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Genetically Modified Crops-Boon or Bane?

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Abstract

Agricultural crops in which the DNA has been modified using genetic engineering techniques (addition, deletion, or manipulation of a single trait in an organism to create a desired change) are referred as Genetically modified (GMO) crops.Genetically modified crops possess one or more useful traits, that normally does not exist in the plant in nature. Transgenic technology has been used to increase crop yields and improve their nutrition, reduce the use of pesticide and herbicides by making them tolerant, insect resistant, reduce CO_2 emissions, and decrease the cost of crop production. However, since the first GM crop produced, the debate of using/not using GMO crops is ongoing. A number of concerns like toxicity and allergenicity to animals and human beings, potential environmental risks, such as chances of gene flow, adverse effects on non-target organisms, evolution of resistance in weeds and insects etc. have been the major roadblocks in its application. In this review, we present a comprehensive update on the current status of the genetically modified (GMO) crops under cultivation. We also discuss the issues affecting widespread adoption of transgenic GM crops and comment upon the recent tools and techniques developed to address some of these concerns.

Keywords: Genetically modified crops (GMO), *Bacillus thuringiensis* (Bt)

Introduction

Domestication of crops has been going on from time immemorial. Farmers started cross-pollinatingcrops to get better yields. Efforts were made to modify the crops by incorporating the desired characters into plants by genetic engineering techniques[1]. Plants and crops are engineered to express resistance to herbicides and/or specific pests, grow plants with better texture, flavor, and higher nutritional value than their wild varieties. Even though the benefits of raising genetically modified crops are vast, however the risks involved in raising such crops are not fully understood. Due to their unpredictable nature, once GMO has been released into the environment, it is very difficult to recall. A lot of parameters (secular, religious, ethical, economical) need to be taken into account before releasing a GM. Criticsblame scientists to be putting themselves as the ‘Creator’ or‘God’ bychanging the nature. Religious groups argue on these points and object to GMO crops.One major objection they have is thatif the modified products are not clearly labelled (eg. If an animal gene has been inserted in fruits and vegetables, vegetarians would never be able to know what they are consuming).As with all normal food products, safety measures and proper labelling must be done for GMO crops [2,3].

Table I – Some important Genetically modified crops

Name of the plant	Modification	Gene involved	Reference
FlavrSavr Tomato	delaying ripening by delaying ethylene production	By blocking the polygalacturonase (PG) gene, which is involved in spoilage	[4]
Roundup Ready Soybean	Resistance to glyphosphate herbicide	RR soybean express a version of EPSPS from the CP4 strain of the bacteria *Agrobacterium tumefaciens*, expression of which is regulated by an enhanced 35S promoter (E35S) from cauliflower mosaic virus (CaMV), a chloroplast transit peptide (CTP4) coding sequence from *Petunia hybrida*, and a nopaline synthase (nos 3') transcriptional termination element from *Agrobacterium tumefaciens*.[7] The plasmid with EPSPS and the other genetic elements mentioned above was inserted into soybean germplasm with a gene gun	[5]
Petunia	Enhanced vase life	Insertion of anti-sense ACC oxidase	[6]
Tobacco	Antibiotic (herbicide) resistance	α/β-tubulin double gene construct containing the mutant α-tubulin gene was used to express a stably inherited dinitroaniline-resistant phenotype. The transgene α- and β-tubulins increased the cytoplasmic pool of tubulin approximately 1.5-fold while repressing endogenous α- and β-tubulin synthesis by up to 45% in some tissues in all the transformed lines.	[7]
Golden Rice	produce high levels of beta-carotene- a precursor to vitamin A. Golden rice contains 37 mg/g of carotenoid, of which 84% is beta-carotene and also contains a gene for a bean iron storage protein, ferritin. The modified rice will provide vitamin A and iron	*psy* genes from daffodils (*Narcissuspseudonarcissus*) and *crtl* genes from soil bacteria (*Erwinia carotovara*)	[8]
Bt brinjal	Parthenogenic fruit	*DefH9-iaaM* gene	[9]

Carnation	manipulation of either anthocyanins (red and blue colors) or carotenoids (yellow and orange colors), with the intent of creating a wider range of flower colors than occurs naturally, as well as to produce natural dyes for industrial purposes		[10]
Transgenic papaya	Papaya ring spot virus (PRSV) resistance	SunUp' and 'Rainbow'. 'Sun- Up' is homozygous for the coat protein gene while 'Rainbow' is an Fl hybrid of 'SunUp' and the non transgenic 'Kapoho'.	[11]
Bt Maize	Insect resistance	*Bacillus thuringiensis* produces a bacterial toxin (Delta-endotoxin). It stops the insect from feeding by attacking the insect gut lining.	[12]
Cassava	lower cyanogen glucosides and enhanced protein and other nutrients	MCol2215 cotyledon explant was used to construct several RNAi and antisense vectors to interfere with the expression of CYP79D1 and AYP79D2, and transformed the somatic cotyledons of cassava MCol22 using an Agrobacterium-mediated technique.	[13]
Suntory "blue" rose	blue rose (actually lavender or mauve)	genetic engineering involved three alterations – adding two genes, and interfering with another. One of the added genes was for the blue plant pigment	[14]
Carnation	enhanced vase-life, as a result of alteration of either ethylene biosynthesis or ethylene perception. The flowers from the transgenic plants do not require chemical treatment for maximum vase-life	Petunia F3'5'H (flavonoid 3',5'-hydroxylase) gene along with DFR (dihydroflavonol reductase) was overexpressed in carnations under the control of a constitutive promoter from snapdragon CHS gene.	[15]
Bt Cotton	Insect resistance	*Bacillus thuringiensis* produces a bacterial toxin (Delta-endotoxin). It stops the insect from feeding by attacking the insect gut lining.	[16]

Purple tomatoes	Enrichment of tomato fruit with health-promoting anthocyanins by expression of selected transcription factors. Anthocyanins offer protection against certain cancers, cardiovascular disease and age-related degenerative diseases.	Expression of two genes from snapdragon that induce the production of anthocyanins in tomatoes	**[17]**
Soybean	improved oil profiles (high levels of oleic acid greater than 80%) for processing or healthier eating	By silencing, or knocking out, the delta 9 and delta 12 desaturases.	[18]
Tearless onion	Conversion of valuable sulphur compounds to the tearing agent was inhibited	By shutting down the lachrymatory factor synthase gene using RNAi technology	[19]
Potato (Russet Burbank, Ranger Russet and Atlantic varieties).	resist black spot bruising, browning and contains less of the amino acid asparagine that turns into acrylamide during the frying of potatoes.	does not contain any genetic material from other species and RNA interference to switch off genes.	[20]
Arctic apple (Granny Smith and Golden Delicious varieties)	resistance to the antibiotic kanamycin	Gene silencing was used to reduce the expression of polyphenol oxidase (PPO), thus preventing enzymatic browning of the fruit	[20]
Cammelina sativa	produce plants that accumulate high levels of oils similar to fish oils.	Five-gene construct contained a set of genes optimised for EPA synthesis: a Δ6-desaturase gene from *Ostreococcustauri* (OtΔ6), a Δ6 fatty acid elongase gene from *Physcomitrella patens* (PSE1), a Δ5-desaturase gene from *Thraustochytrium* sp. (TcΔ5), a Δ12-desaturase gene from *Phytophthora sojae* (PsΔ12) and an ω3-desaturase from *Phytophthora infestans*	[21]
Bt tobacco	Insect resistant	glyphosate insensitive *EPSPS* gene isolated from *Agrobacterium* sp. strain CP4	[22]

Boon

Plants have been modified with traits to provide us with useful drugs, products that alleviate illness, clean up the environment, help in bioremediation, increased crop and livestock yields and biofuels[22,23;Table I].Some important benefits of genetically engineered crops are-

1. Improved shelf life- The genetically modified tomato-*Flavrsavr* have a longer shelf life than the normal tomatoes.

2. Drought resistant crops- Tobacco plants have been engineered to make them resistant to drought.

3.Salt-tolerant crops- Plants like rice, tomato, cotton etc have been engineered to make them salt tolerant.

4. Resistance topesticides and herbicides- Many crops have been genetically engineered to resist herbicides and pesticides. Some of them are tobacco, brinjal, cotton, etc.

5. Improved crop quality- Flowers have developed with varying colours and increased vase life.eg. carnations.

6. Improved nutritional quality- GMO crops offer nutritional benefits. Today we have rice design with increased levels of Vitamin A, cassava with lower cyanogen glucosides and increased protein and other nutrients, vitamin-enriched corn, healthier edible oils, etc.

7. Production of useful by-products- Plants have been engineered to make edible vaccines (banana), produce antibodies (tobacco), bioplastics (cotton) etc.

8. Bioremediation- GMO plants have been used for remediation of contaminated soils.

Bane

Critics claim that there are potential risks associated with transgenic crops[23]. Some of the most discussed risks are-

1. Allergic reactions- One of the most disadvantage of GMO crops is that they may cause allergies to many people. Since GMO crops are not labelled people may consume food to which they are allergic and thus fall sick**.** Though there is a very little risk that GMO foods can trigger an allergic reaction, it is only possible if the genetic change triggers the production of an allergen.

2. Decreased Antibiotic Efficacy**-** According to critics, GMOs may contain changes that make them resistant to certain antibiotics. The genes from these plants could enter humans or animals when they eat them.

3. Not Safe to Eat - Genetically modified foods are observed to have unnatural tastes and there is a notion that they are not safe to eat.

4. Gene Transfer**-** Opponents to GM crops believe that the modified genes of these crops may escape into the wild weed population, thus creating super-weeds which become impossible to kill. There may be a competition between naturally growing plants and GMO crops, of which the latter may outgrow the former driving them into extinction.

5. Exploitation- Countries may use genetically engineered bioweapons to destroy each other.

6. New Diseases- Since genetically modified foods are created by modifying their genes using viruses and bacteria, there is a fear that they might lead to causing new diseases. This threat to human health is a worrisome.

7. Food Supply at Risk- GMO seeds are identical structurally. If there is any problem in any one of them, it may lead to a total crop failure. This will effect the food supply. Also since these are patented, consumers will have to sign certain agreements for use with the supplier or creator to purchase them.

8. Economic Concerns- It is a lengthy and expensive process to bring in any GMO to the market**.**

Consumers are worried that this will raise seed prices to very high levels that third-world countries and small farmers cannot afford them, thus widening the gap between the rich and the poor.Also countries may increase tariff on GMcrops resulting in conflict among traders.

Conclusion

Even though GMOs have passed safety assessments, scientists need to still consider the applications and procedures of the technology that can minimize potential biological and ecological hazards. Farmers need to be more careful and educated before deciding to use GM seeds for growing. The debate for the pros and cons of the technology is an endless one.

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