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Genetically Modified Crops: Revolutionizing Indian Agriculture

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ARTICLE ID: 20

Abstract:

A large number of genetically modified crops, including both food and non-food crops carrying novel traits have been developed and released for commercial agriculture production. Genetically modified (GMO) crops are those whose DNA has been altered using genetic engineering techniques (adding, deleting, or modifying a specific trait in an organism to produce the desired mutation). Crops that have been genetically modified demonstrate one or more positive features that are not generally found in natural plants. India's agricultural landscape is transforming, with GM crops playing an increasingly prominent role. This article delves into the intricate world of GM crops in Indian agriculture, exploring their history, current status, potential benefits, and the challenges they face. We will examine the regulatory framework, public perception, and prospects of these transformative technologies, shedding light on their impact on Indian farming practices and food security.

Keywords: Genetically modified Crops (GMO) and Bacillus thuringiensis (bt)

Introduction:

Genetic modification of crops is a biotechnological process used to alter the genetic material of plants to introduce or enhance specific traits. This process begins with identifying a desirable trait, such as pest resistance or drought tolerance, often derived from other organisms like bacteria or plants. Scientists then isolate the gene responsible for this trait and insert it into the plant's DNA using methods such as Agrobacterium-mediated transformation, where a bacterium transfers the gene into the plant’s cells, or gene guns, which shoot DNA-coated particles into plant cells. Following gene insertion, the modified plants are selected and regenerated to ensure they express the new trait. These GM plants undergo extensive testing for safety and efficacy before receiving regulatory approval for commercial cultivation. This approach allows for precise enhancements in crop traits, aiming to improve agricultural productivity and sustainability. Crop production in India faces limitations caused by a variety

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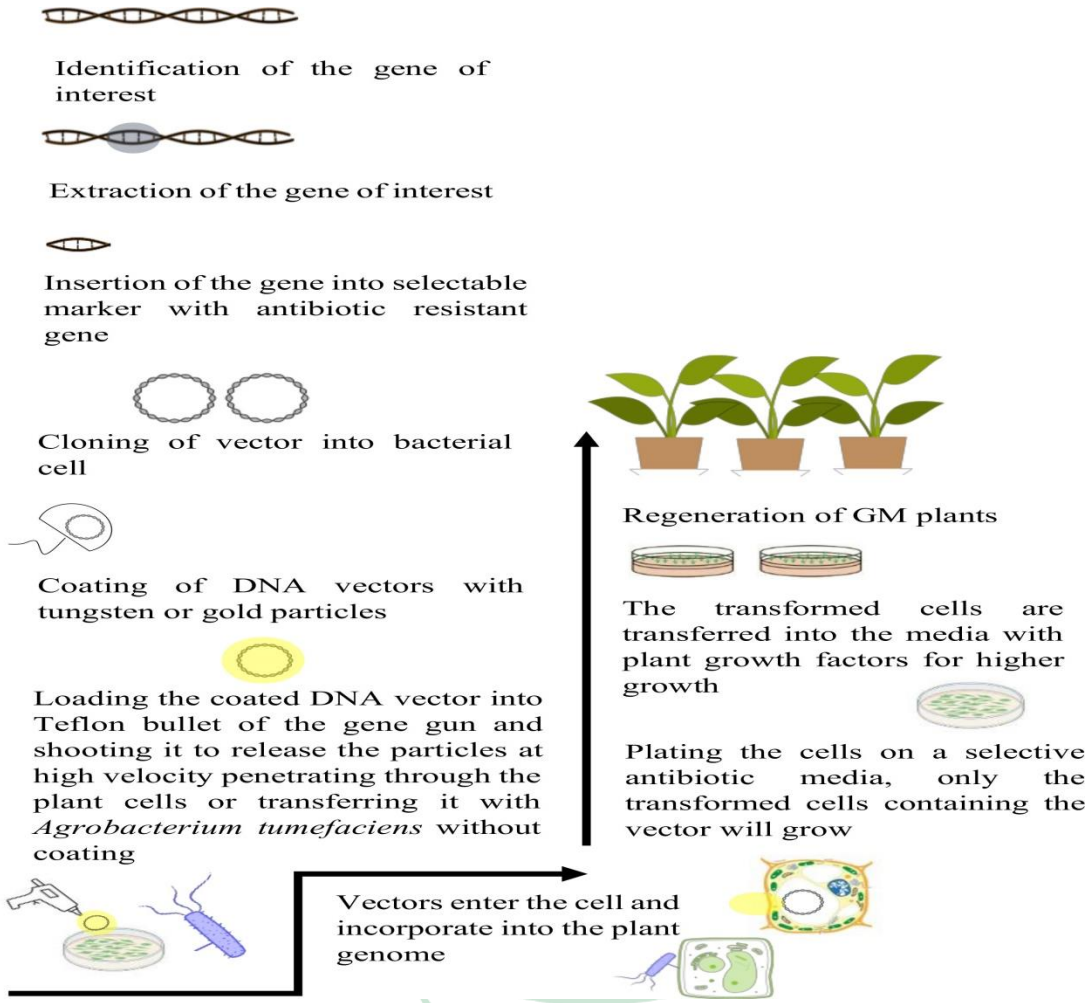
of biotic and abiotic stresses. It is probable that genetically modified crops will prove to be efficient in tolerating those pressures. GM crops could be an option for nutrient enhancement and yield increase in major crops and solve the problem of malnourishment and food security. India makes up 6% of global acreage under GM crops and ranks 5th in GM cropland, behind the USA, Brazil, Argentina, and Canada.



Genetically engineered crops for sustainably enhanced food production systems.

Emergence of GM Technology:

The journey of GM crops in India began in the early 1990s, with initial research and field trials aimed at evaluating their potential benefits and risks, focusing on cotton. Research institutions like the Indian Agricultural Research Institute (IARI) and The Maharashtra Hybrid Seed Company (Mahyco) spearheaded these initial efforts, exploring the potential of GM technology for enhancing crop yields and resilience. In 1998, The Genetic Engineering Approval Committee (GEAC) was established to regulate and oversee GM crops. The pivotal

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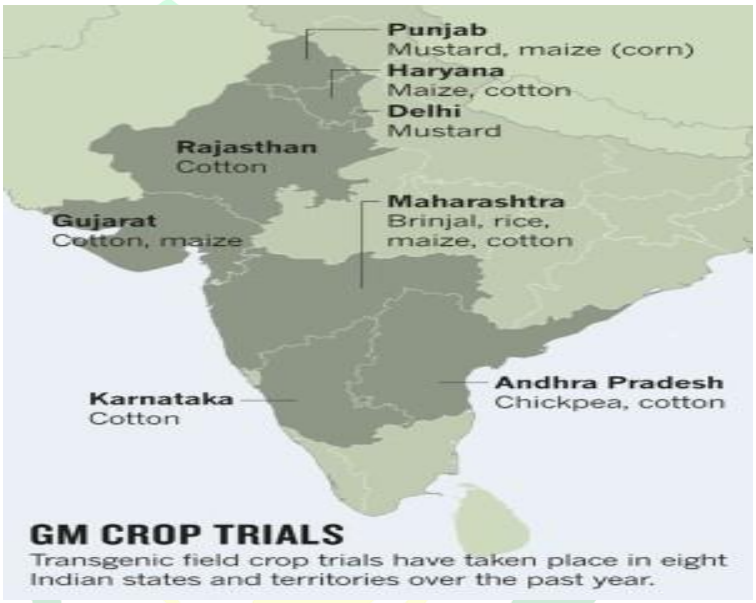
moment came in 2002 when a joint venture between Monsanto and Mahyco came with the approval of Bt Cotton, engineered to resist bollworm pests, which significantly boosted yields and reduced pesticide use. Despite this success, the introduction of other GM crops, such as Bt brinjal, faced substantial public opposition and regulatory challenges, leading to a moratorium on its commercialization in 2010. In 2022, a notable development occurred with the approval of GM mustard, marking a significant policy shift towards a more pragmatic approach to GM crop regulation.



Current Status of Major Gm Crops in India:

In India, only cotton is now commercially grown as a GM crop. Other crops such as tomato, Soyabean, cabbage, okra, lentil, maize, and chickpea are currently undergoing transgenic technology trials. GM mustard and Bt-brinjal are two additional GM crops that are set to be released to Indian farmers for farming, but they are currently caught up in legal and regulatory conflicts. Both of the upgraded crops have the potential to increase both productivity and sustainability.

Bt cotton

Bt Cotton is the first and only transgenic crop that was approved for commercial cultivation in 2002, by the Government of India. It has significantly decreased the use of hazardous pesticides. Bt., a widespread soil bacterium, is produced by Bt cotton. It is a natural pest-repelling bacteria that is toxic to numerous worms and pests that might harm crops but is safe for people. Organic farmers commonly spray Bt, on their crops as a pesticide. As a result

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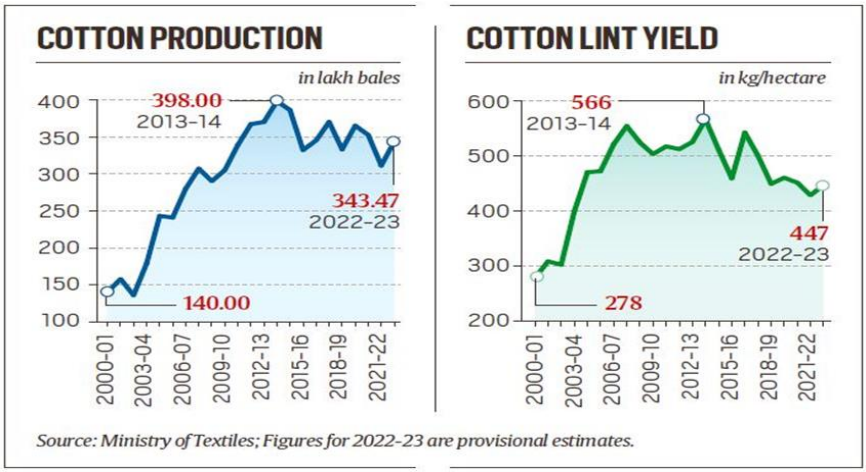
of the adoption of Bt cotton, India has become the world's largest cotton grower. It decreases the usage of pesticides and insecticides in farming, which could be a positive step toward improving the food supply. It can feed a rapidly growing population since its yields are considerably higher. 7 out of 8 Million Cotton Farmers have adopted BT Cotton in India.



GM Mustard

DMH-11, also known as Dhara Mustard Hybrid-11, is a hybrid variety of the mustard plant Brassica juncea that has been genetically modified. Professor Dr. Deepak Pental from the University of Delhi created it with the goal of decreasing India's need for importing edible oils.The approval of GM mustard was seen as a major milestone in India's agricultural biotechnology sector. The Genetic Engineering Appraisal Committee (GEAC) has approved the environmental release of DMH-11, a genetically modified mustard strain. If allowed for commercial cultivation, it will be the first genetically modified food crop available to Indian farmers. DMH-11 is the product of a hybrid between the Indian mustard variety 'Varuna' and the East European variety 'Early Heera-2 mustard. DMH-11 was developed using transgenic technology, mainly incorporating the Bar, Barnase, and Barstar gene systems. The presence of the Barnase gene causes infertility in males, whereas the Barstar gene enables DMH-11 to produce seeds that are capable of reproduction. The incorporation of the third gene Bar allows DMH - 11 to generate phosphinothricin-N- acetyl-transferase, the enzyme that provides resistance to Glufosinate. DMH-11 has demonstrated a yield that is around 28% higher than the national check and 37% higher than the zonal checks, with its adoption being declared and authorized by the GEAC. In October 2022, the GEAC approved the environmental release of DMH-11, this is one step away from the full commercial cultivation.

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Bt Brinjal

Mahyco, an Indian seed company located in Jalna, Maharashtra, created the Bt brinjal to protect against lepidopteron insects, specifically the Brinjal Fruit and Shoot Borer (*Leucinodes orbitalis)*, by creating holes in their digestive system.

Event EE 1 is the name given to the genetically modified brinjal, and Mahyco has also requested approval for two brinjal hybrids. The first agreement to develop Bt Brinjal was signed in 2005 between India's leading seed company, Mahyco and two agricultural universities - University of Agricultural Sciences, Dharwad and Tamil Nadu Agricultural University in Coimbatore. The GEAC cleared Bt Brinjal for commercialization on 14 October 2009. Therefore, without the approval of the environmental ministry, growing and selling Bt brinjal remains banned in India and is a violation of the rules under the environmental ministry.

Regulatory Framework for GM Crops in India:

In India, GMOs are broadly regulated under Rules for the manufacture, use, import, export & storage of hazardous microorganisms, genetically engineered organisms or cells, 1989 notified under the Environment Protection Act, 1986 (EPA, 1986).

- **Genetic Engineering Appraisal Committee (GEAC):** The GEAC, established under the Environment Protection Act, of 1986, is the apex body responsible for regulating the development, testing, and release of GM crops in India. It assesses the safety and environmental impact of these crops, granting or denying approvals for commercial cultivation.
- **Biosafety Rules, 2000:** These rules provide a comprehensive framework for regulating the use of genetically engineered organisms (GMOs) in the country. They establish guidelines for field trials, biocontainment, and monitoring of potential risks associated with GM crops.
- **Department of Biotechnology (DBT):** The DBT plays a crucial role in promoting research and development of biotechnology, including GM crops. It provides funding, infrastructure, and technical support for research projects related to GM crops and their applications.
- **Other Regulatory Bodies:** Other regulatory bodies, such as the Ministry of Agriculture and Farmers Welfare and the Food Safety and Standards Authority of India (FSSAI), also play a role in regulating the cultivation, processing, and marketing of GM crops,

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ensuring adherence to safety standards and consumer protection. Field Trials are managed by the Review Committee on Genetic Manipulation (RCGM) and conducted under controlled conditions.

The Case for GM Crops: A Potential Boon

As the global population continues to expand and climate change intensifies, the challenges facing modern agriculture have never been more pressing. In this context, GM crops have emerged as a potentially transformative solution. Far from being a mere technological trend, GM crops offer significant benefits that could address some of the most critical issues in food production and sustainability. Here's a closer look at why GM crops might be considered a potential boon.

1. **Enhanced Crop Yield:** Since Bt brinjal is resistant to fruit and shoot borer, farmers report around 30% higher yield. In the period from August 2022 to July 2023, 95 per cent of the nation's cotton output of 26 million bales (equivalent to 13 million hectares) was accounted for by Bt cotton, with 1.2 million bales being sent abroad.
2. **Reduced Dependence on Pesticides:** Bt cotton, has resulted in significant reductions in pesticide poisoning cases due to reduced applications and reduced levels of insecticide exposure. Bt brinjal can reduce pesticide usage by up to 80% as it contains a pest-resistant gene. This not only lowers the cost of cultivation but also mitigates the environmental impact of pesticide use, promoting more sustainable farming practices.
3. **Nutritional Enhancement:** Biofortification of GM crops can address malnutrition by enriching staple crops with essential nutrients. For instance; Golden Rice, which is genetically modified to produce beta-carotene, could potentially address vitamin A deficiencies in large segments of the Indian population and Biofortified Mustard which have been developed to produce higher levels of Omega-3 Fatty Acids, which are essential for heart health and brain function.
4. **Climate Resilience:** With the increasing threat of climate change, GM crops can be designed to withstand extreme weather conditions such as Drought tolerant Maize, flood-tolerant Rice (Sub1Gene) and -tolerant rice, Heat-tolerant Cotton.This resilience could be crucial in maintaining food security in the face of unpredictable climate patterns.

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The Case Against GM Crops: A Potential Bane

In recent decades, GM crops have become a cornerstone of modern agriculture. Promoted as a solution to global food insecurity, climate challenges, and agricultural inefficiencies, these crops have certainly revolutionized farming practices. However, their introduction has sparked significant controversy and debate. While GM crops have their advocates, it is crucial to examine the potential drawbacks and underlying risks associated with their widespread adoption.

1. **Environmental Concerns:** The development of pest resistance in cotton pests has led to increased use of alternative pesticides, and biodiversity loss due to monoculture practices. Example: Bt Cotton.
2. **Economic Issues:** High costs of Bt cotton seeds and associated inputs have led to financial strain and debt among farmers, exacerbating economic vulnerabilities. Example: Cotton Farmer Debt.
3. **Health and Safety Risks:** Although GM crops undergo rigorous testing, concerns remain about their long-term impact on human health. Sceptics worry about potential allergenicity, toxicity, and unintended consequences of consuming GM foods, although scientific evidence supporting these claims is limited. Example: Public Health Debate.
4. **Increased Dependence on Chemicals:** GM crops engineered to be herbicide-resistant can lead to an increase in the use of herbicides, contributing to chemical pollution and harming soil health. Example: Herbicide-Resistant Crops.

The Case of Illegal Cultivation of GM Crops:

Many biotech proponents indicated the illegal cultivation of GM crops as a signal of farmers' willingness to embrace GM technologies (Jayaraman 2001).

- GUJARAT, 2001, 11,000 hectares of illegal GM cotton worth $ 30 million discovered.
- In 2017, 15% of cotton farmers in main cotton-producing states had transitioned to the HtBt variety (Department of Biotechnology).
- AKOLA, 2019, 1,500 farmers led by Shetkari Sanghatana, a pro-GM farmers union gathered to plant illegal GM crops such as HtBt cotton & Bt Brinjal in protest of the regulatory logjam.
- Sales of illegal HtBt cotton have doubled during 2020-2021 from 3.5 million to 7.5 million.

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- Nearly 50% of cotton cultivated in Maharashtra in 2021 was expected to be HtBt Cotton.
- When Down To Earth visited the director of ICAR-DRMR, P K Rai, on November 4, he had denied the trial plantation of GM mustard. However, on November 14, 2022, he admitted the seeds were planted on six occasions before the Supreme Court hearing was scheduled for November 3.

Challenges in the Commercialization of GM Crops:

The commercialization of GM crops in India faces several challenges. Regulatory hurdles pose a significant barrier, as the approval process involves rigorous safety assessments and can be lengthy, creating delays in market entry. Environmental concerns, such as the potential for unintended effects on biodiversity and the development of pest resistance, also generate substantial debate and scrutiny. Economic issues, including high seed costs and intellectual property rights, can strain smallholder farmers and limit accessibility. Additionally, public perception and opposition based on health and ethical concerns can hinder acceptance and adoption. Addressing these challenges requires a balanced approach, including transparent regulation, ongoing research, and effective stakeholder engagement to ensure that GM crops can contribute positively to Indian agriculture.

Future Outlook and Prospects for GM Crops in India:

The future outlook for GM crops in India is marked by both promising opportunities and significant challenges. As agricultural demands intensify due to a growing population and climate change, GM crops offer potential solutions through enhanced yields, reduced pesticide use, and improved resilience. Innovations in genetic engineering, such as CRISPR technology, could lead to the development of crops with even more beneficial traits, including drought tolerance and nutritional enhancement. However, the adoption of these technologies hinges on addressing regulatory, environmental, and socio-economic concerns. Ensuring robust safety assessments, balancing farmer interests with corporate control, and fostering public trust through transparent communication will be crucial. Additionally, integrating GM crops into sustainable agricultural practices and addressing issues like pest resistance and seed cost will play a key role in shaping their future. If managed effectively, GM crops could significantly contribute to India's food security and agricultural sustainability, but careful consideration and proactive management are essential to realize their full potential.

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Conclusion:

The current status of GM crops in India, particularly GM mustard and Bt brinjal, highlights a complex landscape of potential and controversy. While GM mustard has shown promise for improving yields and reducing fertilizer use, its commercialization remains stalled due to regulatory delays and public opposition. Bt brinjal, despite its potential to combat pests and reduce pesticide use, faces strong resistance and has yet to be widely adopted. These examples underscore the broader challenges facing GM crop commercialization, including regulatory hurdles, environmental concerns, economic implications, and societal acceptance. The future outlook for GM crops in India remains cautiously optimistic; if these challenges are addressed through transparent regulation, ongoing research, and effective public engagement, GM crops could indeed be a boon to Indian agriculture, offering significant benefits in terms of productivity and sustainability. However, without careful management and resolution of existing issues, they risk becoming a bane, potentially exacerbating existing problems and failing to deliver on their promises. Balancing these aspects will be crucial for leveraging GM technology to its fullest potential while ensuring it aligns with India's agricultural goals and societal values.