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# Transgenic Plants: Advantages and Disadvantages

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## Abstract

Crop's amendment to enhance their production was based on selection previous to the conception of transgenics. This assortment has been going on for thousands of years. By the year 2050, the world population may exceed ten billion. In some older centuries, food production will need to enhance at the same rate or more to comply with the needs of such an enormous number of people. So, there is a necessity of implying genetic techniques to upgrade crops over recent decades. Through the employ of transgenics, one can produce plants with preferred traits and even amplified yields. The transgenic crops are more capable of last longer and resist diseases and pests. Transgenic plant production will allow us to nourish or feed the mounting population and produce more desirable products. The future of GM crops remains an imperative debate, as its applications have several merits and demerits.

## Introduction

Transgenic plants are the ones whose genome is modified *via* genetic engineering techniques either by artificially inserting a foreign gene or eliminating a specific detrimental gene. The main objective is to affix a new trait to the plant, which doesn't occur naturally in the species. The inserted or incorporated gene sequence is known as the transgene; it may come from a distinct plant or an entirely different species. The aim of introducing an amalgamation of genes in a plant is to make it as beneficial and productive as possible. This process offers improved shelf life, improved quality, higher yield, pest resistance, tolerance to cold, heat, and drought resistance against a range of biotic and abiotic stresses. Transgenic plants expressing foreign genes with industrial and pharmaceutical value can also be produced. Plants having vaccines or antibodies (Plantibodies) are especially striving as plants are free of human diseases, thus plummeting screening expenses for viruses and bacterial toxins (Herbers *et al*., 1999). In 1983 first transgenic plants were reported. Since then, several recombinant proteins have been expressed in several imperative agronomic species of plants comprising tobacco, tomato, potato, corn, alfalfa, banana, and canola. Tobacco plants were commonly used; however, bananas and potatoes are also considered for vaccines for human beings (Rani *et al*., 2013).

## Advancement in Transgenic Plant

The genetic make-up of genetically engineered plants is altered artificially in the lab, generally by incorporating one or more genes sequence of a plant's genome. The target site of the plant cell is its nucleus for the new transgenic DNA. Most genetically modified plants are engendered by the *Agrobacterium tumefaciens* mediated transformation method or the biolistic method (Particle gun method).

## Biolistic/ Gene Gun/ Micro-Projectile Bombardment Method

This method has successfully been applied for many crops, especially monocots, like wheat, maize, or rice. In this method, DNA bound with tiny particles of Gold or Tungsten is subsequently shot into single plant cells or plant tissue under high pressure using a gun. The particles accelerate and penetrate both into the cell wall and cell membranes. The DNA detaches from the coated metal, and it integrates into the plant genome inside the nucleus (Rani *et al*., 2013). The mere drawback of this process is that severe damage can happen to the cellular tissue.

## *Agrobacterium tumefaciens* Mediated Transformation Method

*Agrobacterium tumefaciens* is a soil-dwelling bacteria having the aptitude to infect plant cells with a piece of its DNA. The portion of DNA that infects a plant is incorporated into a plant chromosome through a tumor-inducing plasmid (Ti plasmid). The Ti plasmid took over the plant's cellular machinery and used it to amplify its own bacterial DNA. The large circular DNA particle replicates independently of the bacterial chromosome. The significance of this plasmid is that it possesses regions of transfer DNA, where a researcher can introduce a gene, which can be inserted in a plant cell through a process called the "floral dip." Floral Dip is a technique in which flowering plants are dipped into a solution of *Agrobacterium* containing the gene of interest, followed by the transgenic seeds being collected directly from the plant. One of the most significant limitations of *Agrobacterium* is that not these bacteria can infect all-important food crops. This process works exceptionally well for dicotyledonous plants like tomatoes, potatoes, and tobacco plants (Rani *et al*., 2013).

Tobacco and *Arabidopsis thaliana* usually serve as model organisms for other plant species due to their well-developed transformation methods, easy propagation, and well-studied genomes. Bioremediation of contaminated soils can also be done by using transgenic plants. Mercury, selenium, and organic pollutants, like polychlorinated biphenyls (PCBs), have been removed from soils by transgenic plants containing genes for bacterial enzymes (Rani *et al*., 2013).

## Advantages

As the global population continues to inflate, food remains a scarce resource. The following examples show how transgenic crops are used in solving some of the specific problems of agriculture, indicating the potential for benefits.

***1. Herbicide Resistance***

Herbicides tolerable plants are called herbicide-resistant plants. The active ingredient of most of the broad-spectrum herbicides is glyphosate. By reassigning aro A gene into a glyphosate EPSP synthetase from *Salmonella typhimurium*, and *E. coli*, glyphosate-resistant transgenic tomato, potato, tobacco, cotton, *etc*. are produced. Transfer of the mutant ALS (acetolactate synthetase) gene from Arabidopsis results in sulphonylurea-resistant tobacco plants. QB protein of photosystem II from mutant Amaranthus hybrids is transferred into tobacco and other crops for producing atrazine-resistant transgenic plants (Rani *et al*., 2013).

***2. Insect Resistance***

*Bacillus thuringiensis* is a bacterium that is acknowledged for its pathogenic behavior against various insect pests. It produces a protein toxin that arbitrates its lethal effect. Through recombinant DNA techniques, the toxin gene can be incorporated directly into the plant's genome, where it is expressed and help in the defense against insect pests of the plant.

***3. Resistance against Pest***

By developing a transgenic plant with resistance against the specific pest, there is a clear benefit for farmers. For example, In Hawaii since 1996, papaya resistance against papaya ringspot virus has been commercialized and grown. The environment can also be benefited by reducing the use of pesticides. In the USA, the quantity of insecticide applied to cotton has significantly reduced due to transgenic crops having insect resistance genes from *Bacillus thuringiensis*. However, populations of pests and disease, causing organisms, adapt readily and become resistant to pesticides (Rani *et al*., 2013).

***4. Improved Nutritional Value***

Each year approximately half a million children become partially or blind due to the deficiency of vitamin A. In no small fraction of the World's human population, milled rice acts as the staple food. Crops consisting of a high concentration of vitamin A cannot be produced merely using traditional breeding methods. Researchers have created a transgenic variety of rice having yellow color seeds, showing enhanced production of beta-carotene as a precursor to vitamin A, by merely changing their genetic make-up, incorporating three new genes, one from a microorganism and two from daffodils. For young children living in the tropics, such as yellow or golden, rice may be a useful tool to cure vitamin A deficiency (Rani *et al*., 2013).

***5. Utilization of Marginalized Land***

A gigantic landmass across the globe, both coastal and terrestrial, has been marginalized due to extreme salinity and alkalinity. A transgenic plant was developed that exhibits tolerance to higher concentrations of salt by introducing a salt tolerance gene from Mangroves (*Avicennia marina*). The salt-tolerant transgenic maize plants have been generated by using the gut D gene from *Escherichia coli*.

Researchers have developed transgenic tomatoes that grew well in saline soils at the University of California Davis campus. The transgene was a highly-expressed sodium/ proton antiport pump, which sequestered excess sodium in leaf cells' vacuole. There was no sodium buildup in the fruit (Rani *et al*., 2013).

***6. Reduced Impact on the Environment***

Nowadays, one of the global issues is water availability and efficient usage. There is a severe loss of water content as extensive tillage (plowing) and preparing seedbeds made soil prone to erosion. There is a need to substitute the tillage method by developing crops that thrive under such conditions, including the induction of resistance to root diseases currently managed by tillage to herbicides (Rani *et al*., 2013).

***7. Transgenic Plants as a Source of Therapeutic Proteins***

Through recombinant DNA technology, therapeutic proteins (used in the treatment and diagnosis of human diseases) can be produced in plants. The area of research combining agriculture and molecular biotechnology is called Molecular pharming. Three types of therapeutic proteins are produced in transgenic plants, namely, (i) antibodies, (b) proteins, and (iii) vaccines. Antibodies aim against dental caries, cholera, rheumatoid arthritis, *E. coli* diarrhea, malaria, certain cancers, rhinovirus, HIV, influenza, herpes simplex virus, and hepatitis B virus are known to be produced in transgenic plants. For infectious diseases of the gastrointestinal tract, vaccines have been produced in plants like potatoes and bananas. In rice and wheat seed, an anti-cancer antibody has recently been expressed that distinguishes cells of breast, lung, and colon cancer. Hence, it could be useful in both diagnosis and therapy (Rani *et al*., 2013).

***8. Other Benefits of Transgenic Plants***

Genetically modified food has enhanced the ability to withstand the transportation of long distances. The GM crops are picked when still green, which allowed ripening during transport, thereby yielding a longer shelf life. Through prolonged shipping and storing periods, the product attains its destination without spoiling.

According to the producers of these GM crops, using these seeds will give up several benefits, counting increased yields and decreased costs. They shove GM crops as a second "Green Revolution" in a world with billions of hungry mouths to feed.

## Disadvantages

The application of transgenic crops was an issue for many years. Many apprehensions have been raised, and these are falling into two categories.

***1. Effects of the Transgenic Crop on Human Health***

For example, transgenic crops have been proposed to cause allergies in some people, although it is vague whether transgenic plants are the cause of this reaction. The antibiotic resistance genes sited in these crops have been advised to cause antibiotic resistance, resulting in superbugs, which cannot be killed with antibiotic treatments. The population being uncomfortable with consuming DNA obtained from another source, like bacteria or viruses (Rani *et al*., 2013).

***2. Are Transgenic Crops Destroy the Natural Environment***

There is a report on the death of monarch butterfly larvae and other non-target organisms after ingesting transgenic corn pollens. The hybrid corn expresses a bacterial toxin in its pollen (Rani *et al*., 2013).

Nevertheless following are potential issues of concern for plant protein production.
• Plant and product contamination by mycotoxins, herbicides, pesticides, and endogenous metabolites.
• Allergic response to plant protein glycans and other plant antigens.
• Regulatory uncertainty, particularly for proteins requiring endorsement in drug uses for humans.

## Transgenic Plant Regulations

In the United States, the provision of transgenic organisms or plants is governed by the Coordinated Framework for Regulation of Biotechnology. The three Agencies involved in this are as follows.

• ***USDA Animal and Plant Health Inspection Service:*** Under USDA (U.S. Department of Agriculture), Animal and Plant Health Inspection Service offers the Biotechnology Regulatory Services program, which is accountable for controlling the introduction (importation, interstate transportation, and field release) of genetically engineered organisms that may establish a plant pest risk. APHIS protects agriculture and the environment by making sure that biotechnology is developed and used safely. Through a robust dogmatic structure provided by BRS, the accidental release of any new hybrid material or plant is avoided by assuring safe and restricted establishment (Rani *et al*., 2013).

• ***EPA:*** Environmental Protection Agency assesses potential environmental impacts, particularly for genes that produce pesticides.

• ***DHHS, FDA:*** If the plant is proposed for human consumption, the human health risk is evaluated by the Food and Drug Administration.

## Should We Use Genetically Modified Crops?

Offering a crop that is environmentally sound and non-hazardous, the professed merits and demerits of transgenic crops must be conjugal to each other. The agencies that study their effects and producers of transgenic crops are aware of this point. Though, so far, there has been slight substantiation to support either case. However, this field needs more research to determine the proper security of these plants and to decide whether they are secure for both the environment and consumers of these products over the years. At the least, the majority would agree that the possible benefit of producing crops, which offer the human population more and low-cost food, makes transgenic technology a useful invention.

## Future Prospective

Around the globe, even though genetically modified crops offer a potential solution to food shortages, the feasibility of their cultivation remains dubious. The race of eliminating hunger by enhancing GM crops' production carries hidden costs to the environment and health concerns. The subject continues to be debatable, and the future of transgenic crops remains uncertain.

From the year 1994-2002, the commercial success of transgenic crops has revealed that significant benefits are going to ensue from the use of genetically engineered crops for commercial cultivation in farmer's fields. Significant advantages will comprise the following: (i) improved and more efficient weed control; (ii) increase in nutritional quality (oil in canola); (iii) decreased losses due to disease and pests, therefore, decreased need of pesticide; (iv) resistance against storage pests results in a reduction in postharvest losses due to better shelf life and marketing flexibility (*e.g.*, tomato); (v) more effective production of hybrid seed. The above will aid in not only a sustainable food security system but also a secure environment due to the lesser use of insecticides and pesticides. It will necessitate the seed industry to act against this changing situation by providing these advanced crops to the farmers. The developing countries will have to expand the mechanisms and commercialization of these transgenic crops. In the future, the transgenic crops will be used not only for enhanced agronomic traits but also for pharmaceuticals (including edible vaccines), food processing, and specialty chemicals. Thus transgenic crops hold a bright and optimistic future.

## Conclusion

In the future, researchers hope to provide vaccinations and medicines in GM foods, which can give drugs to people in developing countries more easily. Drugs incorporated into food are easier to transport and store than conventional medicine. The encroachment made with transgenic plants has and will continue to have a significant influence on many lives. Transgenic plants bid a new approach to produce and administer human antibodies. Genetic engineering made the treatment of anemia and diabetes possible through the production of biopharmaceuticals like erythropoietin and insulin, respectively. Future generations of GM plants are intended to be suitable for harsh environments and the enhancement of nutrient content, production of pharmaceutical agents, and production of bioenergy and biofuels.

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