GENETICALLY MODIFIED ORGANISMS (GMOs): FOOD SECURITY OR THREAT TO FOOD SAFETY

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ABSTRACT: Biotechnology is a vital issue that impacts all of us. Development of genetically modified organisms is one of the highest achievements of this technology. It is being released throughout our environment and deployed with superficial or no risk assessments about its matchless powers to harm life. Within the next few years, many types of transgenic commodities will be ready for commercialization, including varieties with higher yields, greater tolerance of biotic and abiotic stresses, resistance to herbicides, improved nutritional quality, and novel pharmaceutical proteins. Transgenes present therein are expected to disperse to nearby weedy and wild relatives through pollen-mediated gene flow. Information is scarce about health hazards, such as toxicity in GM crops. Therefore urgently need publicly available ecological assessments of the risks and benefits of transgenic crops before new varieties are released.

Key words: GM Crops, food safety, pollen mediated ecological pollution.

INTRODUCTION

As described by Holst-Jensen (2001) genetically modified organism (GMO) is a living organism (bacteria, plant, animal) whose genetic composition has been altered by means of gene technology. The genetic modification usually involves insertion of a piece of DNA and/or synthetic combination of several smaller pieces of DNA, into the genome of the organism to be modified. This process is called transformation. These DNA pieces are usually taken from other organisms such as bacteria or virus. (Pawlowski and Somers, 1996; Johnston and Tang, 1994; Tripathi, 2005; Viljoen *et al*., 2006).

World population is increasing day by day which is a threat to food security. According to the United Nations Food and Agriculture Organization (FAO) widely accepted definition of *"Food security" is that food is available at all times; that all persons have means of access to it; that it is nutritionally adequate in terms of quantity, quality and variety; and that it is acceptable within the given culture. Only when all these conditions are in place can a population be considered "food secure"* (Mustafa *et al*., 1999; WHO, 1991). To maintain an adequate supply of food for the tremendous annual increase in population between now and 2020 and beyond is a formidable challenge to the scientific community (Bao-Rong and Allison, 2005). To achieve the goal of providing food to everyone world scientists are working to develop new technologies which create some food safety issues (Brown and Funk, 2008). In spite of the advances in food grain production, over 800 million people, mostly from the developing countries go to bed hungry everyday, while chronic hunger takes the lives of 2400 people everyday (Khush, 2005). Over 13 million children under the age of five die because of hunger and malnutrition, whereas, one out of five babies is born underweight (Borlaug, 2000). Conventional processes of crop breeding are insufficient to meet the demands of growing global population, especially in developing countries. The combination of genetic engineering with improved plant breeding offers a solution to the demand for food security (Khush, 2005).

These days, genetically engineered crops appear as the most recent technological advances to help boost food production, mainly by addressing the production constraints with minimum costs and environmental pollution. Transgenic crops offer significant production advantages such as decreased and easier herbicide and/or pesticide use (Baker and Preston, 2003). This has a double advantage; first, it reduces the cost of production and second, it escapes environmental pollution due to the indiscriminate use of pesticides and herbicides. Moreover, production of transgenic plants using transformation technology can overcome the limitations of species incompatibility and the desirable genes can be incorporated into elite plants with very little disturbance of the original genetic constitution (Liang and Gao, 2001). According to Uzogara (2000) and Sharma *et al.* (2002) genetic engineering has the potential to produce improved varieties in terms of quality and yield traits, more quickly than traditional breeding.

The first report of genetic transformation representing the first success of genetic engineering was published in 1983 which enabled the further development of GM varieties. The first commercial GM crop is reported to be tomato developed by Calgene® under the trade name of Flavr Savr™ were approved for sale in the United States in 1994 (Greiner *et al.,* 2005: Martineau and Belinda, 2001). According to Brookes and Barfoot (2005), the year 1996 was the first year in which a significant area (1.66 million ha) was planted with crops containing GM traits. The global area of GM crops increased 67-fold, from 1.7 million ha in 1996 to 114.3 million ha in 2007, with an increasing proportion grown by developing countries. GM crops were grown in 23 countries (12 developing and 11 industrial) and their ranked order of area coverage against the crops they are growing are presented in Table-1.The world's leading producers of GM crops are the United States, Argentina, Brazil, Canada, India and China (James, 2007; GMO compass, 2007). Almost all of the global GM crop area derives from soybean, maize, cotton and canola (Brookes and Barfoot, 2005). But, the two most cultivated GM crops are maize and soybean, which represent the staple constituents of many foods (Gachet *et al.,* 1999: Abdullah *et al.,* 2006). Other GM crops for field trials include: tomato, potato, wheat, sugar beet, rape, cucumber, melon, alfalfa, lettuce, sunflower, rice and tobacco (Adugna and Mesfin, 2008).

Yet in most other countries, the same approach is subject to debate and partially banned, restricted or requires labeling with stiff legal penalties for non-compliance. This refers to laws in Great Britain, France, Germany, Italy, Spain, and Greece or in virtually all European nations. The same trend has further spread to Latin America, the near East and Asia (Nathan, 2009).

Biosafety issues of GM food is most hot topic of world because if on one side it has benefits then on other side provokes concern about health and environmental risks. Over two hundred scientists have signed a statement outlining the dangers of GM foods and the Union of Concerned Scientists (a 1000 plus member organization with many Nobel Laureates) has expressed similar reservations. The prestigious medical journal, Lancet, issued a warning that GM foods should never have been allowed into the food chain. Britain's Medical Association with 100,000 physicians and Germany's with 325,000 issued similar statements (British Medical Association, 1999).

The National Academy of Science released a report that GM products introduce new allergens, toxins, disruptive chemicals, soil-polluting ingredients, mutated species and unknown protein combinations into our bodies and into the whole environment. This may also raise existing allergens to new heights as well as reduce nutritional content. Even within the FDA, prominent scientists have repeatedly expressed profound fears and reservations. Their voices were muted not for cogent scientific reasons but due to political pressures from the Bush administration to buttress the nascent biotech industry (Nathan, 2009).

Debates over the transformation technology have been, and still are, in many parts of the world very controversial and address ethical, human and animal health related concerns, food safety and the possible impact on the environment. To reap the many potential benefits from transgenic crops providing food security these crops must be safe to humans and the environment ensuring food safety (Jaffe, 2004).

Some of the major health and environmental hazards, genetic uncertainties, impact on farming, control and dependency, economic, political and social threats created by GM food/crops are as listed below.

HEALTH HAZARDS

Recorded Deaths: In 1989, dozens of Americans died and several thousands were afflicted and impaired by a genetically altered version of the food supplement – L-tryptophan. A settlement of $2 billion dollars was paid by Showa Denko, Japan's third largest chemical company (EmslieSmith *et al.,* 1994).

Near-deaths from Allergic Reactions: In 1996, Brazil nut genes were inserted into soybeans by a company called Pioneer Hi-Bred. Some individuals, however, are so allergic to this nut; that they go into anaphylactic shock (similar to a severe bee sting reaction) which can cause death. Animal tests confirmed the peril and fortunately the product was removed from the market before any fatalities occurred. (Jeffery, 2007)

Direct Cancer and Degenerative Disease Links: In 1994, FDA approved Monsanto's rBGH (recombinant bovine growth hormone), a genetically produced growth hormone, for injection into dairy cows – even though scientists warned the resulting increase of IGF-1 (Insulin-like Growth Factor-1), a potent chemical hormone, is linked to 400-500% higher risks of human breast, prostrate, and colon cancer. The contention was that the hormone may be killed by pasteurization. But in research conducted by two Monsanto scientists, Ted Elasser and Brian McBride, only 19% of the hormone was destroyed despite boiling milk for 30 minutes when normal pasteurization is 30 seconds. Canada, the European Union, Australia and New Zealand have banned rBGH. The UN's Codex Alimentarius, an international health standards setting body, refused to certify rBGH as safe. (Spiroux *et al.,*2009, Codex Alimentarius, 2004)

Antibiotic Threat via Milk: Cows injected with rBGH have a much higher level of udder infections and require more antibiotics. This leaves unacceptable levels of antibiotic residues in the milk. Scientists have warned of public health hazards due to growing antibiotic resistance. (Mazza *et al.,*2005).

Antibiotic Threat via Plants: Much of genetic implantation uses a marker to track where the gene goes into the cell. GM maize plants use an ampicillin resistant gene. In 1998, the British Royal Society called for the banning of this marker as it threatens a vital antibiotic's use. The resistant qualities of GM bacteria in food can be transferred to other bacteria in the environment and throughout the human body. (Benbrook,2004).

Birth Defects and Shorter Life Spans: As we ingest transgenic human/ animal products there is no real telling of the impact on human evolution. It is reported rBGh in cows causes a rapid increase in birth defects and shorter life spans. (Mead *et al.,*1999).

Lowered Nutrition: A study in the Journal of Medicinal Food conducted by Lappe and Bailey (1998) showed that certain GM foods have lower levels of vital nutrients – especially phytoestrogen compounds thought to protect the body from heart disease and cancer. Other studies show that if GM foods are fed to animals, GM material can appear in the resulting products (Sharma, 2006; Agodi*,* 2006; Ran *et al.*, 2009) and affect the animals' health (Tudisco *et al.,* 2010; Heinemann, 2009).

Radical Change in Diet: Humanity has evolved for thousands of years by adapting gradually to its natural environment - including nature's foods. Within past few years a fundamental transformation of the human diet has occurred. In short, the human diet, from almost every front, is being radically changed - with little or no knowledge of the long-term health or environmental effects.(Jeffery, 2007).

Poisonous to Mammals: In a study with GM potatoes, spliced with DNA from the snowdrop plant and a viral promoter (CaMV), the resulting plant was poisonous to mammals (rats) – damaging vital organs, the stomach lining and immune system (Kuiper *et al.,* 2001). CaMV is a pararetrovirus. It can reactivate dormant viruses or create new viruses - as some presume have occurred with the AIDES epidemic. CaMV is promiscuous, therefore biologist Ho (1998) concluded that "all transgenic crops containing CaMV 35S or similar promoters which are recombinogenic should be immediately withdrawn from commercial production or open field trials. All products derived from such crops containing transgenic DNA should also be immediately withdrawn from sale and from use for human consumption or animal feed."

ENVIRONMENTAL HAZARDS

Toxicity to Soil: The industry's marketing pitch to the public is that bioengineered seeds and plants will help the environment by reducing toxic herbicide/pesticide use (Benbrook, 2009). Isolated examples are given, but the overall reality is exactly opposite. According to an article by Goldburg (1992) scientists predict that herbicide use will triple as a result of GM products.

Soil sterility and Pollution: In Oregon, scientists found GM bacterium (*klebsiella planticola*) meant to break down wood chips, corn stalks and lumber wastes to produce ethanol - with the post-process waste to be used as compost - rendered the soil sterile. It killed essential soil nutrients, robbing the soil of nitrogen and killed nitrogen capturing fungi. Professor Guenther Stotzky of New York University conducted research showing the toxins that were lethal to Monarch butterfly (a beneficial insect) are also released by the roots to produce soil pollution (Nathan, 2009). The pollution was found to last up to 8 months in soil with depressed microbial activity (Conner *et al.,* 2003).

Extinction of Seed Varieties: A few years ago *Time* magazine referred to the massive trend by large corporations to buy up small seed companies, destroying any competing stock, and replacing it with their patented or controlled brands as *"the Death of Birth*." Monsanto additionally has had farmers sign contracts not to save their seeds - forfeiting what has long been a farmer's birthright to remain guardians of the blueprints of successive life.(Taylor and Tick, 2003)

Superweeds: It has been shown that genetically modified Bt endotoxin remains in the soil at least 18 months (Lappe and Bailey, 1998) and can be transported to wild plants creating superweeds - resistant to butterfly, moth, and beetle pests – potentially disturbing the balance of nature. Another study showed 20 times more genetic leakage with GM plants – or a dramatic increase in the flow of genes to outside species.

Destruction of Forest Life: Monsanto has developed plans with the New Zealand Forest Research Agency to create still more lethal tree plantations. These super deadly trees are non-flowering, herbicide-resistant and with leave exuding toxic chemicals to kill caterpillars and other surrounding insects – destroying the ecology of forest life. This kind of development has been called "death-engineering" rather than "life-" or "bio-engineering." More ominously pollen from such trees, because of their height, has traveled as much as 400 miles or 600 kilometers - roughly 1/5 of the distance across the United States.(Losey *et al.,*1999)

Superpests: Lab tests indicate that common plant pests such as cotton boll worms will evolve into Superpests immune from the BT sprays used by organic farmers (Bates *et al.,* 2005). The recent epidemic in North Carolina and Georgia seems linked to bioengineered plants that the bugs love. Now seed companies like Monsanto, on their Farm source website, is recommending spraying stink bug affected areas with **methyl parathion**, one of the deadliest chemicals.(Pollack, 2003)

Genetic Uncertainties

Genetic Pollution: Carrying GM pollen by wind, rain, birds, bees, insects, fungus, bacteria – the entire chain of life becomes involved. Once released, unlike chemical pollution, there is no cleanup or recall possible. Pollen from a single GM tree has been shown to travel 1/5th of the length of the United States. Thus there is no check for such genetic pollution. Experiments in Germany have shown that engineered oilseed rape can have its pollen move over 200 meters. As a result German farmers have sued to stop field trials in Berlin. A recent study in England showed that despite the tiny amount of GM plantings there (33,750 acres over two years compared to 70-80 million acres per year in the US) wild honey was found to be contaminated. This means that bees are likely to pollinate organic plants and trees with transgenic elements. Many other insects transport the by-products of GM plants throughout our environment. (Nathan, 2009).

Disturbance of Nature's Boundaries: Genetic engineers argue that their creations are no different than crossbreeding. However, natural boundaries are violated – crossing animals with plants, strawberries with fish, grains, nuts, seeds, and legumes with bacteria, viruses, and fungi; or like human genes with swine. (Nathan, 2009)

Impact on farming

General Economic Harm to Small Family Farms: GM seeds sell at a premium, unless purchased in large quantities, which creates a financial burden for small farmers. Many GM products, such as rBGH, seem to offer a boom for dairy farmers - helping their cows produce considerably more milk. But the end result has been a lowering of prices, again putting the smaller farmers out of business (Bucchini and Goldman, 2002).

Losing Purity: At the present rate of proliferation of GM foods, within 50-100 years, the majority of organic foods may no longer be organic.(Nathan, 2009).

Control and Dependency

Terminator Technology: Plants are being genetically produced with no annual replenishing of perennial seeds so farmers will become wholly dependent on the seed provider. .(Nathan, 2009)

Less Diversity, Quality, Quantity and Profit: One of the most misleading hopes raised by GM technology firms is that they will solve the world's hunger. Some high technology agriculture does offer higher single crop yields. But organic farming techniques, with many different seeds inter-planted between rows, generally offer higher per acre yields. This applies best to the family farm, which feeds the majority of the Third World. It differs from the large-scale, monocrop commercial production of industrialized nations. Even for commercial fields, results are questionable. .(David, 2001).

Economic, Political and Social Threats

Monopolization of Food Production: The rapid and radical change in the human diet was made possible by quick mergers and acquisitions that moved to control segments of the US farming industry. Although there are approximately 1500 seed companies worldwide, about two dozen control more than 50% of the commercial seed heritage of our planet. (Nathan, 2009).

Impact on Long -Term Food Supply: If food production is monopolized, the future of that supply becomes dependent on the decisions of a few companies and the viability of their seed stocks. (David, 2001).

Biocolonization: In past centuries, countries managed to overrun others by means of fierce or technologically superior armies. The combined control of genetic and agricultural resources holds a yet more powerful weapon for the invasion of cultures. For only when a person loses food self-sufficiency do they become wholly dependent and subservient? (Taylor and Tick, 2003).

Table-1 Global area of biotech crops in 2007

Country	Area	Biotech crops
USA	57.7	Soybean, maize, cotton,canola, squash, papaya, alfalfa
Brazil	15.0	Soybean, cotton
Argentina	19.1	Soybean, maize, cotton
Canada	7.0	Canola, maize, soybean
India	6.2	Cotton
China	3.8	Cotton, tomato, poplar, petunia, papaya, sweet pepper
Paraguay	2.6	Soybean
South Africa	1.8	Maize, soybean, cotton
Uruguay	0.5	Soybean, maize
Philippines	0.3	Maize
Australia	0.1	Cotton
Spain	0.1	Maize
Mexico	0.1	Cotton, soybean
Colombia	<0.1	Cotton, carnation
France	<0.1	Maize
Honduras	<0.1	Maize
Czech Republic	<0.1	Maize
Portugal	<0.1	Maize
Germany	<0.1	Maize
Slovakia	<0.1	Maize
Romania	<0.1	Maize
Poland	<0.1	Maize

Source: James (2007)[12]

Dependency: Under the new regulations of WTO, the World Bank, GATT (General Agreement on Tariffs and Trade) NAFTA (North American Free Trade Agreement), the autonomy of local economies can be vastly overridden. Foreign concerns can buy up all the major seed, water, land and other primary agricultural resources – converting them to exported cash rather than local survival crops. This is likely to further unravel the self-sufficiency of those cultures - and as with the past failures of the "green revolution." (Nathan, 2009).

Conclusion: The reason that GMOs have recently attracted the attention of agricultural, medical and food scientists and governments of many countries in the world is due to an increasing concern that the recombinant gene(s) inserted into an organism may result in unforeseen effects. Alongwith the potential benefits GMO's may have some hazards too. Therefore the first and most important reason for regulating GMOs use is to ensure human safety and the second reason is to protect the environment. Whether regulation is established to 'protect' or 'safeguard' human health or the environment, the government's goal is to minimize or eliminate any real or potential hazards. The economic results so far suggest that farmers in developing countries can benefit from transgenic crops, but a certain level of national research and regulatory capacity are prerequisites, along with effective IPR management and input supply systems, especially for seeds Therefore, to reap from the benefits of the new technology with maximum care to the environment, there should be strong detection and quantification tools in place. It is therefore dire need of the hour to create awareness about benefit/hazard analysis of GMOs at all levels. The following strategies would help enable developing countries to satisfy production, consumption, international trade, and risk-management objectives simultaneously and also comply with their international obligations.

A comprehensive but practical biosafety regulatory process for GM crop production and imported GM food for consumption based on international standards must be adopted.

In cases of commodities with proven risk of potential export loss, adoption of strategies that help segregate GM and non-GM food for sensitive exportable markets is recommended.

Adopting these proposed policies would mitigate the observed negative effects of trade-related regulations, allowing developing countries to fully benefit from the use of safe transgenic crops and their products.

Establishment of R&D/analytical facilities to identify transgenes in food items and to develop simple rugged and robust method for detection of GMOs through molecular biology techniques.

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