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GENETICALLY MODIFIED CROPS

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Introduction

Genetically Modified Crops (GMCs) are plants whose genetic material has been altered through biotechnology to exhibit traits that are not naturally present. This process involves adding or modifying genes within the crop's DNA to achieve desirable characteristics such as pest resistance, enhanced nutritional content or improved tolerance to environmental conditions. By manipulating an organism's DNA, scientists can create crops that are better suited to specific environmental conditions or agricultural needs.

The journey of genetic modification in agriculture began in the 1970s with foundational experiments in molecular biology. The 1990s marked a turning point with the commercialization of the first GM crops, including Bt cotton and Roundup Ready soybeans. Bt cotton was engineered to produce a protein toxic to certain pests, significantly reducing the need for chemical insecticides. Since then, the technology has advanced rapidly, leading to the development of various genetically modified crops that offer benefits such as improved yield and resistance to environmental stressors.

Importance of GMC's for Indian Farmers and Consumers

In India, the importance of GMOs cannot be overstated. With its vast and diverse agricultural sector, the country faces numerous challenges, including pest infestations, soil degradation and fluctuating climatic conditions. Genetically modified crops offer potential solutions by providing higher yields, reducing the reliance on chemical inputs, and enhancing crop resilience.

For Indian farmers, this translates to increased productivity and reduced costs, while consumers may benefit from improved food security and potentially lower food prices. As India continues to grapple with these agricultural challenges, understanding and integrating GMOs could play a crucial role in shaping the future of its farming and food systems.

Basic Principles of Genetic Engineering:

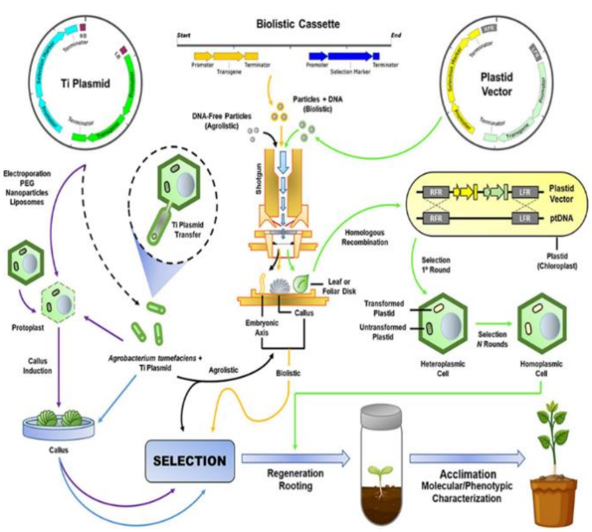
At its core, genetic engineering involves directly manipulating an organism's genes. All living organisms have DNA, which contains the instructions for their development and functioning. To understand GMOs, we must first grasp the basic principles of genetic engineering and how they differ from conventional methods

1. Identify genes responsible for desired traits
2. Extract these genes from the source organism
3. Insert the genes into the target crop's DNA

4. Ensure the new genes function properly in the target crop

Common Techniques Used in Creating GM Crops:

1. Agrobacterium-mediated transformation:
   - Uses a naturally occurring soil bacterium to insert new genes into plant cells
   - Most common method for dicot plants like cotton and soybeans
2. Particle bombardment (Gene gun):
   - Shoots microscopic gold or tungsten particles coated with DNA into plant cells
   - Often used for monocot crops like rice and wheat
3. CRISPR-Cas9 gene editing:
   - A newer, more precise technique
   - Allows for specific modifications within the plant's existing genome conditions for disease development and spread.
   - Can create changes similar to those that might occur in nature, but in a targeted manner.



Plant genetic transformation approaches

Biofortified transgenic crops

Crops	Nutrient	Gene/protien
Arabidopsis	Fe	*At*NRAMP3 and
Arabidopsis	Iodine	*h*NIS
Rice	Fe and Zn	*Hv*NAS1
Rice	Fe	*Os*YSL2
Rice	Zn	*Os*HMA1
Rice	Fe	Rice Rice
Rice	Fe	Ferritin
Rice	Fe	Lactoferrin
Rice	Fe and Zn	*fumigates* phytase
Rice	Fe	*OsNAC5*
Wheat	Fe	*TaVIT2*
Wheat	Fe	*GmFerritin*
Wheat	Zn	*NAM-B1*
Wheat	Zn and Fe	*OsNAS2*
Wheat	Zn and Fe	*Phy A*
Wheat	Zn and Fe	*Phy A*
Barley	Fe	*AtZIP1*
Maize	Fe	*Ferritin and lactoferrin*
Pea	Fe	*Brz and dgl*
Soybean	Fe and Zn	*Phtase*
Tobacco	Iodine	*HMT, S3H and SAMT*

Examples of genetically modified crops:

1. Soybean

- "Roundup Ready" (herbicide-tolerant) - Monsanto, 1996

2. Maize (Corn)

- Bt maize (insect-resistant)

- Drought-tolerant maize (MON 87460) - Monsanto, 2013

- High-lysine maize

3. Cotton

- Bt cotton (insect-resistant)

4. Canola (Argentine)

- Herbicide-tolerant canola

- DHA (docosahexaenoic acid)-enriched canola - Nuseed Pvt Ltd, 2018

5. Potato

- Insect-resistant and virus-resistant potatoes

- Innate® potatoes (lower bruising, less acrylamide) - J.R. Simplot Company

6. Rice

- Golden Rice (provitamin A biofortified) - IRRI
  - GR1 - Syngenta
  - GR2 - Syngenta
  - GR2E - Approved in multiple countries 2017-2018

7. Papaya

- Virus-resistant papaya ("Rainbow" and "SunUp") - University of Hawaii, 1998

8. Squash

- Virus-resistant squash - 1995

9. Bean

- Virus-resistant bean - Embrapa (Brazilian Agricultural Research Corporation), 2011

10. Sugarbeet

- Herbicide-tolerant sugarbeet

11. Brinjal (Eggplant)

- Bt brinjal - Bangladesh Agricultural Research Institute, 2013

12. Alfalfa

- Herbicide-tolerant alfalfa

13. Sugarcane

- Drought-tolerant sugarcane - Indonesia, 2013

14. Safflower

- Modified oil content

15. Camelina

- Omega-3 enriched Camelina - Developed but not yet commercialized

16. Plum

- Virus-resistant plum

17. Sweet Pepper

- Virus-resistant sweet pepper

18. Tomato

- Delayed ripening tomato- increased shelf life (Flavr Savr) - Calgene company, 1994 (later withdrawn)

19. Carnation

- Modified flower color

20. Poplar

- Insect-resistant poplar

21. Wheat

- Herbicide tolerant wheat

22. Sorghum

- Herbicide tolerant wheat - Cry1Ac gene transferred by Polymerase Chain Reaction

Comparision between Conventional breeding and Transgenics:	
Traditional Breeding: Conventional breeding achieves it by crossing together plants with relevant characteristics, and selecting the offspring with the	**Transgenic breeding:** Transfer of genes by crossing involves recombination of genetic material, while genetic transformation allows the transfer

desired combination of characteristics, as a result of particular combinations of genes inherited from the two parents.	of only the desired and specific gene sequences.
• Relies on sexual reproduction between related plants • Limited to naturally occurring variations within a species or closely related species • Can take 10-15 years to develop a new variety • May inadvertently introduce undesired traits along with the desired ones	• Can introduce traits from any organism, even unrelated species • Allows for precise introduction of specific traits • Can develop new varieties in 5-7 years • Minimizes unintended trait transfers

Regulatory status of GM food crops

The regulatory status of genetically modified food crops varies significantly across countries and regions, reflecting diverse approaches to risk assessment and approval processes. Globally, as of 2018, 70 countries had adopted biotech crops through cultivation and import.

The United States, Brazil, Argentina, Canada, and India are among the top adopters of genetically modified crops. Regulatory frameworks typically involve safety assessments for human health and environmental impact. In the United States, the Food and Drug Administration, United States Department of Agriculture, and Environmental Protection Agency oversee different aspects of genetically modified crop regulation.

Current Status of Genetically Modified (GM) Crops in India:

India has taken a cautious approach to genetically modified crops. Currently, Bt cotton is the only GM crop approved for commercial cultivation in the country, first introduced in 2002. It has been widely adopted, with over 90% of cotton area under Bt varieties. Despite field trials for several other GM crops, including Bt brinjal, herbicide-tolerant cotton, and GM mustard, none have received final approval for commercial release due to regulatory hurdles and public concerns. The Genetic Engineering Appraisal Committee (GEAC) oversees the approval process, but final decisions often face political and social scrutiny. While research continues on various GM crops, including those with improved nutritional content and stress tolerance, their commercialization remains a contentious issue in India, balancing potential agricultural benefits against biosafety and socio-economic concerns.

Challenges of genetically modified crops

Genetically modified (GM) crops, despite their potential benefits, face several significant challenges across environmental, regulatory, and public perception domains. Environmentally, there are concerns about unintended ecological consequences, such as the development of herbicide-resistant weeds, pesticide-resistant insects, and gene flow to wild relatives, which could impact non-target organisms. These risks have raised questions about the long-term sustainability of GM crops. Regulatory hurdles also present challenges, as inconsistent global policies create trade barriers and complicate commercialization.

For example, the European Union's strict GM crop regulations contrast sharply with the more permissive policies in the U.S., leading to market acceptance issues.

Public resistance and skepticism further exacerbate these challenges, with consumers in many regions expressing doubts about the safety of GM foods, despite a general scientific consensus supporting their safety. This mistrust has fueled demands for mandatory labeling and concerns about the concentration of GM technology in the hands of a few large corporations, which raises issues related to agricultural diversity and farmer autonomy.

Overall, these challenges contribute to the ongoing debates and complexities surrounding the adoption of GM crops.

Conclusion:

GM crops hold significant potential for India's agricultural future by offering solutions to pressing issues such as pest resistance, drought tolerance, and improved nutritional content. These crops can enhance productivity and sustainability, helping farmers cope with challenging conditions and contributing to food security. By integrating advanced biotechnology, India can boost agricultural efficiency and resilience, addressing both the demands of a growing population and the impacts of climate change.

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