Biosafety Issues of Genetically Modified Crops

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For thousands of years, farmers have relied on selective breeding and cross-fertilization to impart desirable traits in plants such as higher yields and resistance to pests. Through trial and error, plant varieties have been developed with altered and stable genetic traits. However, over the past 30 years, the ability to alter life forms has been revolutionized by modern biotechnology. Using sophisticated techniques of genetic engineering or recombinant DNA technology, it is now possible to precisely manipulate the intricate genetic structure of individual living cells by incorporating genes from totally different species. The resulting organisms are known as genetically modified organisms (GMOs) or living modified organisms (LMOs). When the GMO is a crop plant, it is a GM crop or transgenic crop. The emergence of genetically modified crops revolutionized agricultural productivity and nutritional status of several important crops. The genetically engineered traits include insect pests' resistance, herbicide tolerance and virus resistance. Bacterial genes can be used to make insect resistant crops or genes from a cold-water fish can be used to create frost resistant plants.

A transgenic plant contains a gene or genes of a different species artificially inserted in its genome. The inserted gene sequence known as 'transgene,' may come from an unrelated plant or from a completely different species. The first genetically modified crop approved for cultivation is in India is the Bt cotton conferring resistance to bollworm. Bt cotton is a transgenic cotton plant, which incorporates a gene from the bacterium *Bacillus thuringiensis*. It produces crystalline inclusions during sporulation. The biological use of Bt in insect pest control is centered on the exploitation of these crystal proteins especially ∂-endotoxins. These crystalline proteins are found to be highly toxic to agriculturally important pests at very low concentrations.

Conventional plant breeding involves exchange of genes between plants of the same species or from closely related plants to produce a hybrid having desired traits. This crossbreeding however is limited to exchange between the same or closely related species. Therefore, it requires a long time to achieve the desired results as sometimes a related species having the characteristics of interest may not be found and incorporation of undesired characters such as origin of new pest and disease incidences may occur. Genetic engineering enables transfer of genes more easily across taxonomic boundaries. The useful genes can be introduced not just from within the crop species or from closely related plants but even from a wide range of other organisms. This gives a wider range of traits to choose from with the transfer being undertaken in a more controlled and predictable way.

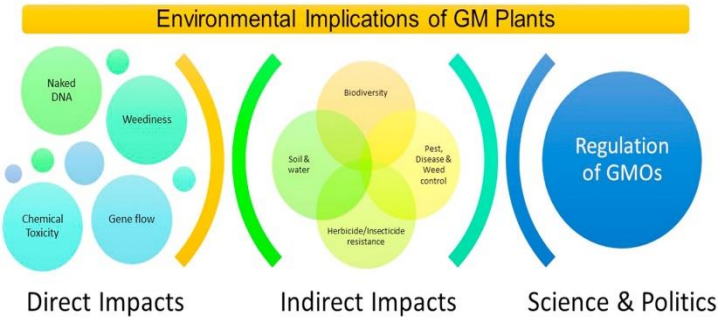

Fig 1: Effect of GMO crops on environment

Source: Aristidis M. T *et al.* 2017

Transgenic crop plants can therefore incorporate the desired traits more quickly and more reliably than through conventional methods. Transgenic crops are produced through genetic engineering in which genes that code for desirable traits are transferred from one organism to another. Although the development of transgenic crops using recombinant DNA techniques is relatively recent, their applications are increasing rapidly because of advantages over the conventional crops. However, as more and more transgenic crops are released for field-testing and commercialization, concerns have been expressed regarding potential risks to both human health and environment. The priorities and parameters of environmental impact assessment of the transgenics should be assessed. These apprehensions arise because transgenic technology crosses the species barrier as compared to classical selection techniques, thereby permitting the gene transfer among microorganisms, plants and animals.

Transgenic crops are not toxic nor are likely to proliferate in the environment. Potential risks from the use of transgenic crops broadly fall under two categories namely Human health and Environment. Consultations on safety in use of GMO's have resulted in a number of National and International recommendations, guidelines and legislation.

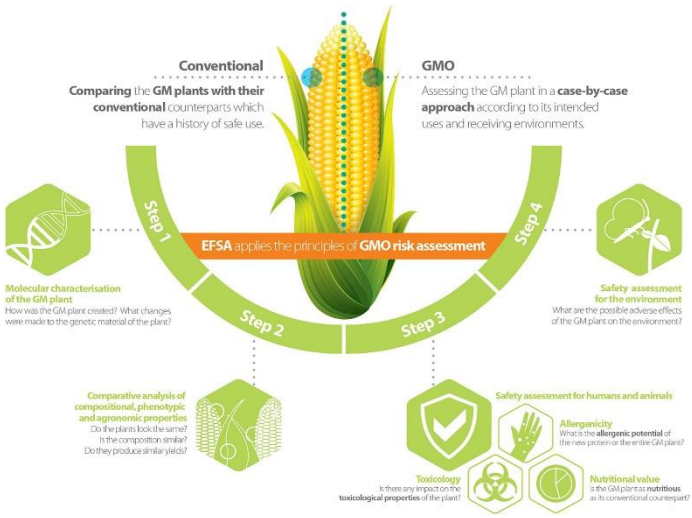

Fig 2: Biosafety Assessment of GMO foods

Source: Nikoletta P *et al*.2020.

India has a well-defined regulatory mechanism for development and evaluation of genetically modified crops as well. The Department of Biotechnology (DBT) and Ministry of Environment &Forests (MoEF) are the two apex bodies. Biosafety issues need to be addressed critically before release of GM crops. Guidelines for safety have been issued by Department of Biotechnology in 1990 covering research in biotechnology, field trails and commercial applications. It also laid separate guidelines for research in transgenic plants. There are six competent authorities for implementation of regulations and guidelines in the country:

1. Recombinant DNA Advisory Committee (RDAC)
2. Review Committee of Genetic Manipulation (RCGM)
3. Genetic Engineering Approval Committee (GEAC), (apex bodies)
4. Institutional Biosafety Committees (IBSC) attached to every organization engaged in rDNA research
5. State Biosafety Coordination Committees (SBCC)
6. District Level Committees (DLC) of the above committees,

The IBSC is constituted by organizations involved in research with GMOs with the approval of DBT. The IBSC is the nodal point for interaction within the institution for implementation of the guidelines.

Risks to human health are related mainly to toxicity, allergenicity and antibiotic resistance. The risk of toxicity may be directly related to the nature of the product whose synthesis. Risks to environment due to release of transgenic crops include impact of imparted traits on other related species, the potential buildup of resistance in insect populations, effect on biodiversity and unintended effects on non-targeted organisms. Accidental cross breeding between transgenic crops and traditional varieties through pollen transfer can contaminate the traditional local varieties with transgenes. The consequences

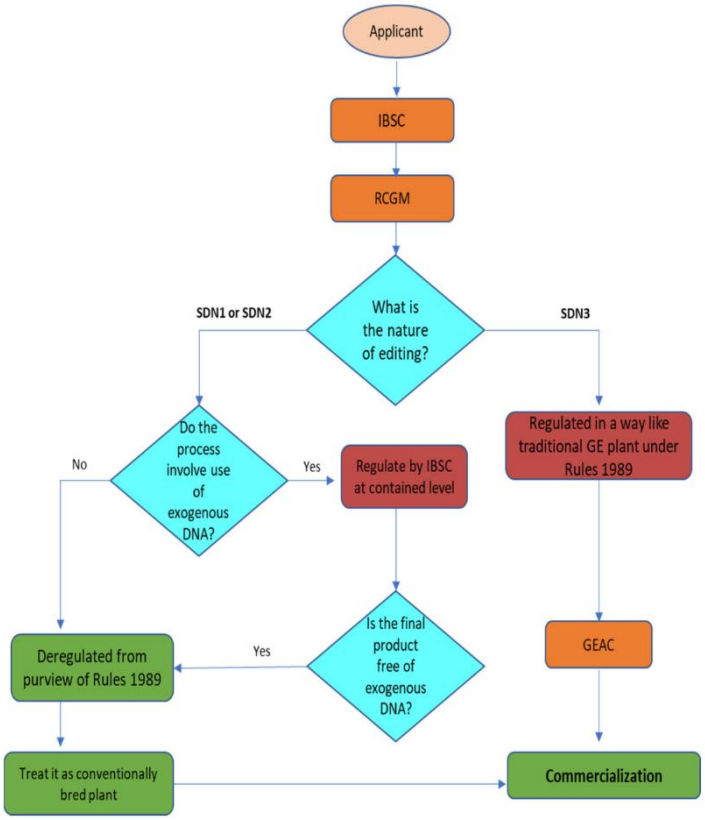

Fig 3: The regulatory pathway for gene-edited plants in India.

Source: Michael G K J *et al*. 2022.

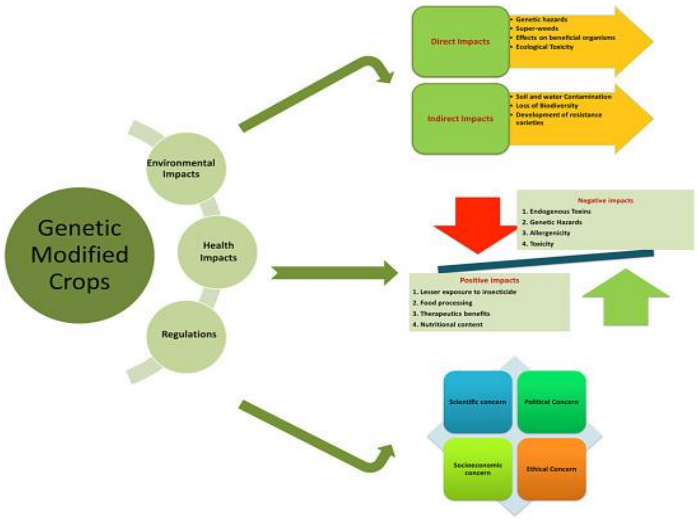

Fig 4: Impacts of GMO crops cultivation

Source : Usha Singh G et al. 2021

associated with such gene transfer may increase weediness if transferred to compatible weedy relatives or lead to extinction endangered varieties of the same genera. There is also fear about the development of super weeds i.e., a weed that has acquired the herbicide tolerant gene due to genetic contamination with a herbicide tolerance GMO crop through cross breeding to related species or by horizontal gene transfer. The gene transferred into plant can actually remain in environment leading to environmental problems. The intentional release of GMOs into the environment has led to interest in possible interactions that occur between other organisms in the environment. Transgenic plants may leak different compounds than conventional plants due to unintended sequence of changed genetic material. This may result in change in ecology of the soil in terms of functional composition and biodiversity. Genetically modified foods can potentially solve many hunger and malnutrition problems across the globe and also protect and preserve environment by increasing yields and reducing dependence on chemical pesticides and herbicides. However, it is important to proceed with caution to avoid unfavorable consequences for the surroundings and our health, considering that genetic engineering technology is very powerful.

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