in others. It has undoubtedly proven to be a huge innovation in the field of science as well as agriculture. From the twentieth century to the present, technology has made significant advances. This innovative technology has also given solutions to many problems, but it cannot be denied that it comes with some disadvantages as well. The genetically modified crops are required to meet the food security in today's world of expanding population. So, it cannot be banned completely. However, strict rules and regulations are needed to control its dissemination in human society. Finally, genetic modification is a relatively new technology that is still in its early stages of development. Only time will reveal their ultimate effect on humans.

References:

Arya D. 2015 Genetically Modified Foods: Benefits and Risks, Massachusetts Medical Society.

Rana S. S. 2011 Current Trends in Agronomy, *Research Gate* 82-84.

Shetty M. J., K. Chandan, H.C. Krishna and G. S. Aparna (2018) Genetically modified crops: An overview. *Journal of Pharmacognosy and Phytochemistry*; 7(1): 2405-2410.

www.staticia.com/statistics/271897/leading-countries-by-acreage-of-genetically-modified-crops/