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GENETICALLY MODIFIED CROPS: RISKS, ADVANTAGEOUS AND BIO-SAFETY

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***Abstract*:** Crops that have their genetic makeup altered by the addition of a gene of interest are considered genetically modified (GM). The safety of consuming GM crops/food has recently become a major source of debate and concern among scientists. This review contains critical information on GM crop adoption, as well as the hazards and advantages of GM crops to biodiversity, human health, and safety. The majority of researchers believe that cultivating GM crops is beneficial because they are pest, virus, and disease resistant; herbicide tolerant; drought resistant; nutritionally increased quality; and a solution to food scarcity. Others believe that GM crops are harmful to human and livestock health because of allergic reactions, leads to biodiversity loss, the advent of superweeds and superpests, food security and increased antibiotic resistance in crops. Furthermore, in long-term animal experiments, dietary administration of GM crops (maize, soya bean, rice) showed no/minor adverse effects. As a result, our basic understanding of the last two decades outcomes reveals that overall health and environmental advantageous outweigh the associated risks. The accompanying hazards can be controlled in the future as new technologies arise.

Index Terms: **Genetically modified, crops, safety, herbicides, superweeds.**

I. Introduction

Genetically modified (GM) crops are those crops that are being manipulated genetically to enhance characteristic of plant by altering their DNA using genetic engineering techniques. When compared to traditional breeding methods, genetic modification directly alters the DNA of organisms (Halford & Shewry, 2000; Hull et al., 2020). Various products from GM crops, such as tomato paste made from slow ripening tomatoes, oil made from oilseed rape, soya and brewer's yeast have been approved for commercial use (Hull et al., 2020). This review focuses on genetically modified crops in particular: (a) what are the advantages and risks associated with GM crops? (b) Are there any concerns about public safety associated with them?

2. Gene-modifications

Flavr Savr-delayed-ripening tomato was first commercially available GM crop, introduced in 1994.An antisense gene against enzyme Beta polygalacturonase was added to the Flavr Savr tomato which prevented degradation of pectin in the cell wall (Belinda, 2001). Golden rice with high nutritious content was genetically modified in the year 2000(Raman, 2017; Nazir et al., 2019). The CRISPR button mushroom (*Agaricus bisporus*) was transformed in 2016 thanks to breakthrough in technology (Waltz, 2016).

Glyphosate-tolerant soybeans, Bt-maize, Bt-cotton, canola, alfalfa and virus-resistant squash have all recently been genetically engineered. (Domingo & Bordonaba, 2011; Raman, 2017; Nazir et al., 2019;Table 1). *Bacillus thuringiensis*(Bt)-Potato was brought in the market to combat the colorado potato beetle, as it contained pesticide producing properties but now it has been withdrawn (Catchpole et al., 2005). Furthermore, introducing blb1 and blb2 genes to Mexican wild potato *Solanum bulbocastanum* made it resistant to late blight (Bawa & Anilakumar, 2013; Table 1). GM crops include genes that produced non-toxic proteins for human consumption, such as *Bacillus thuringiensis* protein which has been ingested safely by humans for the last 50 years. Bt-Corn produces delta endo-toxin from cry gene which is poisonous to certain insects such as the European corn borer and root worms but not to humans and cattle's (Hull et al., 2020). When insects eat Bt-modified plants, Bt-protein in their gut is activated; producing endotoxins that paralyses the insect's digestive system, causing them starve to death. *CryIF*, *Cry2Ab*, *Cry34Ab1*, *Cry35Ab1* are some of the cry genes employed in Bt-corn and cotton (Castagnola & Jurat-Fuentes; 2012; Table 1). Transgenic tobacco modified with cowpea trypsin inhibitor (CpTI) had enhanced resistance against *Heliothis virescens* (Smart et al., 2017). However, when CpTI gene was transferred to rice and potato it did not provide much resistance against this insect (Baig et al., 2017). Transgenic tobacco containing both Bt-toxin and CpTI was found to be more resistant to the *H. armigera* (Nazir et al., 2019).Therefore, different genes might had different effects on different insects and animals.However there lies huge potential in future for GM crops with enhanced resistance against virus and delayed senescence (Raman, 2017; Nazir et al., 2019).

3. Genetically modified crops-benefits

Nowadays, genetically modified crops have gained unambiguous importance in agriculture and food industry. GM crops consist of more than 10% of world crops (Klümper & Qaim 2014; Dimitrios et al., 2020). Scientist around the world believes that GM crops can helps to alleviate the world's hunger crisis since they are more productive and grow faster than traditionally grown crops. In GM crops "beneficial gene" or "candidate gene" is inserted resulting in gains, lose or alterations in specified plant traits (Karalis et al., 2020; Hull et al., 2020). The Majority of GM crops have advantageous genes for the following fundamental traits: pests or viruses resistance, disease resistance, herbicides tolerance, drought resistance and nutritionally enhanced quality (Fig. 1). Better shelf life and crops that can endure adverse weather conditions can also be developed via genetic engineering. When compared to traditional crops, which can only be cultivated in specific season and climates, GM crops can be grown in area that experience regular droughts and unfavourable climatic circumstances. Because most GM crops are pest and insects resistant, the use of toxic pesticides and insecticides can be limited to significant amount, making them both cost-effective and environmentally beneficial (Karalis et al., 2020; Hull et al., 2020; Redden, 2021).

4. Risks and public safety

The major areas of concern of GM crops includes: (a) humans and other living organisms health, (b) environmental concerns, and (c) socio-economic issues. On food safety, a group of scientists, environmentalists and farmers hold opposite viewpoints. GM crops are being considered by Agricultural biotechnology researcher as a potential answer to famine, food storage and pest infection. Other groups consider it as a threat to food security, biodiversity, antibiotic resistance, the environment, nutritional changes, formation of toxins, and human health (Bawa & Anilakumar, 2013; Hull et al., 2020; Fig. 2).

Because of the of selectable marker gene that can stimulate antibiotic and/or diminish antibiotics ability to cure disease, food and environment safety has always been a top consideration when developing GM crops (Maghari & Ardekani, 2011). Some people develop allergic reactions and experience a variety of side effects, including immunological disorders, changes in blood biochemistry and kidney problems (Metcalfe, 2002; Kieran et al., 2002; Hull et al., 2020). Furthermore, frequent use of antibiotics on GM crops may result in mutated plant products. These products could enter the food chain as a part of animal feed and human digestive system result in development of resistant bacteria, insects and diseases in humans (Carter et al., 2011). A gene from Brazil nuts was transferred into soybean to increase the amount of sulphur-rich amino acids. The soya was only fit for animal feed, not human consumption. The protein that was transferred to soybean was allergic to humans (Hull et al., 2020). The majority of field trials on GM foods such as maize, potato, rice and tomatoes with herbicide tolerance and insect resistance did not indicate detrimental effects on exposed animals. Furthermore, it claimed that that heat processing of dietary material destroys antibiotic genes (Hull et al., 2020).

Over time, GM crops may result in the development of herbicide-tolerant weeds and may be harmful to non-target plants (Sweet & Kostov, 2014; Schütte et al., 2017). Furthermore, cross-pollination caused by the transfer of genes from GM plants to other plants resulted in genetic contamination (Oliver & Li, 2013). Most wild plant species may face selected disadvantages when compared to GM crops, culminating in their extinction. Palmer amaranth (*Amaranthus palmeri*) is a weed that competes with Bt-cotton and has developed herbicide resistance. It happened in less than a decade (Webster & Grey, 2015). As a result, using GM crops to replace traditional crops may have an impact on the biodiversity of animals and insects that rely on traditional crops.

5. Regulations

GM crops, however, entails concerns for the environment and human health in addition to countless benefits. This resulted in a conflict of interest among scientists and creation of GMO regulatory frameworks (Karalis et al., 2020). The release of a GM crop for commercial purposes is highly regulated, and field experiments require specific licensing and approval (Domingo & Bordonaba, 2011; Friedrichs et al., 2019). The Majority of countries have approved rules governing the use of GM crops.

6. Outlook of public concern

Initially, due to lack of information on the merits and drawbacks of GM crops ("deficit model") to the market this technology was rejected (Scholderer & Frewer, 2003). Many individuals sought to avoid these foods since the health and environment effects implications were unknown. According to Principal components analysis (PCA), various factors such as nutrient value, environmental protection, affordability and quality, organic products certification and so on prevented people from choosing GM free crops over GM crops (Tsourgiannis et al., 2011).

7. International Scenario

In the last fifteen year, the global production of GM crops has expanded dramatically. GM crops are currently grown on more than 150 hectare of land (Maghari & Ardekani, 2011). Around, 29 countries planted GM crops in 2010. The United States, Argentina, Canada, and China are among the major countries that currently grow GM crops (Fig. 3; Hull et al., 2020). Globally, more than half of GM crops are planted in developing countries, illustrating the socio-economic spread of GM crops. Despite the fact that usages of GM crops are not widely acknowledged, most studies have shown that they boost farm profit and crop yield.

8. Conclusions

GM crops now cover the market all over the world. It satisfies human expectations in terms of nutritional value, biotic resistance, high production, and a variety of other factors. However, it is self-evident that genetic engineering's consequence is unpredictable and uncertain. All we have control over is preventing and minimising ill-effects on the human population, animals, plants, and Mother Earth. However, our current understanding of GM crops shows that the health concerns connected with them are not significantly higher than those associated with traditional crops. Instead, the overall health and environmental advantages far outweigh the hazards.

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Table1: List of genetically modified crops, their uses, modified traits and transgenes

GM Crops	**Uses**	**Traits Modified**	**Transgenes**
Soybean	Animal feed, Soybean oil	Glyphosate resistance, Increased oleic acid, stearidonic acid production, Insect resistance	*Cry1A.105,gm-fad2-1,pat, csr1-2, aad-12, gat4601, gm-hra*
Maize	Animal feed, corn syrup, corn starch	Herbicides resistance (glyphosate), Insect resistance (European corn borer), Drought resistance, Increased lysine	*Cry1A.105, pat, phyA2, bar, cry9C,pinII, cry1Ac, dam*
Cotton	Fiber, animal feed, cotton seed oil	Insect Resistance to bollworms	*CryIF, Cry2Ab, Cry34Ab1, Cry35Ab1, mCry3A, Cry1A.105, CpTI, dmo*
Canola	Emulsifier, Margarine, Cooking oil	Glyphosate Resistant, High Laurate, Phytase Production	*te,gat4621,pyrco-delta-6E, pavsa-delta-5D*
Alfalfa	Animal feed	Herbicides resistant (glyphosate), Broad spectrum herbicides	*Cp4 epsps, ccomt*
Rice	Food and industrial use	Herbicide resistant (Glufosinate and Imidazole), Pest resistant (Rice borer), Product quality enriched (Vitamin A)	*crt1, psy1, 7crp, cry1Ab, cry1Ac, bar*
Potatoes		Resist insect (Colorado potato beetle), pests and disease, prevent blackspot bruising, modified starch	*cry3A, gbss, ppo5,pvy_cp, plrv_orf2, blb1, blb2*
Brinjal	Food	Pest and insect resistance (fruit and shoot borer)	*cry1Ac*
Sugar beet		Glyphosate resistance weed	*cp4 epsps,goxv247, pat*
Sweet pepper		Virus resistant	*cmv_cp*
Papaya		Resist ringspot virus.	*prsv_rep*
Apple		Delayed browning when expose to air	*PGAS-PPO*
Tomato		Pest resistant (tomato fruit worm, pinworm, bacterial wilt and root knot nematode), Stress tolerance	*accd, cry1Ac ,pg, sam-k,acc,*
Plum		Resistant to virus (Plum pox virus)	*ppv_cp*
Wheat		Herbicides, insect and virus resistant (especially *Fusarium*), resistant to salinity and heat	*cp4 epsps*
Tobacco	Cigarettes	Herbicides tolerance, Resistant to pathogens (tobacco mosaic virus), Drought and cold resistant, Nicotine reduction	*NtQPT1*
Poplar	Tree	Foster Disease resistance, herbicides tolerance	*API, cry1Ac*
Petunia	Ornamental	Flower colour modified	*chsA*
Rose		Contain delphinidin plant pigment that is antioxidant and give blue colour to rose	*bp40, 5AT*

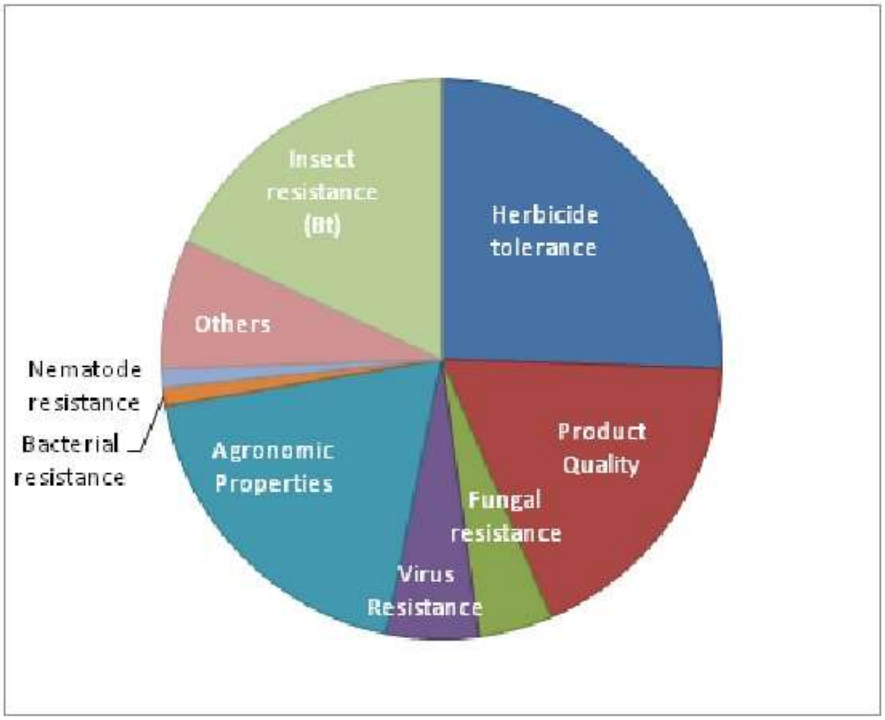

Figure 1: Genetically modified crops with modified features

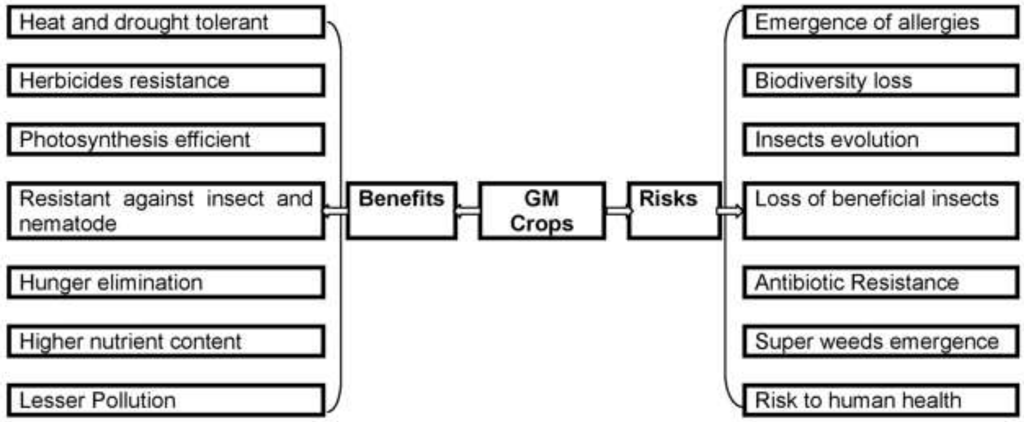

Figure 2: Benefits and risks associated with genetically modified crops

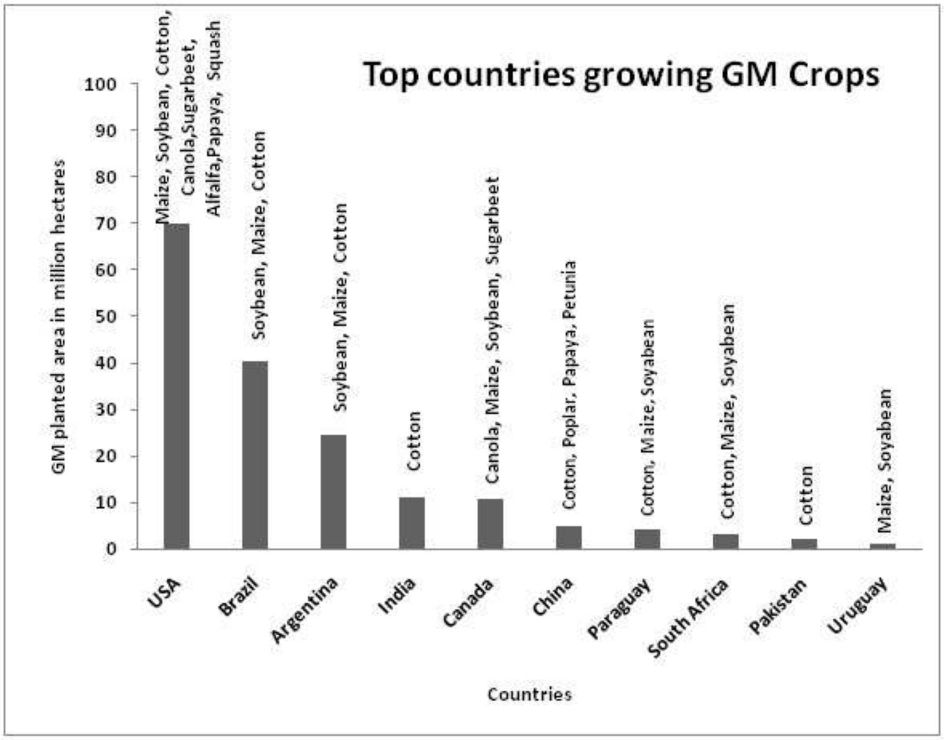

Figure 3: A graphical representation of the world’s genetically modified crops