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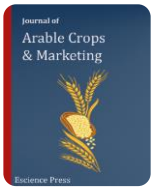

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Genetically Modified Plants and Climate Change

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ABSTRACT

Adaptive advantages to the environment, improved nutritional features, and reduced use of agrochemicals are just a few of the economic benefits gained through plant breeding with the help of genetic engineering. Despite the benefits, the justification for creating and employing such technology will vary depending on the context of the surrounding culture. This paper aims to introduce genetically modified organisms (Genetically modified plants), discuss their potential benefits and drawbacks, and argue that these organisms present a unique opportunity for breeding new plant varieties with desirable benefits that cannot be obtained through conventional breeding. Plant breeding, nhr1 gene, GMO, and genetically modified plant are some examples of gaining novel kinds or qualities and molecular enhancement of plants by recombinant DNA technology. The potential for using this method to enhance crop plants' genetics is apparent benefits for farmers, merchants, and sellers for developing lines with improved yield, quality, disease resistance, or tolerance to abiotic stress. The risks and hazards prevent it from being widely used in agriculture.

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INTRODUCTION

The ever-increasing need for agricultural products and essential commodities is a direct consequence of the world's ever-increasing population. Unfortunately, this issue has only been partially resolved through the selection and crossing of specimens with desirable characteristics; therefore, it is anticipated that adding molecular methods to the conventional approaches will result in plants with improved yields and quality and brand-new agricultural products (Ahmar, Gill *et al.,* 2020). Plant breeding improves plant species to create new types with enhanced qualities. Crop enhancement involves making crosses between genetically modified plants who already have the desired traits; then picking the seeds from the offspring that best display those traits(Leibovici and Santacreu 2020).

These genetically modified seeds can be used in further breeding to produce a new variety with the desired trait;

this unique variety will then be subjected to additional tests before being made available to consumers. Contribution of biotechnology to agriculture is substantial because a wide range of benefits have been achieved by this technology (Steed, Ramirez *et al.,* 2021).

The Common Practice of Plant Breeding

Initially, crop domestication was thought of as a way to hasten the evolutionary process already existent in creatures, in this case, plants, and produce changes of interest to man (Cong *et al*., 2008). Artificial mating or crossing two individuals from different parents to create a hybrid with desirable traits, is one method. However, it can only be employed with species capable of sexual reproduction that are genetically compatible(Van Tassel, Tesdell *et al.,* 2020).

The plants we grow today evolved from wild, self-sufficient individuals to those entirely reliant on humans for survival (Acquaah, 2006). During this process, humans selected traits such as increased fruit production, size, color, texture, flavor, ripening, appearance, quality, and plant architecture (Paran *et al*., 2007; Schubert *et al*., 2009). Because the crosses must be performed between organisms of the same species or be sexually compatible, and because, maybe simultaneously, they create fertile offspring, crop compatibility is a crucial consideration for applying this approach (Winter 2019).

Due to extensive domestication, this crop started in Europe in the 1800s and 1900s. In the last century, breeders created diverse cultivars from the same domesticated species(Lamichhane and Thapa 2022). The fruit's dimensions, size, and color are essential for this harvest. Fruits that grow from today's cultivated variety are more numerous and significant than those from the wild parent(Zhan, Qu *et al.,* 2018). The regulatory shift in a protein termed YABBI, which controls the expression of other genes or factors involved in regulating the number of carpels during the blooming and fruit development process, is responsible for the observed variations in fruit mass.

This case study exemplifies how some desirable agronomic traits may be governed by genes that could be improved by genetic engineering in the species or varieties in question. Maize, Zea mays L., is another famous example of a plant domesticated from a wild ancestor, teosinte (Zea mays ssp. parviglumis or spp. Mexicana) (Beadle, 1939). Its center of origin is in Central America, most likely Mexico or Guatemala, due to the variety of species and genetic variability. Studies reveal that selection effects are limited to changes in areas of regulatory genes (gene promoters) rather than coding regions, explaining the observed molecular shifts.

For instance, ramifications are a distinguishing feature of both ancestral teosinte and modern forms; based on genetic investigation, it was discovered that the branched teosinte gene -tb1- controls this process (Doebley *et al*., 1995). Current maize varieties also have huge ears and many grains, which appear to result from mutation processes that supplement the natural and human selection processes(Razifard, Ramos *et al.,* 2020).

Transgenic plant breeding

Using genetic engineering techniques has led to the creation of enhanced plant varieties that can serve as a more precise and efficient substitute. Molecular plant breeding uses various techniques to alter a plant's genetic material to introduce new genes for multiple reasons. This approach has allowed scientists to accomplish feats previously thought impossible, such as moving a gene of interest from bacteria to a plant (Acquaah, 2006; Gelvin, 2009).

Transgenic technology allows the incorporation of attributes from the same or another species without the need for sexual reproduction (Acquaah, 2006); this was made possible due to the discovery of restriction enzymes, which can cut DNA in specific areas, and ligases, which join two ends of DNA because they allow one DNA fragment to replace another. Because of their low complexity, obtaining a transgenic in simple organisms like bacteria or yeasts is pretty simple.

The problem is exacerbated in multicellular organisms has undergone selective breeding to produce hybrids with increased yields and a greater capacity to adapt to different growing conditions. All the cells of a transgenic organism, also called a genetically modified organism (GMO), have been transformed by introducing foreign DNA. There is a procedure one must follow to receive a transgenic (Figure 1).

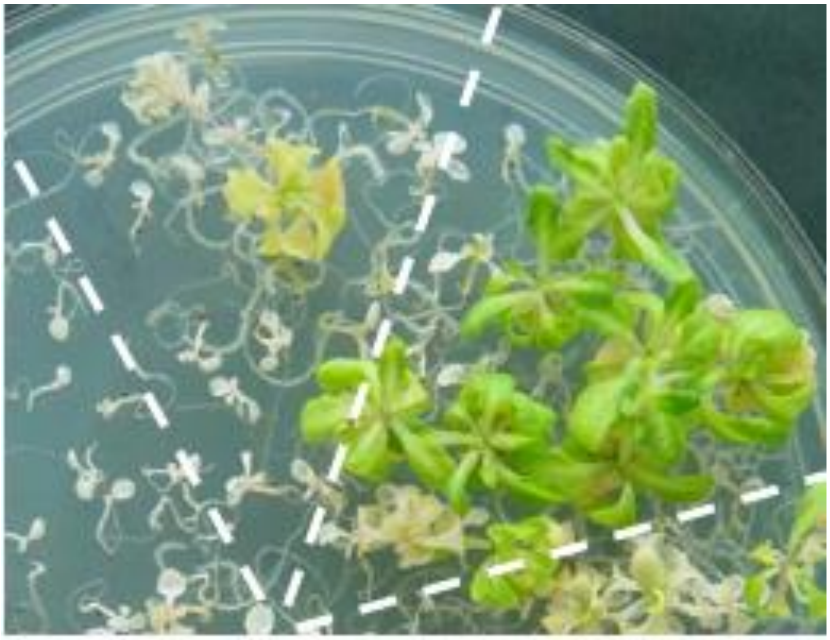

Figure 1. Genetically modified organism (GMO) transformed by introducing foreign DNA.

Plant cells are transformed using bio ballistics, Transgenic technology; there is a dire need to justify the development of the transgenic; the gene or genes that correspond to the characteristic to be introduced or eliminated; the vector of transformation in which a selection gene must also be included to distinguish transformed cells from non-transformed ones; the propagation of transformed cells as opposed to non-transformed ones. To determine the number of transformation events (No. of copies of the construct in the cell) and whether the insertion was transcribed and translated into a protein, the next step is the growth and regeneration of plant tissue transformed using an appropriate in vitro regeneration system or by the transformation of meristems. Finally, the effectiveness of the gene transfer is assessed in three distinct environments: the laboratory, the greenhouse, and the field.

Microinjection technology, in which the gene of interest is introduced directly into the nucleus, has a 15% fertilization rate for mammalian embryonic cells because of the lack of a cell wall in these cells. This technology, however, is challenging to use in plant cells due to their cell walls.(Kumar, Gambhir *et al.,* 2020).

Biolistic is the most common way to deliver DNA fragments into a plant cell. Using compressed air or helium, Biolistic involves firing metal particles coated with gene molecules at the cells to be converted at high speed and pressure. Many of the cells are killed by the mechanical impact of this technique. Still, in the best-case scenario, the metallic particles containing the genetic material penetrate the cell's nucleus without damaging them, and the exogenous DNA may become incorporated into the genetic material of the plant cell and undergo transformation.(Kuluev, Gumerova *et al.,* 2019). Then, both the endogenous DNA from the original cell and the exogenous DNA (composed of sequences of millions of base pairs) make up the genetic substances of the transformed cell (usually hundreds to thousands of base pairs). It is important to note that the insertion site of the foreign DNA fragment is completely arbitrary due to the nature of the procedure (Batty *et al*., 1992; Sanford, 2000).

The second most common approach involves infecting plants with Agrobacterium tumefaciens (Broothaerts *et al*., 2012). This bacterium is naturally present in soil and is responsible for the illness crown gall in plants.T-DNA contains genes that promote tumor growth in the context of infection by activating genes involved in cell proliferation (Chilton *et al*., 1980; Gelvin, 2009). By replacing the genes in the T-DNA fragment with genes of interest, such as a gene for herbicide resistance, scientists have taken advantage of the transferability of the DNA fragment from the bacterium to the plant (Mingard, Wu *et al.,* 2020).

It regenerated an entire plant from transformed cells after transformation using any of the above methods. The in vitro tissue cultivation method is commonly used for this purpose, which involves directing the division of cells in a controlled environment to produce specific tissues and organs. This is accomplished by combining various phytoregulators, such as auxins and cytokinins, in a synthetic culture medium to induce cell division, differentiation, and organization into a specific organ, such as a root, leaf, or shoot (Henry *et al*., 1994). It's crucial to remember that the new organ is a brand-new cell that originated in the original tissue fragment. By including the antibiotic in the selection medium, only the cells that were transformed and are now resistant to antibiotics can divide and form organs; in contrast, the non-transformed cells would die from the antibiotic. It is essential to evaluate the transformation's success and that the added feature is functioning before marketing the plants regenerated through change.

Inverting Genealogy

Some transgenics involve the insertion of new or altered genes to determine gene functions, such as the part the gene under study plays in the plant's life cycle, its morphology, whether or not it participates in the manufacture or breakdown of any substance, etc. Transgenic technology also allows for the replacement or enhancement of "defective" genes. One way to determine a gene's function in a plant is to silence it transcriptionally.

Deletion mutations, also called "Knockout" mutations, result from a gene's DNA malfunctioning. RNA interference (iRNA, after its acronym in English) technology has become increasingly popular as a means to create "Knockout" mutants by targeting and eliminating particular messenger RNA (mRNA; this mRNA will be translated into protein). When a double-stranded RNA (dsRNA) is introduced into a eukaryotic cell, the cell's defense mechanisms kick in. The dsRNA cleaves into fragments of about 21 base pairs and unwinds into single chains by a nuclease called "Dicer." Next, an enzyme called "RISC" searches for and aligns the mRNAs that contain the complementary strand, and when the complementary mRNA is found, any mRNA can be silenced by adding a dsRNA tailored to target it.(Kuluev, Gumerova *et al.,* 2019).

Loss-of-function mutants, also known as null mutations, are those in which an entire gene loses its function due to a modification. Homozygotes and hemizygotes for a gene with a null mutation are nevertheless at risk of death. Conversely, gain-of-function mutations cause a protein to acquire new, substantial, or constitutive functions or expression patterns (generally, the modifications are of dominant hereditary character). Mutations that do not result in overt changes to function or phenotype are called "silent mutation. Use of genetic engineering in commodity crops.

Genetically modified plants have a broad range of potential uses, and many Genetically modified plants are already well known in agriculture sector (Salanga and Salanga 2021).Cultures exhibit environmental tolerance, such as adapting to various climate conditions, drought, salinity, high and low temperatures, and more.

They are designed to meet requirements in regions where water scarcity and extreme heat limit agricultural output. Produce that can handle high salt levels. Molecular breeding is one way to get cultivars with saline tolerance, which could be helpful in locations where soil or water salinity is a concern. Increasing salinity tolerance in sensitive species might have significant economic benefits by allowing farmers to cultivate previously unsuitable land for growing commercially available kinds.

Conventional breeding, introgression of crops whose wild parents have the tolerance to salinity, domestication of species that inhabit saline regions (halophytes), strategies where the genes for tolerance to salinity are identified, cloned and manipulated using molecular biology techniques, and other methods have all shown promise over the years for increasing crop tolerance to salinity (Salanga and Salanga 2021).

Tomato plants engineered to grow and produce fruit in saline conditions (NaCl) have been created by overexpressing the AtNHX1 gene of Arabidopsis thaliana, which encodes for channels in vacuole Na^+ /H^+. While a high sodium concentration was found in the leaves, the fruits contained low amounts of sodium. Compared to the results of conventional breeding, where many characters are combined to produce crops that are tolerant of these conditions, the goal of adding a single character was accomplished by employing this approach. When tested in high salinity (100 mM NaCl).

Arabidopsis thaliana plants with a T-DNA loss-of-function mutation in the gene encoding the protein Amino Oxidize (AO) fared better than their wild-type counterparts (Fig. 3). Abscisic acid (ABA), a plant hormone, has been shown to regulate some functions, including those related to growth, development, and adaptation to environmental stresses like drought, salinity, and cold (Grill *et al*., 2007). When plants are under pressure, ABA controls the stomatal opening and shutting to limit transpiration and water loss. Hydrogen peroxide generation involves the AO enzyme, as has been observed (H2O2)(Wang, Shi *et al.,* 2021).

Salanga and Salanga(2021)found that H2O2 generation and activation of Ca+ channels in the plasma membrane play critical roles in the induction of ABA-regulated stomatal closure. ABA induces stomatal closure through a mechanism in which the AO enzyme produces H2O2 in guard cells; in this process, the calcium ion works as a messenger and is an essential intermediary (An *et al*., 2008). Expanding investigation into the mutant AO is required because the data acquired with the T-DNA mutant lines cannot be explained. However, in cultivars where salt is an issue that limits agricultural productivity, the search for orthologous genes of AO in plants of commercial relevance and the use of technology to deactivate the gene and research the effect of silencing could be valuable.

Botanicals that take their sweet time to grow u the Flavr Savr tomato was one of the first commercially available genetically modified cultivars; it was developed using anti-sense technology to suppress polygalacturonase, an enzyme linked to cell-wall weakening (through the destruction of pectin polymers). The Tomato Flavr Savr exhibited delayed softening compared to traditional cultures, allowing for harvesting at later stages of ripening when the tomato flavor has developed better (Kramer *et al*., 1994).

The heterozygous variety resulted from a spontaneous gene mutation in the rin gene (inhibitor of maturation, for its acronym in English) (Vrebalov *et al*., 2002). Examples demonstrate how mutations might cause transgenesis to introduce new variants. Therefore, using this technology is only considered when there is no alternative through regular plant breeding due to concerns about consumer acceptance of GMO products (Ma, Zhang *et al.,* 2018).

Enhanced nutrient-content plant species and improved crop nutritional value are yet another area of study. The amino acid methionine is found in trace amounts in fruits, vegetables, and seeds. We are restricting the potential of plants to provide protein. The current state of affairs involves making an effort. Plant seed methionine enhancement using techniques derived from genetic engineering, such as the expression of storage proteins in seeds abundant in the amino acid methionine (Altenbach *et al*., 1990; Avraham *et al*., 2005).

Nevertheless, the finding, various studies' results have failed to demonstrate a noteworthy uptick in Research is needed because plants have a high methionine content to improve plant food's nutritional value. Engineering pest- and insect-resistant crops through genetic modification. Successful applications of genetic engineering include insect-resistant crop varieties. Agriculture; cotton the plant species *Gossypium hirsutum* is immune to damage caused by lepidopteran larvae (caterpillars) and corn.

According to Meinke, Souza *et al*.(2021), they can withstand invasion from Lepidoptera and Coleoptera (rootworms)widely, which has led to less need for pesticides and herbicides in food production—lessening the price of output (Gatehouse, 2008). The discovery of the naturally occurring poison by the potential insecticide in Bacillus thuringiensis (Bt), a bacterium, allowed the introduction of new plant genetics that enables them to withstand insect damage. Bacillus thuringiensis (B. t.) strains collection of thousands of genes that code for insect-killing proteins (Cry protein and Cyt protein) as crystalline inclusions by the sporulating bacteria. Essential proteins are expressed explicitly in growing bacteria Action is triggered by alkaline proteolysis in the insect's gut after ingestion.

Diet and the way it affect intestinal cells. In particular, this understanding motivates protein oligomerization, leads to channel formation in the cell membrane and subsequent cell death from an inadequate supply of ions, and intestinal decay from a lack of increased bacterial growth and the eventual demise of the insect (Bravo *et al*., 2007). "Cry" proteins are safe for consumption by humans and other animals alike because of the way digestion works.

As its toxicity is not activated in acidic environments, it is not a threat. Modern engineering without the need for applications of transgenes to use the protein in question(Meinke, Souza *et al.,* 2021).Use of pesticides to get rid of unwanted insects. Difficulties in implementing crop use among specific demographics It is because growing these crops may harm insects that aren't the intended target. That is pest-free but still susceptible to the Bt crop (they feed on plant tissue). However, crop implementation reduces the need for chemical insecticides and their environmental impact.

Release into the environment, so the non-crop-eating good bugs aren't harmed or benefited. Another disadvantage is the potential for the targeted insects to evolve resistance. Ahmar, Gill *et al.,* (2020) disclosed that some insects had developed resistance to Bt toxins. The industry pioneer in biotechnology has unveiled a breakthrough in crop tolerance to the Bt toxin. The pink bollworm, a pest that thrives on GMO cotton, has managed to stick around for some reason. It consists of the Cry1 gene (Bagla, 2010).

There are, however, ways to mitigate or eliminate accelerating resistance development by employing activities like transgenic crop planting and subsequent harvesting of non-transgenic crops in terms of percentage to alleviate the strain on the insect-killing poison that's a component of the toxin. The hope is that all those bugs which cultivate Bt crops may build up resistance to the toxin it produces.

Breed with non-resistant people who live in the non-transgenic crop, but that could cause problems technique only delays the onset of resistance to The Bt poison. Combinations of different Cry proteins are also possible, as it has been observed that these decrease the amount of time it takes for tolerance or resistance to the toxin to develop again (Balasubramani, Raghavendra *et al.,* 2021)

A potential repercussion is the spread of antibiotic resistance by soil bacteria to areas where Bt crops are cultivated because, while building the vector to produce, Selective antibiotic resistance is achieved in transgenic plants utilizing a transformed gene. However, studies of bacterial populations in soil have shown that there doesn't appear to be any difference between these bacteria and those found in Bt cultures.

The commercialization of papaya transgenic for tolerance to the PRSV virus (Papaya ring spot virus) is a significant success story in the annals of genetically modified organisms. In 1995, this virus wreaked havoc on papaya production, creating two new varieties. Modified organisms through genetic engineering, transgenic animals, and conventionally bred infection of cells with the virus capsid protein gene (cp) for viral resistance to develop, disease control, and population growth production. It was the growth of transgenic papaya that led to the trophies.

Because the number of infectious viruses was lowered, non-transgenic papaya could be replanted in those areas. Plants infected with viruses alleviate the inoculum pressure from industrial-scalein Puna, where transgenic papaya has been planted in fields. The growing of genetically modified papaya (Hamim, Borth *et al.,* 2018).

Farmers were permitted to increase their harvesting areas where crops had not yet been impacted by the crops that are resistant to herbicides Herbicide-tolerant crops have made it possible to expand the use of some chemicals for weed control that are guaranteed to have no adverse effects on crop application, as improper use of herbicides may interfere with the natural growth of the crop. The effective use of the herbicide glyphosate is made possible by introducing the bacterial gene (CP4) for resistance to the chemical.

The plants are resistant to the herbicide; it is an effective method of weed control and can boost yields as a bonus. Thrive in a sterile, weed-free setting. Glyphosate prevents the(Ceballos, Kannan *et al.,* 2020). How the enzyme 3-phosphate works in plants (EPSPSp)crucial for making essential metabolites and synthesizing aromatic amino acids; without it, the plant dies quickly (Service, 2007).

However, glyphosate, due to the absence of this enzyme in insects and animals, does not affect them, which brings us to transgenic crops that display glyphosate resistance and harbor a bacterial-originated gene that codes for a protein (EPSPSb) found in bacteria that acts similarly to the enzyme (EPSPSp) found in plants. One of bacterial origin is not inhibited by glyphosate, so the glyphosate resistance can be artificially bred into plants by introducing the bacterial EPSPSb protein. Glyphosate, when sprayed on fields, does not quickly enter waterways. Instead, it sticks to the soil, and in a few short weeks, it becomesa non-harmful by-product (Duke 2020).

Non-glyphosate-tolerant crops are also available. The compound is also effective on crops into which the bar gene conferring glufosinate tolerance was introduced. Decreases Gln synthetase activity, leading to toxic ammonia accumulation.The result of photorespiration, an electron transport system disruption in chloroplasts'mitochondria, which leads to free radical production and lipid peroxidation, particularly in membranes), harm to other cell components, and eventually, cell death.

The bar gene, which codes for the enzyme phosphinothricin, was used in transgenic plants (Mbatyoti, Daneel *et al.,* 2020). The Phosphoadenylate Acetyl Transferees (PAT) inactivates the glufosinate by adding an acetyl group. Due to the presence of acetyl, it is inactive (Botterman *et al*., 1991). The use of Genetically modified plants (Genetically Modified Organisms)has been widely abused, and the introduction of novel traits in more crops will be grown, emphasizing those providing direct consumer benefits. The advantages of genetically modified organisms, which have already been mentioned, are numerous.(Takano and Dayan 2020).

Many harmful pests and diseases are coming back, posing a threat to human health of new diseases brought on by these toxins. Because of the pests' current resistance, pesticides are unnecessary. As a result, chemical applications aren't as laborious or expensive, which is excellent news for the planet.

Due to less pollution being released into the environment (on land, in the air, or water) and less work being required of the expenses incurred during production. Crops resistant to herbicides, for instance, make it possible the using a single class of herbicide that is effective against all weeds and use various permutations to wipe out all the multiple herbs at once. Reducing chemical waste dumped into the environment can increase the producer's significant financial gains and eliminate time-consuming application work(Hawkins, Bass *et al.,* 2019).

Drug-Resistant Organisms

Researchers are worried about a resurgence in resistance to certain antibiotics of some pathogenic bacteria, particularly in crops grown for human consumption, because the technology used to create a transgenic organism necessitates the use of genes resistant; in addition to the gene of interest to various types of antibiotics that serve to resolve the problem of selection and regeneration of transformed cells (Nielsen *et al*., 1997). However, it has been hypothesized that antibiotic-resistant genes from transgenics could be transferred to bacteria in the intestines of animals. No such gene was found in the intestines of animals evaluated, suggesting that the transfer of antibiotic-resistant genes from transgenics to bacteria in the intestines is highly unlikely (Chambers *et al*., 2002). Additionally, the cooking of some foods degrades the DNA. In the case of the consumption of fresh products, the digestive process would degrade transferable DNA, making a horizontal transfer of a gene from the digestive tract to bacterial cells highly unlikely.(Anyaegbunam, Anekpo *et al.,* 2022).

Genetic exchange

One issue resulting from this technology is the transfer of traits to wild plants compatible with interbreeding with Genetically modified plants that develop naturally in the vicinity of transgenic crops. Because the inserted genes are present in every cell of transgenic plants, including the pollen in cross-pollinated plants, the wind may have spread them to other sexually compatible plants. A pollen's lifespan, though, is short and must be considered. Soybean fields have been plagued by the return of superweeds resistant to glyphosate to stop the spread of glyphosate resistance through wind pollination or insects, and it has been suggested that transformation techniques, such as transformation into chloroplasts or mitochondria, be modified (Service, 2007). Altering genetic diversity in regions where certain plants are the center of origin or diversity due to the possibility of transfer by pollination is also a cause for concern because these areas are the most important source of new characteristics that could be useful (Stewart, Hill *et al.,* 2021).

Comparing myths and facts

It has been said that transgenics can contaminate areas of the center of origin, destroying biodiversity and its associations with traditional cultures. However, it is ignored that the gene flow from which the current consumer corn was derived existed for hundreds of years and that contrary to the idea of loss of diversity, it was thanks to this flow between different populations that the current consumer corn was even possible(Altieri 2005).

One more fallacy is that the crops haven't been altered in any way by humans or that they aren't natural. This idea overlooks the fact that it is impossible to change the outward appearance of cultures without also changing their DNA, although the enhancement in question does not alter DNA. DNA translocation within the crop plant genome is a natural occurrence that facilitates DNA double-strand repair, as seen in the vicinity of transgene insertion sites. Because of the ability to undergo somatic mutations in response to environmental cues, individuals can experience adaptive evolution and natural selection.

According to Priyanka, Kumar *et al*.(2021), Genetically modified plants can trigger allergic reactions, several times we've heard of a friend who had previously eaten shrimp developing an allergy to it, so we know that natural products can cause spontaneous allergies in individuals who have consumed the food for years. Several studies have demonstrated that transgenic plants have the same potential for allergen induction as non-transgenic plants. Before being made available to the public, each transgenic crop is subjected to extensive testing(Cook, Robbins *et al.,* 2006).

AUTHOR CONTRIBUTIONS

All the authors contributed equally.

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