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Environmental Risk and Biosafety of Genetically Modified Plants

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Abstract.
Genetic engineering and biotechnology research have produced novel plant and animal products that benefit humankind. This review assesses the environmental risk and biosafety of genetically modified crops. Debates on the advantages and disadvantages of genetically modified crops have a significant impact on public discourse around them. Biotechnology advocates emphasize how it may treat illnesses, prevent malnutrition, lessen hunger, and enhance general health and quality of life. However, there are a lot of issues to biotechnology with some critics oppose it on moral and ethical grounds, others claim that it poses threats to human health and the environment. Agricultural goods that are herbicides resistant and can withstand abiotic challenges like salinity, high temperatures, frost, and drought as well as biological pressures can be produced via genetic modification. Products utilizing gene-editing technology have generated debate and raised questions about the possible dangers of applying these novel methods to genetic alteration for the environment and general public's health. Regarding the evaluation and risk management of genetically modified organisms, there is no definitive consensus. Numerous accords have been released that emphasize the need of biosafety in safeguarding biodiversity; the most significant of them is the United Nations Convention, known as the Cartagena-Columbia Protocol on Biosafety, which was issued in 2000. Despite the potential and enormous benefits of biotechnologies, the issue of the products of these technologies is receiving great international attention due to the potential risks they could pose to human health and the environment.

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Introduction

The fields of genetic engineering and biotechnology have advanced remarkably in recent years, allowing scientists to interpret the genetic codes of living things, discover their secrets, and even transfer genes from one organism to another. Due to the pressing demand for food considering the world's population growth, plants are seen to be among the areas in which genetic engineering has played a significant role to improve plants both quantitatively and qualitatively (Anmar *et al.,* 2024). According to Coalia *et al.* (2018), genetically modified organisms are those whose genetic material has undergone modifications through natural recombination and/or mating that do not occur in normally occurring species. The utilization of genetically modified (GM) crops in contemporary agriculture has surged owing to their apparent advantages, including heightened resilience against pests and diseases and enhanced agricultural productivity. To create genetically modified crops, transgenes must be inserted into the plant's DNA, usually with the help of promoters, markers, and certain designer genes (Cao, 2017). This makes it possible for crops to develop the desired qualities, such tolerance to herbicides or resistance to pests.

The argument over genetically modified organisms (GMOs) has been and is intense, with proponents and opponents taking adamant and sometimes fierce stands. The insertion of transgenes into a plant's genome can have a variety of outcomes, such as the creation of unidentified proteins and the control of certain internal biological functions. Furthermore, the environmental evaluation of genetically modified crops (GM) has sparked worries about the possible effects on non-target creatures, including beneficial insects and significant soil bacteria, especially those containing *Bacillus thuringiensis* (Bt) genes (Healy, 2002). Studies have largely demonstrated that Bt-incorporated GM crops are safe, with any adverse impacts on non-target organisms being regarded negligible. These highlight how crucial comprehensive investigation and evaluation are to guaranteeing the security and legal compliance of GM crops. To aid in the testing and regulation of genetic modification occurring in many nations worldwide, biodiversity has called for the development of quick and well-researched techniques for the detection of genetically modified plants and seeds. Using genetic elements frequently employed in genetic modification, protocols are used to detect genetically modified elements (Anmar *et al.,* 2024)

Biosafety

The term "biosafety" refers to the necessity of safeguarding the environment and public health against the possible harm that genetically modified organisms (GMOs) and contemporary biotechnology products may cause (Al-Rubaie *et al.,* 2016). The tremendous advancements in contemporary biotechnologies throughout the 1970s in the 20th century made scientists cautious of the risks associated with them and the necessity of using extreme caution in their work to prevent any unfavorable consequences. Products utilizing non-traditional genetic modification techniques have generated controversy and raised questions about possible dangers to the general public's health and the environment (Jarvis 2007; Jarvis 2010).

The assessment and management of genetically modified organisms (GMOs) lacks universally accepted worldwide standards; however, several international organizations have collaborated to coordinate the many pillars of food safety and regulation (EFSA Panel on Genetically Modified Organisms, 2010). The term "biosafety" was first used in the United States during the Biosafety Conference in 1975. The Organization for Economic Co-operation and Development (OECD) released the rules for laboratory trials in 1985, followed by the rules for small field trials in 1992. The so-called biosafety rules were first published in 1976. At the 1992 earth summit in Rio de Janeiro, Brazil, the United Nations released the Convention on Biological Diversity (CBD), which placed a strong emphasis on the value of biosafety in preserving biodiversity. The cartagena-Columbia protocol on biosafety was released by the UN in 2000 as a means of putting this convention's recommendations into practice, and it came into effect in September 2003. Considering the potential risks to human health and the safety of trans boundary movement of these genetically modified organisms, the Cartagena Protocol on Biosafety aims to provide adequate protection when transmitting, handling, and using genetically modified organisms (GMOs) resulting from modern biotechnology that may have an adverse impact on the protection of biodiversity (Anmar *et al.,* 2024). The 1992 Nairobi convention on biological diversity draft gave rise to this Protocol. Using genetically modified organisms, it seeks to accomplish both biosafety and biosecurity, whether on the environment or human health. The protocol gives the transportation of genetically modified organism’s special consideration (Syrian National Biosafety Framework. 2006).

Genetically Engineered Plants' Possible Hazards to The Environment

Science is undergoing a revolution through biotechnology, which is also providing promise for ending poverty, malnutrition and lowering dependency on plant- and animal-based industrial resources. Biosafety remains a problem despite its potential benefits, especially when it comes to the unanticipated and detrimental effects of genetically modified crops on human health, the environment, and both target and non-target organisms (Zaidi *et al.,* 2019). The possible dangers of genetically engineered crops and foods have been extensively studied and documented in scholarly literature. The public is generally more concerned with questions like the ethics of genetic manipulation and the labeling of meals containing genetically modified ingredients than with the possible health implications of eating genetically modified food (Monroe, D 2006). Environmental concerns encompass a wide range of issues, such as flow genes, altered food webs, altered agricultural practices, altered habitats, decreased ecological suitability, fitness, genetic invasion, emergence of new viruses, toxicity to non-target organisms, and increased use of chemicals in agriculture. It should be mentioned that depending on local circumstances, genetically modified crops may pose different environmental dangers (Anmar *et al.,* 2024). If the number of genes transported from genetically modified plants in the natural human environment, then modified genes may likewise have a noticeable effect on the environment. This leads us to observe that these difficulties bear similarities to those associated with the cultivation of plants cultivated by conventional means. Biodiversity is at risk from gene flow or vertical gene transfer from genetically engineered plants to the environment (James, 2011). The following are the only possible effects of gene flow from genetically modified plants on the environment: the plant turning into cannabis; the foreign gene spreading from the GMO plant to its wild relatives; and the environmental side effects of the product made from genetically modified plants, i.e., the product's effect on non-target organisms (Klaus *et al.,* 2001). If the conditions are met for hybridization and the production of offspring, there is a chance that genes from modified plants will spread to their wild relatives. The ability of plants with modified genes to survive and thrive depends on their capacity for adaptation and competition. One of the first genetically engineered crops to record gene transfer to wild relatives is oil seed rape. The determination of the true gene flow of this crop reference has received a lot of attention in this topic. To prevent undesired gene flow, isolation distances between non-transgenic and genetically engineered oilseed rape plants have also been established (Dale *et al.,* 1993).

Therefore, depending on the type and percentage of cross-pollination, flowering synchronization, and the presence of the crop or wild relatives at a sufficient distance for pollination to occur, there is a direct effect of gene flow from some types of modified plants to sexually compatible plants from crops and wild relatives. As a result, numerous risk factors need to be considered, such as:
i). Can a plant that has undergone genetic modification grow outside of a cultivated area?
ii: Does a GM plant transfer its DNA to native wild breeds, and if so, are the breeds produced additionally fertilized?
iii). Does the introduction of a transmitted gene give plants or hybrids in wildlife a selective advantage?

Numerous plants possess the capacity to procreate and form hybrids with other species of nearby wild plants. Additionally, any genes present in *cultivated* plants can be transferred to offspring that are hybridized. This holds true for all plants, genetically modified or not; both have unique genes that could result in undesirable characteristics if the plants are released into the surrounding environment. Nevertheless, despite worries about the proliferation of mutant plants in wildlife, this is not a major problem (Safadi, 2014)

Evaluation and Control of Genetically Modified Crop Risks
The importance of carrying out in-depth risk evaluations for biotechnology products is highlighted by bio policy. It entails assessing any threats to public health, the environment, and animal welfare before putting risk management plans into action to lessen or eliminate dangers that are found. These tactics could involve laws governing labeling, adverse event monitoring programs, containment measures used in research, and techniques for dealing with accidental leaks or contamination (Amare and Zemenu, 2024).

Ethical Considerations

Bio-policy deal with ethical conundrums brought on by the application of biotechnology, such as genetic privacy, informed consent in human subject research, equitable access to medical technology, and the preservation of culture and biodiversity. The creation and application of biotechnological innovations are guided by ethical norms, which make sure they respect social justice, human rights, and environmental preservation (Gebretsadik and Kiflu, 2018).

Intellectual Property Rights of Biotechnology

Intellectual property rights (IPR) pertaining to biotechnology goods are a common topic of discussion in bio policy. The assignee or inventor is given complete control over the creation, manufacturing, and marketing of the innovation thanks to these rights. Protection of IPR encourages investment and research in biotechnology, but it also raises questions regarding benefit distribution, costs associated with healthcare products, and fair access to necessary technologies (Godheja 2013). Some of the laws governing IP rights and protection in Nigeria include:

(i) *Copyright Act (as amended), Cap. C28, Laws of the Federation of Nigeria 2004*
(ii) *Patents and Designs Act, Cap. P2, Laws of the Federation of Nigeria 2004*
(iii) *Trademarks Act, Cap. T13, Laws of the Federation of Nigeria 2004*
(iv) Merchandise Marks Act, Cap. M10, Laws of the Federation of Nigeria 2004
(iv) *Trade Malpractices (Miscellaneous Offences) Act, Cap. T12, Laws of the Federation of Nigeria 2004* (Oluyinka,2022)

Conclusion

Nevertheless, the immense advantages and promise of biotechnology, the issue of these technologies' byproducts is gathering a lot of attention globally because of the possible threats they may present to the environment and human health. Genetic engineering techniques have made it possible to manipulate the genetic composition of some unclassified species and create previously unseen genetic combinations. This has triggered many people to fear for the environment, fearing that these genetically modified organisms will spread throughout the ecosystem or harm non-target organisms and endangered species, ultimately resulting in a loss of biodiversity.

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