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Genetically Modified Crops: Boon or Bane

Botany

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Dr. Parveen Garg Department of Botany, Swami Shradhanand College, University of Delhi

ABSTRACT

Intervention by mankind in biodiversity is as old as agriculture itself in the form of conventional breeding or first generation biotechnology also known as traditional biotechnology. By definition, biotechnology is any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific uses (1). The definition encompasses traditional biotechnology and traditional animal plant and animal breeding. It also includes modern biotechnologies such as genetic modification. Genetic modification (GM) is the artificial insertion of a specific gene, which controls as specific characteristic from one organism to another organism in ways that do not occur through natural crossing and recombination.

Traditional methods of gene exchange are limited to crosses between the same or very closely related species, a footing which modern biotechnology (genetic engineering or genetic modification) departs from by facilitating gene transfer between species irrespective of taxonomic positioning. An organism that has been modified or transformed using such latest techniques of molecular biology is commonly referred to as a genetically modified organism (GMO).

Genetically Modified crops

Benefits of GM foods

There is a need to produce inexpensive, safe and nutritious foods to help feed the world's growing population. Genetic modification may provide:

- Better quality food.
- Higher nutritional yields.
- Inexpensive and nutritious food, like carrots with more an tioxidants.
- Foods with a greater shelf life, like tomatoes that taste better and last longer.
- Food with medicinal benefits, such as edible vaccines – for example, bananas with bacterial or rotavirus antigens.

Crops and produce that require less chemical application, such as herbicide resistant canola.

For the development of improved food materials, GM has the following advantages over traditional selective breeding:

- Allows as much wider selection of traits for improvement: e.g. not only pest, disease and herbicide resistance (as achieved to date in plants) but also potentially drought resistance, improved nutritional contents and improved sensory properties.
- It is faster and lower in cost.
- Desired change can be achieved in very few generations.
- Allows greater precision in selecting characteristics.
- Reduces risk of random occurrence of undesirable traits.

These advantages, in turn, lead to a number of potential benefits, especially in the longer term, for the consumer, industry, agriculture and the environment.

- Improved agricultural performance (yields) with less labour input and less cost input.
- Benefits to the soil of "notill" farming practice.
- Reduced usage of pesticides and herbicides.
- Ability to grow crops in previously inhospitable envirments (e.g. via increased ability of plants to grow in conditions of drought, soil salinity, extremes of temperature, consequenc es of global warming, etc.) improved sensory attributes of food (e.g. flavor, texture, etc.)
- Removal of allergens or toxic components, such as the research in USA to produce a nonallergenic.

Nutritional Enhancement

Genetic engineering is used to increase the amount of particular nutrients (like vitamins) in food crops. Research into this technique, sometimes called 'nutritional enhancement', is now at an advanced stage. Researchers are especially looking at major health problems like iron and vitamin A deficiency. The removal of the protein in peanuts that causes allergies in some people is also being researched.

- Ingo Potrykus's EU research project jointly funded by the Rockefeller foundation, resulting in increased Vitamin A content in rice, which will help to prevent blindness among children in Southeast Asia.
- The announcement in September 2003 by Edger Cahoon and his team at the Donald Danforth Plant Science Center in Missouri that by inserting a gene extracted from barley into a common type of field corn, they have created a strain that grows with six times the usual amount of vitamin E, powerful antioxidant.
- Improved processing characteristics leading to reduced waste and lower food costs to the consumer.
- Prevention of loss of species to endemic disease (e.g. the Cavendish dessert banana which is subject to two fungal diseases that have struck Africa, Sought America and Asia, but could be reprieved by GM development of a disease resistant version.

Positive Impacts of GM crops

The world population has topped 6 billion people and is predicted to double in the next 50 years. Ensuring an adequate food supply for this booming population is going to be a major challenge in the years to come. GM foods promise to meet this need in a number of ways:

• Pest resistance

Crop losses from insect pests can be staggering, resulting in devastating financial loss for farmers and starvation in developing countries. Farmers typically use many tons of chemical pesticides annually. Consumers do not wish to eat food that has been treated with pesticides because of potential health hazards, and run – off of agricultural wastes from excessive use of pesticides and fertilizers can poison the water supply and cause harm to the environment. Growing GM food such as B.t. can help eliminate the application of chemical pesticides and reduce the cost of bringing a crop to market (2).

• Herbicide tolerance

For some crops, it is not cost – effective to remove weeds by physical means such as tilling, so farmers often spray large

quantities of different herbicides (weed – killer) to destroy weeds, a time – consuming and expensive process, that requires care so that the herbicide doesn't harm to crop plant or the environment. Crop plants genetically – engineered to be resistant to one very powerful herbicide could help prevent environmental damage by reducing the amount of herbicides needed. For example, Monsanto has created a strain of soybeans genetically modified to be not affected by their herbicide product Roundup (1). A farmer grows these soybeans which then only require one application of weed – killer instead of multiple applications, reducing production cost and limiting the dangers of agricultural waste runoff (3).

Plants can be genetically modified to be tolerant to a specific weedkiller. This allows farmers to control a wide range of weeds with less weedkiller while not affecting the modified crop. Herbicide tolerant crops are grown mainly in developed countries. However, recently they have been used in some developing countries; for example, more than 90% of soybeans grown in Argentina during 2002 were GM.

• Disease resistance

There are many viruses, fungi and bacteria that cause plant diseases.

Plant biologists are working to create plants with genetically – engineered resistance to these diseases (4 and 5).

Plants can be genetically modified to be resistant to bacterial, fungal or viral infestation. Examples include research on sweet potatoes to improve viral resistance and bananas modified to resist the Black Sigatoka fungus. Untreated, this fungus can reduce banana yields by as much as 70% but fungicides are expensive.

• Cold tolerance

Unexpected frost can destroy sensitive seedlings. Antifreeze gene from cold water fish has been introduced into plants such as tobacco and potato. With this antifreeze gene, these plants are able to tolerate cold temperatures that normally would kill unmodified seedlings (6).

• Drought tolerance / salinity tolerance

As the world population grows and more land is utilized for housing instead of food production farmer need to grow crops in locations previously unsuited for plant cultivation. Creating plants that can withstand long periods of drought or high salt content in soil and groundwater that help people to grow corps in formerly inhospitable place (7 and 8).

• Nutrition

Malnutrition is common in third world countries where impoverished peoples rely on a single crop such as rice for the main staple of their diet. However, rice does not contain adequate amounts of all necessary nutrients to prevent malnutrition. If rice could be genetically engineered to contain additional vitamins and minerals, nutrient deficiencies could be alleviated. For example, blindness due to vitamin A deficiency is a common problem in third world countries. Researchers at the Swiss Federal Institute of Technology Institute for plant science have created a strain of "Golden" rice containing an unusually high content of beta – carotene (vitamin A).

Since this rice was funded by the Rockefeller Foundation, a non – profit organization, the institute hopes to offer the golden rice seed free to any third world country that requests it. Plans were underway. To develop golden rice that also has increased iron content. However, the grant that funded the creation of these two rice strains was not renewed, perhaps because of the vigorous anti – GM food protesting in Europe, and so this nutritionally – enhanced rice does not come to market at all (9).

Crops can be genetically modified to contain additional nutrients that are lacking from the diets of many people in developing countries. One example is Golden rice, which has been modified to have enhanced levels of B – Carotene, in order to help to prevent vitamin A deficiency. 14 million children under five suffer clinically from this deficiency,

• Which can cause childhood blindness.

Pharmaceuticals

Medicines and vaccines often are costly to produce and sometimes require special storage conditions not readily available in third world countries. Researchers are working to develop edible vaccines in tomatoes and potatoes (10). These vaccines are much easier to ship, store and administer than traditional injectable vaccines.

Plants could be genetically modified to produce vaccines or other medicines. Potatoes have been modified to produce edible vaccines against *E. coli* bacteria which cause diarrhea. This would allow cheap and easy distribution of the vaccine, but research is till at a very early stage.

• Phytoremediation

Not all GM plants are grown as crops. Soil and groundwater pollution continues to be a problem in all parts of the world. Plants such as poplar trees have been genetically engineered to clean up heavy metal pollution from contaminated soil.

The risks of genetically modified corps: Assessing market safety

Food regulatory authorities require that GM foods receive individual pre-market safety assessments. Also, the principle of 'substantial equivalence' is used. This means that an existing food is compared with its genetically modified counterpart to find any difference between the existing food and the new product. The assessment investigates:

- Toxicity (using similar methods to those used for conventional foods)
- Tendency to provoke any allergic reaction
- Stability of the inserted gene
- Whether there is any nutritional deficit or change in the GM food.
- Any other unintended effects of the gene insertion.

A GM food is only approved for sale if it is safe and is as nutritious as its conventional counterparts. The safety of GM foods is still being debated, as it is impossible to predict all of the potential effects on human health and the environment. Some public health experts, however, advocate caution and believe that 'we are only at the "scientific starting line", we simply don't know whether GM foods are safe'. Stephen Leeder, "Genetically modified foods – food for thought', MJA 5.

Negative Impacts of GM crops

There are following unintended impacts on environment, health, markets:

Environment

Unintended environmental impacts include harming non target and/or beneficial species in the case of crops with engineered insecticidal properties, as well as the development of new strains of resistant pests. Additionally there is concern that pollen from genetically engineered herbicide resistant crops could reach wild, weedy relatives of the crop and create so called superweeds. This is of particular concern in the U.S. with crops such as canola and squash.

Health
At present, there is no evidence to suggest that GM foods are unsafe. However, there are no absolute guarantees, either. Unintended health impacts from GMOs concern allergens, antibiotic resistance, decreased nutrients, and toxins.

Allergens
Because protein sequences are changed with the addition of new genetic material, there is concern that the engineered or modified organism could produce know or unknown allergens. A recent National Research Council committee report on GMOs recommended the development of improved methods for identifying potential allergens. "Specifically focusing on new tests relevant to the human immune system and on more reliable animal models".

Known allergens can be transferred from traditional foods into GM foods. For instance, during laboratory testing, a gene from the Brazil nut was introduced into soybeans. It was found that people with allergies to Brazil nuts could also be allergic to soybean that has been genetically modified in this way. No allergic effects have been found with currently approved GM foods. (ill effects of Gm crops)

Antibiotic resistance
Plant genetic engineers have frequently attached genes they are trying to insert to antibiotic resistance genes. This allows them to readily select the plants that acquire the new genes by treating them with the antibiotic. Sometimes these genes remain in the transgenic crop that has lead critics to charge that the antibiotic less effective. However, several panels of antibiotic resistance experts have concluded that the risk is miniscule. Bioengineers insert a 'marker' gene to help them identify whether a new gene has been successfully introduced to the host DNA. One such marker gene is for resistance to particulars antibiotics. If genes coded for such resistance enter the food chain and are taken up by human gut microflora, the effectiveness of antibiotics could be reduced and human infectious disease risk increased. Research has shown that the risk is very low; however, there is general agreement that use of these markers should be phased out. Stephen Leeder, 'Genetically modified foods – food for thought', MJA www.mja.com.au, john Huppatz and Paula A Fitzerald, MJA 2000.

Decreased nutrients
Because the *DNA* of genetically engineered plants is altered, there is concern that some GMOs could have decreased levels of important nutrients, as DNA is the code for the production of nutrients. However, it must be noted that nutritional difference also have been documented with traditionally bred crops.

Introduced toxins
Residual toxins resulting from introduced genes of the bacteria *Bacillus thuringiensis* in so-called Bt crops are unlikely to harm humans. This is because the toxin produced by the bacteria is highly specific to certain types of insects. Prior to its inclusion in GE / GM crops, Bt has been used as a biological insecticide, causing no adverse effects in humans consuming treated crops.

Naturally occurring toxins
There is concern that genetic engineering could inadvertently increase naturally occurring plant toxins. However, traditional plant breeding also can result in higher levels of plant toxins.

Cross - breeding
Other risks include the potential for crossbreeding between GM crops and surrounding vegetation, including weeds. This could result in weeds that are resistant to herbicides and would thus require a greater use of herbicides, which could lead to soil and water contamination. The environmental safety aspects of GM crops vary considerably according to local conditions.

Pesticide resistant insects
The genetic modification of some crops to permanently produce the natural biopesticide Bacillus thuringiensis (Bt) toxin could encourage the evolution of Bt – resistant insect, rendering the spray ineffective. Wherever pesticides are used, insect resistance can occur and good agricultural practice includes strategies to minimize this.

Biodiversity
Growing GM crops on a large scale also have implications for biodiversity, the balance of wildlife and the environment. This is why environmental agencies closely monitor their use.

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