# GMO CONTROVERSY AND THE FUTURE OF TRANSGENIC PLANTS IN DEVELOPING COUNTRIES

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**Abstract**
In the past crop yields were significantly improved through conventional plant breeding and through the practice of Green Revolution. More recently population growth is fast outpacing food production, hence the need for new approaches. Genetic engineering (GE) may likely play a key role in the effort to feed the world's growing population with fewer inputs and on less available land. GE is a powerful technique that offers numerous and compelling farmer-and consumer-oriented benefits, but it is not without controversies. Attaining the goal of food security for all, hinges on the contributions of the new technology and the other conventional methods of agricultural production.

## Introduction

The history of man has been that of adventure, innovation and advancement. The early quest for food and survival by man culminated into hunting and gathering to crop cultivation. The emergence of Green Revolution about 49 years ago with its "revolutionary increase " in food production so far helped to keep the rate of increase in food production above the population growth rate. The Green revolution was, however, as a result of public good research, supported by public funds while the emerging gene revolution by contrast, is spearheaded by proprietary science and can come under monopolistic control. To a reasonable extent, Africa's food crisis is as a result of long-time neglect of agriculture by political leaders. Even though agriculture provides the livelihood of about 85% of the people in most African countries, agricultural and rural development has been given low priority. Investments in education and agricultural research and in distribution and marketing are woefully inadequate. In addition, many of the African environments have deeply-weathered soils that lose fertility rapidly under repeated cultivation. With more continuous cropping on the rise, organic material and nitrogen have been depleted while phosphorous and other nutrient reserves are being depleted slowly but steadily (Borlaug and Dowsdell, 2005). Other factors that contributed to Africa's food crisis include, extreme poverty, uncertain rainfall, increasing population and pressures, lack of roads, shortages of trained agriculturists and weak research and technology delivery systems all accounting for more difficulties in agricultural development.

The biotech revolution is a major change in how we approach agriculture and how we approach agricultural science. The change is incremental to the scientists who are engaged in it, but for those who are on the outside, it is a colossal set of advances, and a total change in how we are approaching science. As the Green Revolution miracle fades out as an ecological disaster, the biotechnology revolution is being heralded as an ecological miracle for agriculture. It is being offered as a chemical-free, hazard-free solution to the ecological problems being created by chemically intensive farming and biotechnology has benefitted from its falling under the 'biological" category which has connotations of being ecologically safe (Shiva, 2001).

## The population challenge

For about 2015 years ago the English economist Thomas Malthus predicted that it would be impossible to maintain a rapidly multiplying human population on a finite resource base. His argument was based on three factors as follows: that the survival of the human race depends on food; that birth rate will continue to increase due to "passion" between the sexes and that the strength of population is greater than that of the earth to produce subsistence. Though his critics were of opinion that technologies will continue to save us from this Malthusian fate but going by the current trend in population growth in most countries especially in the developing nations, Malthus prediction may be right, as population growth is now outstripping food production in the world especially in the developing countries. Table 1 is a projected population explosion in some selected developing nations. Presently, over 1 billion people – about 15% of the world population live in abject poverty and most of the poor live and work on farms. The probable reasons are that these resource poor farmers do not have access to loans, and their nutrient depleted farms are just a couple of acres in size, and as such could not fend for the immediate family. Even given the great strides that can take place in food production from the use of new crops, genetic engineering, more fertilizer, and more water, there is a limit to the production of food on Earth. If populations continue to grow at present rates, the production of food must double or triple by the first decade of the next century for all people to be adequately fed.

There are obstacles to this increase; only some lands can be used for agriculture, second, for many crops we appear to have reached the limit of production gains realized for fertilizer applied. In the future, increases in yield per unit area must come from the development of new, higher production crops or new superstrains of existing ones. Such increases can cause additional environmental problems. Another limitation is that climate change is more likely to decrease yield than to increase it. Thus, most climatic changes are likely to make things worse. If global warming takes place as forecast by models of global climate, there will be major disruptions to agriculture (Smith and Tirpak, 1989). Figure 1 depicts a typical food price index graph. As gains of Green revolution forces food prices to go down, the current upsurge in population explosion is already pushing the prices of commodities up. It is therefore hoped that the compelling gains of gene revolution in combination with conventional breeding will reverse the trend. The desire to improve the quality of life in rural areas underscores the need to invest in both agricultural biotechnology and other methods of traditional farming. Such will also help to slow down urban sprawl due to migration and its attendant environmental problems. However, beyond the associated benefits of the new science there is also a need to address the larger confusing issues that borders on safety and environment. Arguably, biotechnology can complement agriculture in so many ways through reduced use of agro-chemicals, reduced insect pests and virus diseases and postharvest deterioration through the development of genetically reprogrammed plants. Another aspect is the presence of hazardous substances in foods such as cyanide in cassava, aflatoxins in groundnut, which has caused much human misery. Agricultural biotechnology has the potential to ameliorate these undesirable traits and thus improve the quality of these food crops. Malnutrition that is unleashing pathetic health problems in the lives of many children and pregnant mothers in some countries in the developing nations could be reversed by the combined efforts of vitamin A enriched rice, and through biotech developed health improvement pills.

**Expectations from Biotechnology**

The emergence of biotechnology in the past several years was based upon recombinant DNA techniques which have developed new scientific methodologies and products in food and agriculture. This scientific journey to the molecular level is the continuation of our progressive understanding of the workings of nature (Borlaug and Dowsdell, 2005). Crop productivity depends both on the yield potential of crop varieties and the crop management employed to enhance input and output efficiency. Continued genetic improvement of food crops by using both conventional as well as biotechnology research tools is needed to shift the yield output higher and to increase stability of yield. While biotechnology research tools offer much promise, it is also important to recognize that conventional plant breeding methods are continuing to make significant contributions to improve food production and enhanced nutrition. Moreover, engineered genes, such as *Bacillus thuringiensis* (Bt), are only of value when incorporated in the very best commercial varieties and hybrids. So far, the resulting gene alterations have conferred producer-oriented benefits, such as resistance to pests, diseases and herbicides. Other benefits include crop varieties with greater tolerance to drought, water logging, heat and cold. In addition, are many consumer-oriented benefits, such as improved nutrition and taste, and other health-related benefits (eg. pharmaceutical crops) (Ubalua, 2009). Despite the compelling benefits of this modern biotech, its adoption has witnessed a formidable opposition but still the commercial adoption by farmers of the new varieties has been one of the most rapid cases of technology diffusion in the history of agriculture. For example, between 1996 and 2003, the total area of commercially planted transgenic crops has increased from 1.7 to 67.8 million ha (James, 2004) with USA and Argentina accounting for 63% and 20% respectively. In the near future, the already established techniques of recombinant DNA will also enable us to transfer the genes for gliadin and glutenin in wheat to the other cereals. These two proteins (gliadin and glutenin) are responsible for the superior dough in making leavened bread and other bakery products. Another aspect is the ability of the new science to fasten the transfer of the genes for high lysine, high-tryptophan in maize varieties into other cereals. This is necessary because using conventional breeding; the development took about two decades of painstaking research work. The breakthrough with the "Golden rice" research will pave the way for a high vitamin A, iron and other micronutrients in rice which can significantly reduce the incidences of blindness and anemia especially in children.

**Environmental benefits**

Modern biotechnology is a revolutionary science that is characterized with various agric-oriented benefits as outlined below;

- Decrease in conversion of forests and natural habitats into farmland as a result of high yield.
- Development of herbicide resistance crops which allows farmers to practice conservation-tillage farming leading to reduced soil erosion and improved water quality.
- The use of biotech derived plants with built-in resistance to insects and diseases translates to less pesticides, insecticides and herbicide use, thus reducing farmer's exposure, a common problem in developing countries where protective masks may not always be available.
- Development of nitrogen ($N_2$) fixing crops through biotechnology could reduce the use of $N_2$ fertilizers as most crops with the exception of legumes, do not naturally produce $N_2$, but requires the application of $N_2$ fertilizers for growth. A breakthrough will drastically reduce the estimated 10 million tons of $N_2$ fertilizer needed each year for rice production worldwide which is expected to double in years to come. Generally, farmers in developing countries like ours stand to enjoy more flexibility in operations, less hard manual labour, efficient pest control built

into crops which means farmers are exposed to less risk and more willing to invest in their farm operations, and they can control weeds at any time. Finally, it makes farming more attractive to the younger generation.

**Concerns**

Genetic modification concerns the transfer of genetic information (DNA sequences) across sexual barriers between species. The resulting organisms are called genetically modified organisms (GMOs) or transgenics. The new science does not only base on new scientific knowledge, rather it also depends largely on the availability of capital and skilled human resources. This makes biotechnology a specialized affair and takes it into the realms of private research funded by multinational organizations. It is this trend and the perceived risks that have aroused the present concern. Genetic engineering is to some extent another step in our continuous process of agricultural development; though in some circles it is seen to be radically different from previous technologies because it allows for the moving of genes between different species across natural boundaries, which makes the risks unpredictable. For example, the insertion of the *Bacillus thuringiensis* (Bt) gene was thought to be a permanent solution to insect problem. Arguably, the model of "one-pest-one solution" does not work forever, as is the case with pesticides, sooner or later resistance builds up. Similarly, building of herbicide resistance in plants is headed for criticisms as it unleashes basic ecological reactions. Excessive use of herbicides as a major or only tool of weed management will eventually reduce the sensitivity of weeds to herbicides and create an even worse weed problem. It is "to a large extent a victim of its own success". A classical example is the case of unexpected impact of gene transfer from a bacterium *Xanthomonas* in USA and its consequences. The gene was transferred to a soil bacterium *Klebsiella planticolla* to ferment stubble into alcohol. Surprisingly, soil test conducted by the authorities revealed that the wheat planted in the soil containing the bioengineered organism was killed by the new organism (LEISA, 2001). Further concern is the reported case of these transgenes through crossing with other plants, igniting fears and anxiety concerning their survival in the wild. This has been observed in Mexico where wild relatives of maize have been contaminated with genes from GM crops (Rosset, 2001).

There are many plants in nature, which provides us with clues for better pest management based on the diversity found in nature itself. One such natural crop protection approach is based on the use of plants with biological control properties. In this respect, Gomero, 1994 argues that herbicide tolerant crops may make little sense to peasant farmers who plant diverse mixtures of crop and fodder species. At the same time, the use of Bt crops affects non-target organisms and ecological processes. Recent evidence shows that the Bt toxin can affect beneficial insect predators that feed on insect pests present on Bt crops, and that windblown pollen from Bt crops found on natural vegetation surrounding transgenic fields can kill non-target insects. As Africa's agriculture is dominated by small peasant farmers who rely for insect pest control on the rich complex of predators and parasites associated with their mixed cropping systems. The possible scale-up of the impact of transgenics in the developing countries is considerable as they constitute centers of genetic diversity. Genetic exchange between crops and their wild relatives is common in traditional agro-ecosystems and transgenic crops are bound to frequently encounter sexually compatible plant relatives, therefore the potential for "genetic pollution" in such settings is inevitable.

Agricultural production in the tropics is dominated by small peasant farmers and small scale systems. Unfortunately, genetically modified (GM) seed companies do not consider small-scale agriculture as an important market. One thing that makes the development of genetic engineering (GE) unique in the history of agriculture is that it is almost fully controlled by private companies. Through patents these companies keep competitors at bay. It therefore appears that GE technologies are not being developed because of their problem-solving capacity, but because of the patent and thus the profit it can bring to the companies. For example in the 1980's Monsanto company based in St. Louis, Missouri, USA had to jettison their research on genetically engineering virus resistance into plants, as it would bring minimal returns. Terminator gene technology even takes the issue further. This technology, in which genes are manipulated to be able to switch seeds on and off by treatment with chemicals provided by the same Monsanto Company, effectively prevents farmers from keeping their seeds for replanting. This line of research has been dropped by the company following strong public protests. However, a new technology has been developed in which the offsprings of modified seeds would revert to normal seeds, but not sterile thereby affording the farmer the option of planting the seed or activating the improved traits by applying the chemical (Pinstrup-Andersen and Cohen, 2011).

**Conclusions**

Modern biotechnology *per se* is a mixed bag of options. The gains and prospects of this technology are numerous and compelling. They range from life saving pharmaceutical products to improved crop varieties, improved shelf life, modern methods of production, improved yield, reduced use of chemicals for plant disease and pest control, less environmental degradation, as well as the development of novel food products, such as foods with improved nutritional quality. Despite all these advantages, public acceptance and adoption of this technology is still shrouded in controversies (Ubalua, 2009). Moreover farmers and consumers in developing countries will certainly be much better off if research efforts and resources are channeled to ecological concerns and food safety but the real threat of GMO's might be the socio-economic dependence it creates for its users. However, reaching the goal of food security for all should be based on the contributions of the new science and the other traditional methods of agricultural production.

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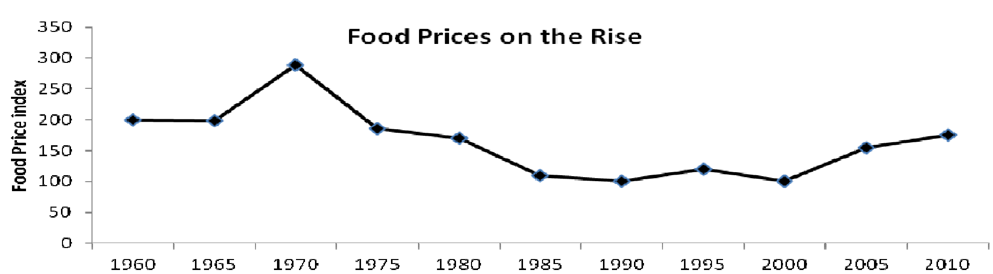
**Table: 1 Nine countries with high population growth rates**

| Country | 2011 Population (in thousands) | 2050 Projection (in thousands) | Percent change |
|---|---|---|---|
| Afghanistan | 32,000 | 77,000 | 136% |
| Democratic Republic of the Congo | 68,000 | 149,000 | 120% |
| Ethiopia | 85,000 | 147,000 | 73% |
| India | 1,250,000 | 1,736,000 | 39% |
| Niger | 16,000 | 56,000 | 246% |
| Nigeria | 163,000 | 392,000 | 14% |
| Pakistan | 178,000 | 279,000 | 57% |
| Uganda | 35,000 | 95,000 | 173% |
| Yemen | 25,000 | 62,000 | 149% |

**Source: United Nations, Department of Economic and Social Affairs, Population Division (2011).**




**The Food Price Index weighs export prices of a variety of food commodities around the world in constant U.S. dollar prices, 2000=100**
**Source: World Bank Global Economic Monitor (GEM) commodities.**