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GENETICALLY MODIFIED CROPS: BOON FOR FOOD SECURITY

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Introduction:

Food security exists when all people have physical and economic access to sufficient, safe and nutritious food. Unfortunately, food security ("when all people at all times have access, to sufficient, safe and nutritious food to maintain a healthy and active life") does not exist for a significant proportion of the world population. Around 900 million people are undernourished, meaning that they are undersupplied with calories. Many more suffer from specific nutritional deficiencies, often related to insufficient intake of micronutrients. Eradicating hunger is a central part of the United Nations' Millennium Development Goals. But how to achieve this goal is debated controversially. Genetically modified (GM) crops are sometimes mentioned in this connection. Some see the development and use of GM crops as key to reduce hunger (Calestous, 2011), while others consider this technology as a further risk to food security. GM technologies could make food crops higher yielding and more robust to biotic and abiotic stresses (Fedoroff *et al.*, 2010). This could stabilize and increase food supplies, which is important against the background of increasing food demand, climate change, and land and water scarcity. In 2014, 181.5 million hectares were planted with GM crops, such as soybean, corn, cotton, and canola, but most of these crops were not grown primarily for direct food use. Paine *et al.*, 2005 reported GM technology can help to breed food crops with higher contents of micronutrients, e.g. Golden Rice. Such GM crops have not yet been commercialized. Projections show that they could reduce nutritional deficiencies among the poor, entailing sizeable positive health effects.

What is GM Crop?

Genetically modified Crops are simply crops, whose genetic material has been modified. The first GE crops were tobacco plants modified in 1986 to be resistant to direct application of herbicides. The following year, tobacco plants were engineered to resist insects. There followed a host of field trials to also develop plants resistant t viral and fungal diseases and to modify traits such as ripening, starch content and so on. In 1995 the FDA approved GE corn, soy, cotton, canola, potato, squash and tomato for commercialization and the amount of GE crops since then has been steadily increasing. Most often the genes are altered to render the plant resistant to either insects or herbicides. The global area of biotech crops has increased more than 100-fold from 1.7 million hectares in 1996 to181.5 million hectares in 2014 – this makes biotech crops the fastest adopted crop technology in recent times. This impressive adoption rate speaks for itself, in terms of its sustainability, resilience and the significant benefits it delivers to both small and large farmers as well as consumers.
of the 28 countries which planted biotech crops in 2014, 20 were developing (including the new biotech crop country Bangladesh) and only 8 were industrial countries.

Global adaption of GM crops in 2014:

Country	Area (m ha)
USA	73.1
Brazil	42.2
Argentina	24.3
India	11.6
Canada	11.6
China	3.9
Total	**181.5**

Each of the top 10 countries, of which 8 were developing, grew more than 1 million hectares providing a broad based worldwide foundation for continued and diversified growth in the future. More than half the world's population, ~60% or ~4 billion people, live in the 28 countries planting biotech crops. Canada increases hectar age of biotech crops whereas area in Australia decreases because of continuing severe drought.

Bangladesh, one of the smaller and poorest countries in the world, approved and commercialized Bt brinjal in record time in 2014. Vietnam and Indonesia moved towards planting their first biotech crops in 2015, for a total of 9 biotech countries in Asia.

India continues to benefit enormously from Bt cotton.

India cultivated a record 11.6 million hectares of Bt cotton planted by 7.7 million small farmers with an adoption rate of 95%, up from 11.0 million hectares in 2013. Notably, the increase from 50,000 hectares of Bt cotton in 2002 (when Bt cotton was first commercialized) to 11.6 million hectares in 2014, represents an unprecedented 230-fold increase in thirteen years.

Stacked traits occupied 28% of the global 181 million hectares.

Stacked traits continued to be an important and growing feature of biotech crops – 13 countries planted biotech crops with two or more traits in 2014, of which 10 were developing countries. About 51 million hectares equivalent to 28% of over 181 million hectares were stacked in 2014, up from 47 million hectares or 27% of the 175 million hectares in 2013; this steady and growing trend of more stacked traits is expected to continue. In 2014, 5.8 million hectares of HT/Bt soybean were grown in Brazil, Argentina, Paraguay and Uruguay in Latin America. USA maintains leadership role, and in 2014 its increase in year-to-year hectarage was higher than Brazil, which has recorded the highest increase of any country for the last five years. Five EU countries planted 143,016 hectares of biotech Bt maize. Spain was by far the largest adopter, planting 92% of the total Bt maize hectarage in the EU.

How are plants engineered to be insect resistant (IR)?

Sections of the DNA from the bacteria known as *Bacillus thuringiensis* (Bt) are isolated and inserted into the plant cells by a process known as genetic transformation. The entire plant is then regenerated from the transgenic plant cells. There are thousands of different Bt strains that produce protein crystals toxic to insect pests. Particular strains are chosen to target specific plant pests. The resulting plan contains the Bt toxin in its cells. When the plant is eaten by the target insect the toxin binds to receptors in the insect's gut, causing the gut wall to break down and allowing toxin spores and normal gut bacteria to enter the body. As spores and bacteria proliferate in the body, the insect dies.

How are plants engineered to be herbicide tolerant (HT)?

Micro-organisms are identified that are tolerant of the active chemical in the herbicide. In the case of glyphosate, the active ingredient in Roundup, glyphosate-resistant enzymes are isolated from a strain of *Agrobacterium.* These are inserted into the genes of the plant via a multi-step process resulting in a plant that can withstand direct application of the herbicide.

Technology Trends in GM Crops

Herbicide tolerant

Crop plants genetically-engineered to be resistant to one very powerful herbicide could help to 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. Micro-organisms are identified that are tolerant of the active chemical in the herbicide. In the case of glyphosate, the active ingredient in Roundup, glyphosate-resistant enzymes are isolated from a strain of Agrobacterium. These are inserted into the genes of the plant via a multi-step process resulting in a plant that can withstand direct application of the herbicide.

Improving quality

The FLAVR SAVR tomato was the first genetically engineered crop product to be commercialized. Circumstantial evidence available in the 1980s suggested that the tomato fruit enzyme polygalacturonase (PG), because of its ability to dissolve cell-wall pectin, was key to fruit softening. Researchers at Calgene, Inc., in Davis, proposed to suppress PG accumulation in ripening tomatoes by introducing a reverse-orientation copy of the gene, an “antisense” copy designed to prevent or drastically reduce the formation of PG.

Disease resistant

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. For Example- Hawaiian Papaya- Hawaiian papaya is made resistant to the devastating effects of Papaya Ring Spot Virus (PRSV). It was the first virus resistant GM crop.

Insect resistant

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Stacked trait seeds (Innate™ potato)

Innate™ potato developed by the private company, Simplot, in the US, was approved for commercialization in the US by APHIS/USDA in November 2014. Innate™ has 50 to 75% lower levels of acrylamide, a potential carcinogen in humans, produced when potatoes are cooked at high temperatures. Innate™ potato is also less susceptible to bruising. Given that potato is a perishable food product, quality can be significantly and negatively impacted by damage to the tubers during harvest, handling and processing. Innate™ potatoes are an excellent example of how biotech crops can enhance food safety, quality and provide benefits for all stakeholders, growers, processors and consumers. It is noteworthy that Innate™ potato was developed by transferring genes from one potato variety to another. Simplot claims that Innate™ potato is a safe and superior product that will confer the following benefits to farmers, processors and consumers: lower levels of asparagine, which in turn lowers the potential for production of undesirable acrylamide, a potential carcinogen, when potatoes are cooked at high temperatures; will not discolour when peeled; fewer spots due to bruising; they store better; reduce wastage and thus contribute to food security. Consumer surveys by Simplot indicate that 91% of those surveyed were comfortable with the Innate™ breeding method. RNA interference technology was used to silence four genes that lowered enzyme levels that in turn led to lower acrylamide level.

Stress tolerant

As the world population grows and more land is utilized for housing instead of food production, farmers will 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 will help people to grow crops in formerly inhospitable places.

Pharmaceuticals

Medicines and vaccines often are costly to produce and sometimes require special storage conditions. Researchers are working to develop edible vaccines in tomatoes and potatoes. These vaccines will be much easier to ship, store and administer than traditional injectable vaccines.

Traits focused so far…

Crop	GM Property for food security
Corn, Canola, Soybean, Sugar beet	Herbicide tolerant
Cotton, Corn, Egg plant, Rice	Insect resistant
Tomato	Delayed ripening
Potato	Higher starch content
Rice	Golden rice (Ferritin, Vit A) Zn-rich rice
Potato, Banana	Disease resistant
Papaya	Virus resistant

Conclusion:

1. GMO's present both positive and negative aspects to society as a whole.
2. They are a topic of much deliberation and tension; very prevalent in some parts of the world and banned in others.
3. GE crops are required for meeting Food Security in today's growing population.
4. Ultimately, GMO's are still a relatively premature technology and in the developmental process. Only time will reveal their ultimate effect on humans.
5. GM crops have positive impact on microbes and their and their activities in soil, except in few cases such as- actinomycetes and nematodes.
6. GM crops have positive effect on nutrient transformations in soil.
7. GM plant can be better utilized as metal accumulator in contaminated in metal contaminated areas.

References

Calestous, J. (2011). Preventing hunger: biotechnology is key. *Nature* **479**: 471–472.

Fedoroff, N.V., Battisti, D.S., Beachy, R.N., Cooper, P.J.M and Fischhoff, D.A. (2010). Radically rethinking agriculture for the 21st century. *Science* **327**: 833–834.

Paine, J.A., Shipton, C.A., Chaggar, S., Howells, R.M and Kennedy, M.J. (2005). Improving the nutritional value of Golden Rice through increased pro-vitamin A content. *Nature Biotechnology* **23**: 482–487.