Study Material

M.Sc. Ag. IV semester
Course: Principles & Practices of Seed Production
Chapter: 03 (GM Crops)

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WHAT ARE GM CROPS?

The term genetically modified (GM), as it is commonly used, refers to the transfer of genes between organisms using a series of laboratory techniques for cloning genes, splicing DNA segments together, and inserting genes into cells. Collectively, these techniques are known as recombinant DNA technology. Other terms used for GM plants or foods derived from them are genetically modified organism (GMO), genetically engineered (GE), bioengineered, and transgenic.

Genetically modified crops (GM crops) are plants used in agriculture, the DNA of which has been modified using genetic engineering techniques. More than 10% of the world's croplands are planted with GM crops.

The aim of producing GM crop is to introduce a new trait to the plant which does not occur naturally in the species like resistance to certain pests, diseases, environmental conditions, herbicides etc.

MAJOR APPLICATIONS OF GM CROP TECHNOLOGY

1. **Nutritional enhancement**: Higher vitamin content; more healthful fatty acid profiles;
2. **Stress tolerance**: Tolerance to high and low temperatures, salinity, and drought;
3. **Disease resistance**: For example, orange trees resistant to citrus greening disease or American chestnut trees resistant to fungal blight;
4. **Biofuels**: Plants with altered cell wall composition for more efficient conversion to ethanol;

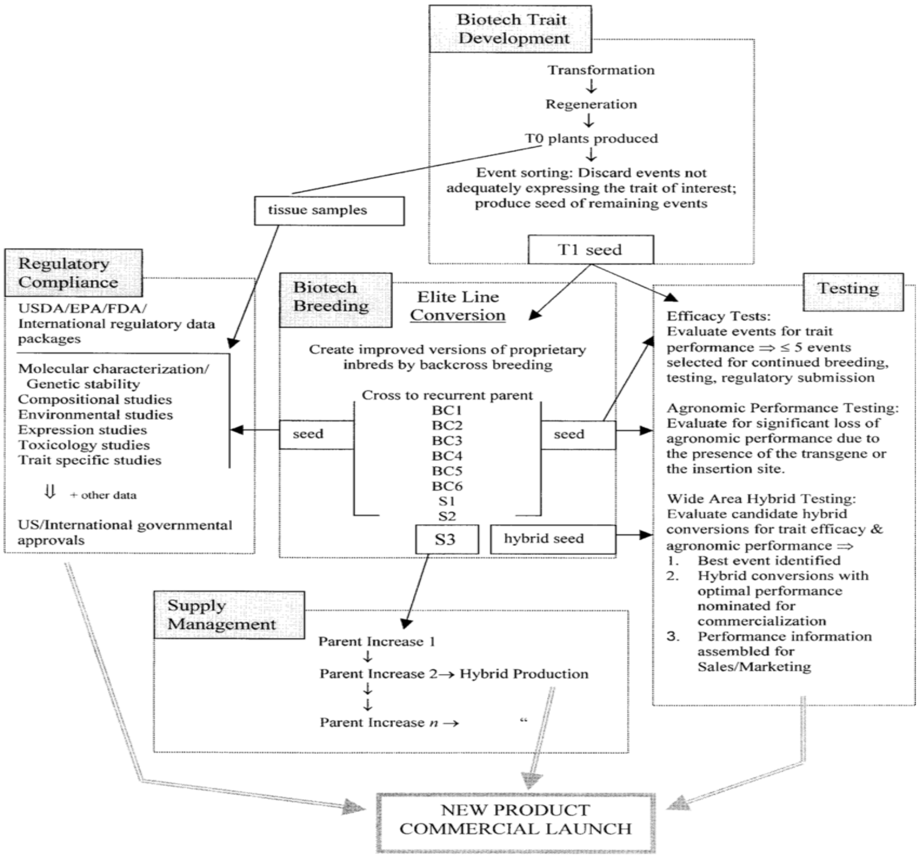
5. **Phytoremediation**: Plants that extract and concentrate contaminants like heavy metals from polluted sites.

GM CROP TECHNOLOGY VS. TRADITIONAL CROP BREEDING TECHNOLOGY

Major plant breeding programs based on manual cross-pollination between genetically distinct plants to create new combinations of genes. The progeny plants are intensively evaluated over several generations and the best ones are selected for potential release as new varieties. Other techniques included within the conventional plant breeding is development of hybrid varieties by crossing two parental strains to produce offspring with increased vigor; and induced mutations to create useful variation while Genetic modification (GM) is the area of biotechnology which concerns itself with the manipulation of the genetic material in living organisms, enabling them to perform specific functions.

Genetic modification in plants was first recorded 10,000 years ago in Southwest Asia where humans first bred plants through artificial selection and selective breeding. Since then, advancements in agriculture science and technology have brought about the current GM crop revolution. GM crops are promising to mitigate current and future problems in commercial agriculture, with proven case studies in Indian cotton and Australian canola. The current growth rate of the GM seed market at 9.83–10% CAGR along with promising research avenues in biofortification, precise DNA integration and stress tolerance have forecast it to bring productivity and prosperity to commercial agriculture.

GENERAL PROCEDURE OF GM CROP PRODUCTION



GM CROPS IN INDIA

The country has yet to approve commercial cultivation of a GM food crop. The only genetically modified cash crop under commercial cultivation in India is cotton.

- **Bt Cotton**

The only genetically modified crop that is under cultivation in India is Bt cotton which is grown over 10.8 million hectares. Bt cotton was first used in India in 2002.

- **Bt Brinjal**

The GEAC in 2007, recommended the commercial release of Bt Brinjal, which was developed by Mahyco (Maharashtra Hybrid Seeds Company) in collaboration with the Dharward University of Agricultural sciences and the Tamil Nadu Agricultural University. But the initiative was blocked in 2010

- **GM-mustard**

Dhara Mustard Hybrid - DMH-11 is a genetically modified variety of mustard developed by the Delhi University’s Centre for Genetic Manipulation of Crop Plants. The researchers at Delhi University have created hybridised mustard DMH-11 using “barnase / barstar” technology for genetic modification. It is Herbicide Tolerant (HT) crop. If approved by the Centre, this will be the second GM crop, after Bt Cotton, and the first transgenic food crop to be allowed for cultivation in the country.

ARGUMENTS IN FAVOUR OF GM CROPS*:*

The proponents argue that the GM technologies have been around for about 15 years and they have been in use across the world including in countries such as Brazil and China. During a visit to India in March 2005, Norman Borlaug – widely regarded as the father of the Green Revolution – supported producing genetically modified (GM) food to eradicate hunger from the world. "It is better to die eating GM food instead of dying of hunger," said the Nobel laureate, who passed away in 2009.

1. Former prime minister, **Dr. Manmohan Singh**, saw biotechnology as key to food security and warned against succumbing to "unscientific prejudices".
2. Former President **Sh. Pranab Mukerjee**- "The concerns over their (GM crops) perceived risks should be addressed by following internationally accepted procedures for assessing safety parameters. ICAR, which is involved in developing useful products and technologies in this field, must contribute to the public discourse and provide clarity on this sensitive issue,"
3. **Agriculture scientists** from research institutions including IARI, ICAR and various Universities demanding "field trials" for GM crops, arguing that "confined field trials are essential for the evaluation of productivity performance as well as food and environmental safety assessment".
4. A group of prominent scientists had met under 'father of Indian green revolution' MS Swaminathan at National Academy of Agricultural Sciences and issued a 15-point resolution in favour of GM crops.

ARGUMENTS AGAINST GM CROPS*:*

Organisations such as **Greenpeace** –

- Argue that the GM crops don't yield better results, but push the farmers into debt. They lose their sovereign right over seeds as they are forced to buy GM seeds and technologies from multinational corporations. The increasing incidence of suicide by farmers cultivating Bt cotton is cited as an example of the perils of GM crops in a country such as India.
- Besides the suspect merits of GM crops, what the opponents also say is that once they are released into the environment, it's irreversible

MAJOR GUIDELINES FOR BIOTECH CROP/ SEED PRODUCTION

- The top biotech regulator in India is Genetic Engineering Appraisal Committee (**GEAC**). The committee functions as a statutory body under the Environment Protection Act 1986 of the Ministry of Environment & Forests (MoEF). It was earlier known as Genetic Engineering Approval Committee. Under the EPA 1986 "Rules for Manufacture, Use, Import, Export and Storage of Hazardous Microorganisms/Genetically Engineered Organisms or Cells 1989", GEAC is responsible for granting permits to conduct experimental and large-scale open field trials and also grant approval for commercial release of biotech crops.

- The Rules of 1989 also define five competent authorities i.e. the Institutional Bio-safety Committees **(IBSC**), Review Committee of Genetic Manipulation **(RCGM**), Genetic Engineering Approval Committee **(GEAC),** State Biotechnology Coordination Committee (**SBCC**) and District Level Committee (**DLC)** for handling of various aspects of the rules.

- **The industry body** — Association of Biotech Led Enterprises- Agriculture Group (**ABLE-AG**) wants a progressive push to the march of GM technology in India.

- All India Crop Biotechnology Association (**AICBA**) was also formed to represent seed industry in addition to existing ones such as Seed Association of India(**SAI**) at New Delhi and Association of Seed Industries(**ASI**) at Mumbai.

- Under Seeds Rules, 1968, Central Government has declared CICR laboratory of ICAR as Referral Laboratory for Bt. cotton seeds in 2003. The detection kits developed at CICR has been recognized by the Government as a standard test for Bt. detection in GM seeds.

- As per the Seed rules, 1968, all seed testing laboratories are to perform purity testing along with genetic purity testing for Bt and the following standards have been specified for the same: Submitted sample size: 25g; Working sample size: 10 seeds; Minimum level of Bt. toxin to be present: 450nanog/sq.cm. or /gm seed; The purity in terms of quantum of gene expression of Bt. Protein should be 90% for labelling of Bt. cotton seed.

REFUGIA

R**efugia** — are fields without pesticides (sprayed or plant-produced) located near fields planted with pesticide-producing crops.

Pests evolve resistance to our pesticides at an alarming rate. However, evolutionary theory tells us how we can slow the rate at which genes for pesticide resistance spread: by providing refuges where non-resistant insects thrive.

But evolutionary theory tells us that these solutions will not work indefinitely. Pest insects have short generation times and large population sizes — which means that they evolve quickly. If pesticides are widely applied, or if fields are widely planted with pesticide-producing plants, insects resistant to the pesticide will evolve. Some degree of resistance has been documented for every major class of insecticide used in agriculture.

Refugia may be particularly important in slowing the spread of insects resistant to the pesticide Bt (produced by a gene in the bacterium *Bacillus thuringiensis*). As one of the few pesticides used by organic farmers, Bt kills a small subset of insects and does not harm many beneficial organisms. However, resistance to this pesticide has become an imminent threat as corn and cotton genetically engineered to produce their own Bt fill more and more fields. These genetically engineered crops increase the selective pressure for Bt resistance on insect populations. If Bt resistant insects become common, organic farmers will have lost one of the few pesticides they are able to use.

Refugia slow the evolution of widespread Bt resistance by providing havens in which the non-resistant insects survive. The allele for Bt resistance happens to be recessive — that means that the resistant allele can be masked by the dominant non-resistant allele. So if a resistant insect (rr) surviving in the Bt-producing field mates with a non-resistant insect (RR) surviving in the refuge, all of their offspring will be non-resistant (Rr).

When two heterozygous pests mate, only one in four offspring (on average) will be homozygous recessive (rr) and therefore resistant to the pesticide.

By keeping refuges for the non-resistant alleles, we can prevent many of the resistant alleles from being expressed. More insects will be vulnerable to Bt and the spread of the resistant allele will slow.

ISOLATION

A major concern related to the adoption of genetically modified (GM) crops in agricultural systems is the possibility of unwanted GM inputs into non-GM crop production systems, there is an urgent need to define measures to prevent mixing of GM with non-GM products during crop production.

- Cross-fertilization is one of the various mechanisms that could lead to GM-inputs into non-GM crop systems. Isolation distances between GM and non-GM fields are widely accepted to be an effective measure to reduce these inputs. However, the question of adequate isolation distances between GM and non-GM maize is still subject of controversy both amongst scientists and regulators. As several European countries have proposed largely differing isolation distances for maize ranging from 25 to 800 m, there is a need for scientific criteria when using cross-fertilization data of maize to define isolation distances between GM-GM and non-GM maize.

- The cultivation area of genetically modified (GM) crops on the global scale is continuously increasing. In Europe, concerns by farmers and the public, however, make the coexistence of GM and non-GM crops critical in some regions. GM material may be transported into protected sites or cross-pollinate neighboring fields with non-GM varieties . Both pathways may cause unwanted effects, such as contaminate non-GM harvests above tolerance threshold for GM material , or adversely affect trophic links and/or other processes within ecological communities . For example, the lepidopteran-active Bt-maize events may do potential environmental harm to non-target lepidopteran species of conservation concern that inhabit protected habitats. This exposure can be reduced to a level of no or minimum concern by imposing isolation distances.

- To minimize cross-pollination and thus secure the freedom of choice for farmers and consumers, as well as to minimize environmental risks, GM cropping in many countries is regulated by coexistence measures , including pollen barriers, flowering asynchrony and crop rotation. These measures are obligatory for GM crop farmers. The measures include minimum isolation distances between GM fields and non-GM fields and, in some countries, to protected sites. Information on pollination distances, cross-fertilization rates, and on potential wild relatives serves as a basis for defining these isolation distances, issued by the individual countries.

- These distances vary considerably between country to country, Ex. with a minimum of 15 m to conventional maize in Sweden and a maximum of 800 m to organic maize in Hungary . Minimum distances of GM maize fields to protected sites in Germany are regulated by individual federal states and range between 800 and 1,000 m; this is significantly more than the 30 m suggested, for instance, for the Bt-maize 1507 by the EFSA Panel on Genetically Modified Organisms (GMO) Minimum isolation distances of GM fields to non-GM and protected habitats may influence the distribution pattern of GM crop fields within agricultural landscapes . These patterns, however, can be expected to vary between different types of landscapes. They depend on landscape characteristics such as crop species grown and their proportions, field sizes and their distribution, and the distribution patterns of protected sites. Thus, the spatial distribution patterns of GM crops, and also the maximum feasible proportion of GM crops in agricultural landscapes, are expected to be landscape specific.

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