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Genetically modified crops (GM Crops)

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Introduction

During the 1970s, India witnessed a Green Revolution in wheat and rice, allowing us to become self-sufficient in food grain production. Climate change and rising population pressure have substantially altered the situation in the twenty-first century. World hunger is on the rise again and eliminating hunger and malnutrition by 2030 will be challenging and it will be achieved by sustainable agriculture and collective efforts by all the stakeholders. Traditional technology will not be able to meet the demands for food and nourishment. The traditional plant breeding approaches when used along with advances in modern biology, particularly biotechnology and molecular biology will provide numerous benefits for sustainable production. On a worldwide scale, scientific and technical advancement in these fields has accelerated dramatically during the previous decade.

According to the World Health Organization (WHO), GMOs, *i.e.* genetically modified organisms *can be defined as organisms (i.e. plants, animals or microorganisms) in which the genetic material (DNA) has been altered in a way that does not occur naturally by mating and/or natural recombination.* Genetically modified organisms (GMOs) are produced using scientific methods that include recombinant DNA technology and reproductive cloning. Researchers have attempted various approaches for preparing genetically engineered crops in last three decades and the first transgenic fruit crop developed and commercialized successfully was the well-known 'Flavr Savr' tomato which had been modified to contain reduced levels of the cell wall softening enzyme polygalacturonase.

The commercial application of GM crops began in the mid-1990s. Since then, the technology has spread rapidly around the world, both in industrialized and developing countries. In 2008, GM crops were being grown on 125 million ha in 25 countries. The countries with the biggest share of the GM crop area were the United States (50%), Argentina (17%), Brazil (13%), India (6%), Canada (6%) and China (3%). In spite of the widespread international use of GM crops, the portfolio of available crop-trait combinations is still very limited. At present, only a few first-generation technologies have been commercialized. The dominant technology is herbicide tolerance (HT) in soybeans, which made up 53% of the global GM crop area in 2008. Herbicide tolerant soybeans are currently grown mostly in the United States, Argentina, Brazil, and other South American countries. This technology accounts for 70% of worldwide soybean production.

Methods of developing GM crops

All the characters of living organisms are determined by their genes and its association with the environment. The genetic makeup of an organism is its genome as DNA is responsible for all these differences and genotype. The genome contains genes, regions of DNA which have the ability to control the synthesis protein. The protein is responsible for every visible or morphological character of any individual whether it is skin colour in humans or petals colour in flower.

Genetic modification of plants involves introducing the genetic material from any source into the plant's genome which introduces a new character in that plant. The new DNA becomes part of the GM plant's genome which will present in the all parts of the plant. The first stage in making a GM plant needs introduction of foreign DNA into a plant cell. There are several direct and indirect methods of gene transfer and one of the methods of them is to coat the surface of small metal particles (Gold or Tungsten) with the desired foreign DNA fragment and bombarding of those particles into the plant cells. Another method of indirect gene transfer is by the vectors. For GM plants, the bacterium most frequently used is *Agrobacterium tumefaciens* and *Agrobacterium rhizogens* which causes crown gall and hairy root disease in dicots. The gene of interest is transferred into the bacterium and the bacterial cells then transfer the new DNA to the genome of the plant cells. Now these cells are identified using the suitable technique. The plant cells that have successfully transformed are then grown to create a new plant.

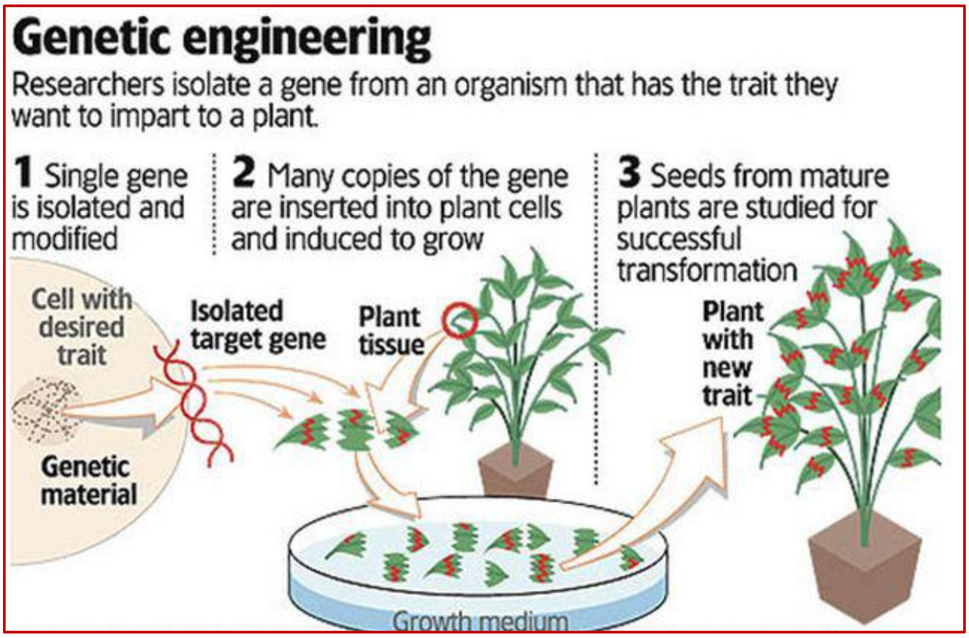

Fig. 1- Method of transferring gene into the plant cell.

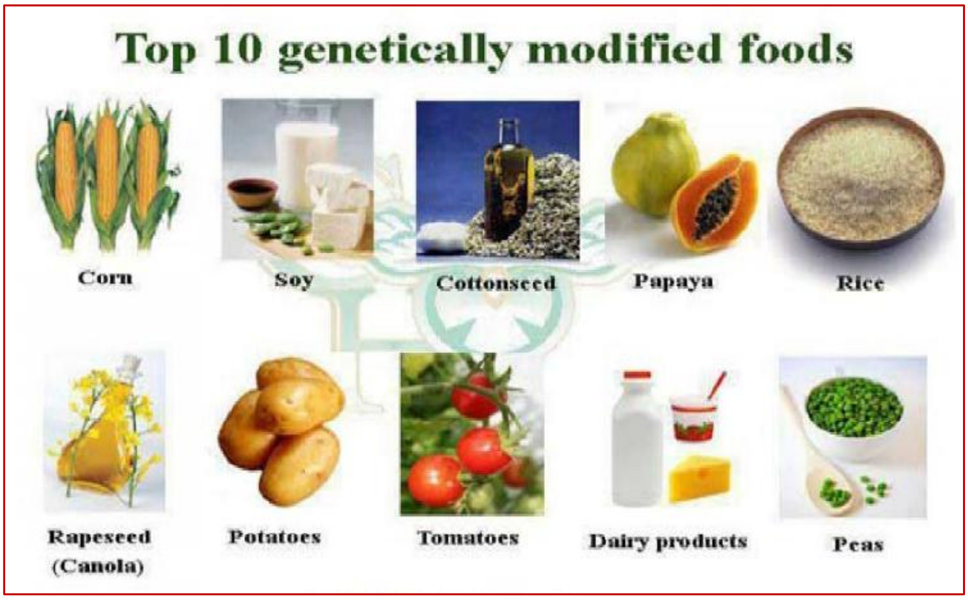

Fig. 2 - Some important GM Crops.

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List of some important GM crops

S. No.	Crop	Trait	Event/*Gene*	Developer	Institutional Type
1.	Cotton	Insect Resistance	MON531/*cry1Ac*	Monsanto	Private
2.	Cotton	Insect Resistance	MON15958/*cry1Ac*	Monsanto	Private
3.	Cotton	Insect Resistance	BNLA-601/*cry1Ac*	ICAR-CICR, Nagpur, UAS, Dharwad	Public
4.	Brinjal	Insect Resistance	EE-1	Mahyco/TNAU/UASD/IIVR	Public-Private
5.	Brinjal	Insect Resistance	Event-142/*cry1Fa1*	Bejo Sheetal	Private
6.	Mustard	Agronomic Performance	Event bn 3.6 and modbs 2.99/*barnase, barstar* and *bar genes*	CGMCP, University of Delhi	Public
7.	Maize	Insect Resistance	MON89034	Monsanto	Private
8.	Maize	Herbicide Tolerance	NK603	Monsanto	Private
9.	Wheat	Salt Tolerance	*OsNHX1 gene*	Mahyco	Private
10.	Wheat	Herbicide tolerance	event MON 71800/*cp4epsps gene*	Mahyco	Private
11.	Cauliflower	Insect Resistance	Event CFE4	Sungro Seeds	Private
12.	Okra	Insect Resistance	*cry1Ac gene*	Mahyco, Sungro Seeds	Private
13.	Potato	Reduced Cold Induced Sweetening	KChipInvRNAi-2214	CPRI, Shimla	Public
14.	Groundnut	Drought Tolerance	*rd29A gene (DREB1A)*	ICRISAT, Hyderabad	Private
15.	Rice	Insect Resistance and Herbicide Tolerance	*dual Bt (Cry1Ab & Cry1Ca)* and *bar genes, Cry1Ab* & *Cry1Ca* and *Cry 2 Ad gene*	Bayer Biosciences	Private
16.	Rice	Herbicide Tolerance	event OS_A17314/ *cp4epsps gene*	Mahyco	Private
17.	Golden Rice	Nutritional Enhancement	GR-2	ICAR-IIRR Hyderabad, IARI New Delhi, TNAU Coimbatore	Public
18.	Chickpea	Insect Resistance	SSL-3/*cry1Ac*	Sungro Seeds	Private
19.	Chickpea	Insect Resistance	SSL-6/*cry2Aa*	Sungro Seeds	Private
20.	Sugarcane	Insect Resistance	*cry1Ac gene*	Sugarcane Research Institute, UPCSUR, Shahjahanpur	Public

Advantages of Genetically modified crops

Genetic engineering is a time saving and reliable technique to get the desired result, in one generation rather than twenty. Genetically Modified (GM) crops offer improved yields, enhanced nutritional value, longer shelf life, and resistance to drought, frost, or insect pests. Examples of GM crops include corn varieties containing a gene for a bacterial pesticide that kills larval pests, and soybeans with an inserted gene that renders them resistant to weed-killers such as Roundup. "Nutritionally enhanced" GM crops which are currently under development include varieties of wheat which are free of gluten, a major cause of food allergy; vegetables with higher vitamin E content to prevent heart disease; and "golden rice" a genetically engineered to contain vitamin A and iron to prevent common nutritional deficiencies in developing countries. Genetically modified maize is being used in many common foods, including cornmeal, tortilla chips, and high-fructose corn syrup (a sweetener in soft drinks and baked goods).

There are following advantages of growing GM crops which are not easily observed in conventionally developed crops.

- The GM crops look more attractive to consumers thus consumers prefer these foods.
- The flavour is also enhanced in the gm crops.
- GM crops show greater resistance towards biotic and abiotic stresses which result in the increased production of the crop.
- The shelf life of GM crops is also more like in Flavr-savr tomato it is more durable than conventional tomato.
- These crops also possess greater tolerance to herbicides, making it easier for farmers to control weeds.
- As in golden rice, these crops are also rich in their nutritive value *i.e.* increased vitamins, proteins and minerals.
- It also shows ability to thrive in a harsh climate, such as drought, salt or heat.

Issues with GM Crops

Genetic Conta mination/Interbreeding

Introduced GMOs may cross with wild types or wild relatives of the species and transfer the traits into them. The novel trait may disappear in wild types unless it confers a selective advantage to the recipient.

Competition with Natural Species

Faster growth of GMOs can enable them to have a competitive advantage over the native organism which will allow them to become invasive, to spread into new habitats and cause ecological and economic damage which will create a pressure on the non-target organisms for the survival.

Horizontal Transfer of Recombinant Genes to Other Microorganisms

One risk of particular concern relating to GMOs is the risk of horizontal gene transfer (HGT). HGT is the transfer of foreign genes (*via* transformation, transduction and conjugation) into the host cell by other organisms.

Adverse Effects on the Health of People or the Environment

These include more pathogenicity, emergence of a new disease, pest or weed, increased disease burden if the recipient organism is a pathogenic microorganism or virus, increased weed or pest burden if the recipient organism is a plant or invertebrate and adverse effects on species, communities or ecosystems.

Ethical Concerns

Various ethical issues associated with HGT from GMOs have been raised including perceived threats to the integrity and intrinsic value of the organisms involved, to the concept of natural order and integrity of species, and to the integrity of the ecosystems in which the genetically modified organism occurs.