An Introduction on the GM Debate in India

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Abstract

The spectre of a food security crisis has raised important questions about future directions for agriculture. Thus long-standing debate about the potential contribution of Agricultural Biotechnology as well as uses of GMOs to ensure food security got a fresh impetus. The GMOs may provide an answer to higher production required to ensure food security. India is at the crossroads so far as acceptance of GMOs towards ensuring food security is concerned. At one hand research on GMOs with utmost care is essential to safe guard the health, environment, bio diversity issues involved. On the other hand there is a need to improve the food distribution mechanism with current modern management techniques. The present article deals with the various facets of GMO crops and their pros and cons.

Keyword

GMOs, Genetic Engineering, Food security, Environment

Introduction

In the next 50 years the global population is expected to double, reaching more than 6.4 billion people by 2050[1]. Expected population growth requires the world food supply to increase at least 250 percent from its current level[2]. The amount of land currently committed to food production i.e. approximately 36 percent of the earth's cumulative land area cannot yield the amount of food needed by this increased population. Although forests could be cleared to obtain needed acreage, a better approach is to find ways of getting greater crop yield from existing land. Thus, with the increasing demand for food coupled with the limiting resources, better and more efficient ways to produce food is the need of the hour. Biotechnology can provide a possible solution.

Biotechnology is the application of the technology to modify the biological function of an organism by adding genes from another organism. More recently, a new generation of improved crops are developed through genetic engineering. Looking back at the scope of biotechnology, genetic engineering is part of its modern and sophisticated application. It is a technique that transfers a gene or genes of interest to develop and improve plants, animals and other organisms. Another application of biotechnology in agriculture is the development of improved vegetables, fruits, fibers and cereals. For instance, through tissue culture it is possible to mass produce planting materials. Higher yielding and more resistant varieties crops are also made available[3].

Pest resistance Crop: losses from insect, pests results in devastating financial loss for farmers and cause starvation in various parts of the world at frequent intervals. Uses of tonnes of chemical pesticides annually are the common practice of farmers which has potential health hazards. The surfeit of agricultural wastes generated from excessive use of pesticides and fertilizers had an adverse impact on the quality of soil, water and cause harm to the environment. Pest resistance crops generated through biotechnology provide an alternative to use of pesticides. For example *Bacillus thuringiensis*, is a naturally occurring bacterium that produces crystal l proteins lethal to insect larvae. B.t. crystal protein genes transferred into corn, makes the corn capable of producing resistance against insects such as the European corn borer. Similarly GM foods such as B.t. corn can help eliminate the application of chemical pesticides and therefore has potential to provide benefit both economically and environmentally.

Herbicide tolerance Crops: To remove weeds by physical means such as tilling, or by use of large quantities of different herbicides (weed-killer) is equally time-consuming and expensive process, moreover to ensure that the herbicide doesn't harm the crop plant or the environment calls for special awareness. Genetically-engineered crop plants, resistant to very powerful herbicide could prevent environmental damage by reducing the amount of herbicides needed. For example, Monsanto has created a strain of genetically modified soybeans which is not affected by their herbicide product Roundup ®.6. Growing this variety of soybeans requires only one application of weed-killer instead of multiple applications, reducing production cost and limiting the dangers of agricultural waste.

There are many viruses, fungi and bacteria that cause plant diseases. Plant biologists are working to create **Disease resistance plants** to provide protection against fall in yield due to effect of these viruses, fungi and bacteria.

Cold tolerance plants: An antifreeze gene from cold water fish has been introduced into plants such as tobacco and potato to create plants which are able to tolerate cold temperatures (unexpected frost) that normally would kill unmodified (sensitive) seedlings.

Drought tolerance / salinity tolerance plants: As world population grows, more land is required for housing; this may necessitate use of land which was formerly unsuited for plant cultivation to grow crops in future. Creating plants that can withstand long periods of drought or high salt content in soil and ground water may provide a way in future to grow crops on these previously in-arable lands.

Malnutrition is common in third world countries where populace rely on a single crop such as rice as main staple. However, rice does not contain adequate amounts of all necessary nutrients to prevent malnutrition. Genetically engineered rice containing 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 Sciences have created a strain of **"golden" rice** containing an unusually high content of beta-carotene (vitamin A).

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

Not all GM plants are grown as crops. Soil and ground water 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 (**Phytoremediation**).

History of genetic engineering

A genetically modified organisms or GMOs are products developed through genetic engineering and are also known as transgenic crops. Looking back at the past, Human beings (Prehistoric times to 1900) gathered food from plants they found in nature. Farmers' saved seeds from domesticated crops for future production. Foods are manipulated through the use of yeast and fermentation. Some naturalists and farmers begin to recognize advantage of "hybrids," i.e. plants produced through natural breeding between related varieties of plants to offer greater yield, characteristics, disease resistance. European plant scientists begin using Gregor Mendel's genetic theory to manipulate and improve plant species. This is called "classic selection." A plant of one variety is crossed with a related plant to produce desired characteristics. In 1953 James Watson and Francis Crick publish their discovery of the three-dimensional double helix structure of DNA. This discovery eventually leads to the ability of scientists to identify and "splice" genes from one kind of organism into the DNA of another to start modern genetic engineering. In 1973, Herbert Boyer and Stanley Cohen combined their research to create the first successful recombinant DNA organism. In 1980, the U.S. Supreme Court in Diamond v. Chakrabarty ruled that genetically altered life forms can be patented. The decision allowed the Exon Oil Company to patent an oil-eating microorganism.

In 1982, The U.S. Food and Drug Administration approved the first genetically engineered drug, Genentech's Humulin, a form of human insulin produced by a bacterium. This is the first consumer product developed through modern bioengineering. 1987, the first field tests of genetically engineered crops (tobacco and tomato) were conducted in the United States. In 1992 Calgene's FavrSavr tomato, engineered to remain firm for a longer period of time, was approved for commercial production by the US Department of Agriculture and the FDA declared that genetically engineered foods are "not inherently dangerous" and do not require special regulation.

In 1996 when the first shipments of GM maize and Soybean travelled from North America to Europe, Genetically Modified Organisms (GMOs) became controversial since then on the question of how to regulate the products and biosafety became the core issue of the debate.

Advantages and disadvantages

GMO research is intended for legitimate beneficial purposes, but it also carries a risk of being misused for malicious purposes. GMOs with added vitamins and nutrients are projected for improving nutritional growth. From economic point of view, bringing a GM food to market is a lengthy and costly process, therefore agro-biotech companies would like to ensure return on their investment to remain economically viable. Patent infringement is also a big concern of agribusiness, which raises the price of seeds so high that small farmers and third world countries may not be able to

afford seeds of these GM crops. Patent infringement lead to the introduction of "Suicide Gene" in the GM plants. That is these plants would be viable only for one growing season and would produce sterile seeds that do not germinate. Farmers need to buy a fresh supply of seeds each year. This would be financially disadvantageous to farmers of third world countries who may not afford purchase of new seeds every time rather traditionally set aside a portion of their harvest to be used as seeds for the next growing season. However, in an open letter to public, Monsanto has pledged to abandon all research using this suicide gene technology[4].

From a basic scientific standpoint, genetic engineering has been an important development in science with great potential and promise, but also need to be assessed adequately in order to ensure that they are safe, as well as environmentally and socially sustainable. Use of recombinant DNA (rDNA) or genetic engineering (GE) technology is intended for beneficial purposes, but may pose a threat to other living systems and the environment, as perceived in case of genetically modified (GM) crops. Result of Laboratory study published in Nature[5] showed that the pollen from Bt. Corn caused high mortality rates in monarch butterfly caterpillars, which eat the pollen and perish. Though the study was not conducted under natural fields' conditions, the results seemed to lend support to the viewpoint about the safety and environmental sustainability of GM products. Unfortunately Bt. toxin kills many species of insect larvae indiscriminately, it is not possible to design Bt toxins that would kill only crop-damaging pests and remain harmless to other insects. Just as some population of mosquitoes developed resistance to DDT, many people are concerned that insects will become resistant to Bt. or other crops that have genetically modified to produce their own pests.

A study by David Mortensen, a plant ecologist at Pennsylvania State University in University Park, predicts that total herbicide use in the United States will rise from around 1.5 kilograms per hectare in 2013 to more than 3.5 kilograms per hectare in 2025 as a direct result of GM crop use[6]. On the other hand the crop plants engineered for herbicide tolerant weeds will cross-breed, resulting in the transfer of the herbicide resistance genes from the crops into the weeds i.e. gene transfer to non-target species. These "Super Weeds" would then be herbicide tolerant as well. Other introduced genes may cross over into non-modified crops plants next to GM crops. Liberal use of glyphosate, were spurring the evolution of herbicide resistance in many weeds. Twenty-four glyphosate-resistant weed species have been identified since Roundup-tolerant crops were introduced in 1996. May be abandoning chemical herbicides completely is not a viable solution, says Jonathan Gressel, a weed scientist at the Weizmann Institute of Science in Rehovot, Israel. He also said that using chemicals to control weeds is still more efficient than ploughing and tilling the soil, and is less environmentally damaging[6].

There is a possibility of introducing a new gene into a plant may create a new allergen or cause an allergic reaction[7] in susceptible individuals. Therefore there is a growing concern that transgenic food plants may have an unexpected and negative impact on human health, though scientists believe that GM foods do not present a risk to human health[8, 9, and 10]. Hence extensive testing of GM foods may be required to avoid the possibility of harm to consumers with food allergies.

For these reasons, developed and developing countries identified a clear need for comprehensive, transparent, scientific guidelines for meaningful pre-release testing and post release monitoring of transgenic plants.

The dilemma of food security

The adoption of modern biotech products needs to be balanced with adequate biosafety safeguards. The biosafety frameworks should be credible, flexible, transparent, predictable, focused on clear objectives, adaptable to different socio-economic and cultural conditions, and cost-effective. The benefits of genetically modified crops can be achieved only if appropriate guidelines for their biosafety are in place and the relevant capacities to implement the guidelines exist.

In 2000 International Biosafety Protocol is approved by 130 countries at the Convention on Biological Diversity in Montréal, Canada. The protocol agrees upon labeling of genetically engineered crops, but still needs to be ratified by 50 nations before it goes into effect. India is one of the 50 countries who already ratified the protocol.

Worldwide cultivation of GMOs

The International Service for the acquisition of Agri-Biotech applications (ISAAA) is a not-for profit international organization that shares the benefits of crop biotechnology to various stakeholders, particularly resource-poor farmers in developing countries, through knowledge sharing initiatives and transfer and delivery of proprietary biotechnology application. In the last 18 year period 1996 to 2013, millions of farmers in ~30 countries worldwide, adopted biotech

crops at unprecedented rates. The research on global biotech crops showed that a total of 18 million farmers in 27 countries have cultivated 175.3 million hectares of biotech crops in 2013. The global hectarage of biotech crops have increased more than a hundred-fold from 1.7 million hectares in 1996 to over 175 million hectares in 2013 making biotech crops the fastest adopted crop technology in recent history. Of the 27 countries which planted biotech crops in 2013 (Figure 1), 19 were developing and 8 were industrial countries[11].

GMO in Indian context

Genetic Engineering is the inevitable wave of the future and a technology that has such enormous potential benefits that perhaps it cannot be ignored. However, caution to avoid unintended harm to human health and environment as a result of over-enthusiasm for this powerful technology is required. In India, government has announced a policy on GM foods though no products are commercially available in Indian markets yet. India is, however, very supportive of transgenic plant research. It is highly likely that India may decide that the benefits of GM foods outweigh the risks because Indian agriculture also needs to adopt drastic new measures to counteract the country's endemic poverty and to feed its increasing population.

All activities involving research of GMO and development of products containing GMOs or HMOs including transgenic crops, pharma products, industrial products, food and foodstuffs need to be monitored thoroughly prior to release. The Government of India follows a policy of case by case approval of GM crops. Basically a four step process is followed: The first step begins in government or private research laboratories and greenhouses, where scientists investigate potential beneficial traits, identify genes and carry out genetic transformations. If these lab results are successful, the plant may advance to the second step i.e. open field trials, where breeding and testing continue in a real life environment. The third step is securing regulatory approval for environmental release. The fourth and final step is market acceptance and large scale production.

The Indian Government has one Statutory Bodies consisting of

Advisory Committee

The Recombinant DNA Advisory (RDAC)

Approval Committee

1. Institutional Biosafety Committee (IBSC)
2. Review Committee on Genetic Manipulation (RCGM)
3. Genetic Engineering AppraisalCommittee (GEAC)

Monitoring Committee

1. State Biotechnology CoordinationCommittee (SBCC)
2. District Level Committee (DLC).

The initial assessment of an application for confined field trial begins at the institutional level itself. Based on information generated by the applicant in lab / greenhouse and on preliminary phenotypic evaluation of event selection, an application is made to IBSC for one to a few events for further evaluation. If recommended by IBSC the applicant may submit an application to RCGM for bio safety assessment of the event along with requisite data requirements .RCGM is the regulatory authority for Bio safety Research Level I (trials BRL I) trials. These trials are limited to no more than one acre per trial site location in 2-3 locations. GEAC is the regulatory authority for Biosafety Research Level II. (BRL II) trials. Size and number of trials will depend on case by case. Minimum of three seasons/ years BRL trials are required for generating biosafety data for an event.

1. APPROVED FOR COMMERCIAL CULTIVATION : *Bt* COTTON

2. MORATORIUM IMPOSED ON 9.2.2010 : *Bt* BRINJAL Event EE-1

3. UNDER VARIOUS STAGES OF FIELD CROPS : BRINJAL, CHICK PEA, GROUNDNUT, MAIZE, MUSTARD, OKRA, PIGEONPEA, POTATO, RICE, SORGHUM, TOMATO, COTTON, RUBBER, CASTOR etc

Conclusion

Genetically modified product has spread throughout the world by multinational companies where profit is the ultimate motive. The GMOs are introduced in the veil of higher productivity, resistance to pests, farmers benefit, eradication of hanger etc. However a big question emerged whether genetically modified products has relevance in developing coun-

try like India? The hunger has grown in India in absolute terms some 320 million people go to bed hungry every night. Two years back, India had a record food grain surplus of 65 million tones. If 65 million tones surplus could not feed the 320 million hungry, how will GM food remove hunger? GM food diverts precious financial resources to an irrelevant research, comes with stronger intellectual property rights, and is aimed at strengthening corporate control over agriculture.

There are 12 million people in India who suffer from Vitamin A deficiency. These people primarily live in food deficit areas or are marginalised. These are people who cannot buy their normal requirement of food, including rice. If they were adequately fed, there would be no malnutrition. If the poor in Kalahandi, for instance, can't buy rice that lies rotting in front of their eyes, how will they buy golden rice? India is under tremendous pressure from the biotechnology industry to allow GM crops. These companies have the financial resources to mobilise scientific opinion as well as political support.

A positive note is that Government of India is expected to remain self-sufficient in production of food staples until at least 2025. The Central Government is attempting to rectify the problem of malnutrition with its National Food Security Bill - 2013, which was introduced to provide for food and nutritional security in human life cycle approach, by ensuring access to adequate quantity of quality food at affordable prices to the people to live a life with dignity and for matters connected therewith or incidental thereto. Rather than correcting supply chain issues, which increases the availability of food at reduced costs, the government has chosen to subsidize grain purchases. In addition, the government is doing this at a time when it can ill afford the expense associated with underwritten grain purchases for almost two thirds of the country's population.

GMOs are good or bad? Perhaps there is scope for a scientific debate on the issue but the real question is the way the GMOs are introduced and marketed in various parts of the world. May be the time has probably not come to conclude and the jury is still out about the usefulness or otherwise of the GMOs products in this country.

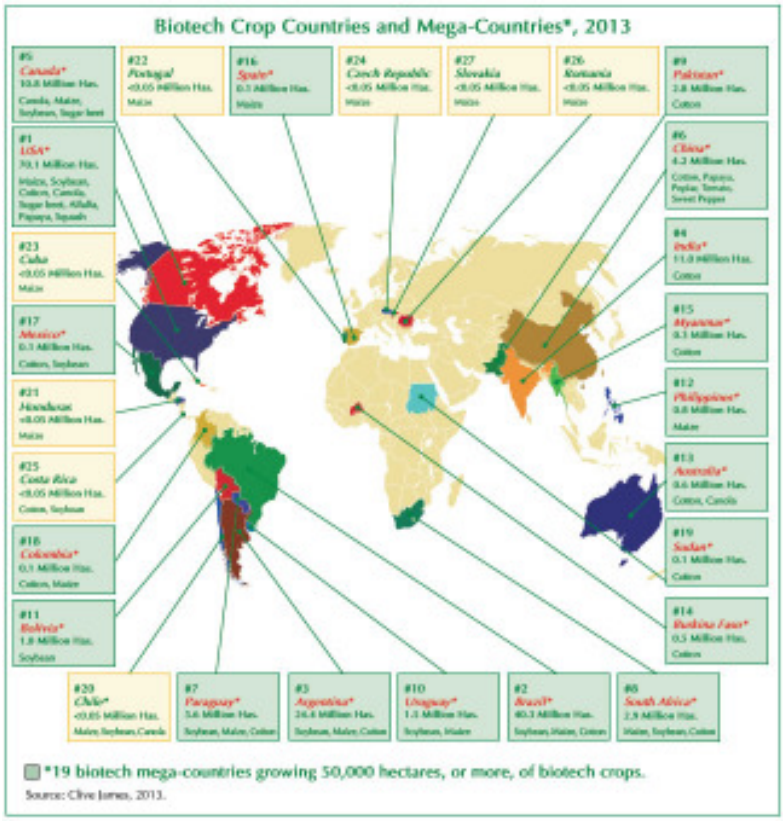

Figure 1. Global Map of Biotech Crop Countries and Mega-Countries in 2013

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