Agricultural Biotechnology: Implications on the Food Supply Chain and Food Safety

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Abstract

This paper analyses the goals and focuses of agricultural biotechnology as well as the attitudes toward food safety in the North (advanced countries) and the South (developing countries) amid the rapid adoption and commercialization of biotech foods worldwide. In advanced countries like the US, EU nations and Japan, the agricultural biotechnology industry is well-organized with advanced and cutting edge technology and they have strong national agricultural research systems and well-placed regulatory frameworks. Here too the consumers are very knowledgeable, sophisticated and demanding so there is pressure for all supply chain agents to provide them with safe food. In developing countries of Asia for example, on the other hand, the agricultural biotech industry is still in the infant stage where much of the R&D are done by public institutions to address more pressing needs such as poverty, malnutrition and food security. Price is still a determining factor in the purchase decisions of consumers and the food supply chain and the regulatory framework in developing countries are still weak. In harmony with the international and regional agreements on food safety, proactively, it is important for developing countries in Asia that are rapidly growing and preparing to commercialize biotech foods (e.g. GMOs), to have in place measures so that food safety is assured throughout the supply chain.

Keywords: Food supply chain, food safety, agricultural biotechnology

Introduction

Issues about food, especially products of biotechnology and food safety have received a lot of attention recently. They deal with the food we and our children eat hence there are a lot of emotions attached to the challenging, complex and wide-range issues about biotechnology and biotech foods (e.g. GMOs) based on health and environmental grounds. These are controversial issues across the world that keep the global community divided. With the globalization of the world economy and as more countries become more interdependent, international trade in biotech food is also expected to grow from now on.

The products of the "Gene revolution" have received much praise and criticisms worldwide as more countries are preparing to commercialize GMO food. The gene revolution has evolved from the Mendelian study to tissue culture to molecular genetics. Molecular genetics is the study and manipulation of DNA molecules that make up the genes that paved the way for the advent of modern biotechnology as it applies to medicine and agriculture (Persley, 2001) and which has gained much momentum since two decades ago. In agricultural biotechnology, gene(s) is introduced to products, plants, animals or microorganisms with novel traits (FAO, 2003). Modern science has allowed the development of agricultural biotechnology which is made up of various kinds of techniques and products and GMO is just one of them (FAO, 2003). Agricultural biotechnology can bring about a wide range of products that has input traits, output traits and medicinal traits as outlined in Table 1.

Given these, the purpose of this paper is first to study the global agricultural

Table 1. Opportunities of Agricultural Biotechnology

Input traits	
Plant engineering/breeding	Crop transformation Trait expression/protection technologies Selective breeding technologies. e.g., genomic mapping/tracking Fertility control and apomixis
Pest control	Disease resistance Insect resistance Nematode resistance Herbicide tolerance
Yield ennancement	Plant biomass Crop and pruduce yield/quantity, *e.g.*, grain, fruit, fiber Abiotic stress tolerance Plant nutrition and water use
Output traits	
Food, feed and nutrition	Micronutrients, *e.g.*, iron, vitamins Protein composition and quality, *e.g.*, amino acids yield/profiles Vegetable oils/waxes, *e.g.*, quality, stability Cabohydrates, *e.g.*, starch/gums yield and quality Phytochemicals, *e.g.*, isoflavones, antioxidants Food quality, improved shelf life, reduced allergenicity/macotoxins.
Food processing	Plants as expression/delivery systems for food enzymes, *e.g.*, lactase, lipase Enzymes for improved food processing and consistency, with reduced waste, *e.g.*, phytase, cellulase
Industrial processing	Bio-energy, *e.g.*, bio-ethanol Bio-catalysis Bio-fibers and bio-polymers Bio-sensors and bio-remendiation
Medicinal traits	
Nutraceuticals and pharmaceuticals	Natural products, nutraceuticals, medicinal phytochemicals Therapeuticallyt bioactive molecules modified *in planta. e.g.*, exploiting novelphytochemistry and/or processing Plants as expression/delivery systems for therapeutics, *e.g.*, edible vaccines, plantibodies

Source: David McElroy, Sustaining Agri-biotechnology Through Lean Times, Nature Biotechnology, Vol. 21, No. 9, 2003, p. 997.

biotechnology industry and the issues at stake that divide the global community. We will then evaluate the attitudes, goals and interests of countries in the North and South in regard to biotech crops. Then we will assess the food safety in the food supply chain. The food safety measures and instruments at the national and international context that are being implemented to pacify the anxieties of people with regard to the food they eat will be examined. Drawing lessons from the experiences and taking a proactive stance, I will present a framework of measures developing countries in Asia can implement before there is full blown adoption, commercialization and trade of biotech food and to assure everyone that the food they eat are safe. It is hoped that the results of this research could serve useful to policy makers not only in Asia but also in other developing countries in the world.

Debates about Agricultural Biotechnology

The adoption and commercialization of biotech crops have remained a much-debated issue worldwide. One camp states the potential risks to human health and the environment that modern biotechnology poses. They argue that consumers see no benefits but rather fear that they are faced with potential risks to their health on the following grounds: risk of food allergens when there is transfer of genes from common food that can cause allergies; toxicity, carcinogenicity; food intolerance; use of gene marking for antibiotic resistance, etc. (Persley, 2001, WTO, 2004). The fear that the genes transferred (e.g. antibiotic resistance gene) may be transferred to the body, which can be hazardous to the health as well as the risk on food safety of genes of GM crops transferred to traditional crops in the wild, is there. The potential risks to the environment likewise have been emphasized time and again. Not only does gene transfer pose health risk to humans but to the environment as well when genes from GMOs cross over to crops of the same species or to other species (e.g. weeds) referred to as gene escape. Genes can also mutate and cause harm and native varieties can be lost threatening biodiversity. Non-target species (e.g., birds and non harmful insects) can become susceptible to the gene product (WTO, 2004). There is also the potential risk of creating a new kind of selection process with the introduction of GMOs in the ecosystem (Persley, 2001).

In the North, there are sentiments against the role of the originators of GMOs, the giant seed/chemical MNCs who tend to monopolize the seed market for GMO crops that could make the farmers highly dependent on them (referred to as terminator technology) (WTO 2004) rather than use their own seed stocks. This is where the issue of intellectual property rights comes in for the seed and chemical MNCs like Monsanto, Dupont, DOW, BASF, Syngenta and Bayer that have to spend substantial time and capital to finance 85% of the global R&D worth $900M per year (Elroy, 2003). On top of this, regulatory approvals of agricultural biotechnology products cost $20-30 M in 2003, which only the large MNCs can afford to pay (Persley, 2001). Elroy (2003) mentioned that in agricultural biotechnology it takes 1-5 years for trait generation; 1-2 years for trait optimization; 1-2 years for proof of concept of model plant; 1-2 years for early event testing and development; 5-8 years for field trial breeding and regulatory approval and 2-3 years commercialization, in total, 11-22 years. Due to much consumer opposition in the adoption and commercialization of GM crops in Europe, Japan and other countries, there are fewer rewards for the companies' investments. Hence there is not much interest in channeling funds to agricultural biotechnology. It is for these reasons that MNCs seek protection of their intellectual property and patents for seeds, planting materials and tools of genetic engineering (Fresno, 2001). These big companies cater only to crops that can be grown in commercial scale such as corn, soybeans, canola and cotton to be able to get a return on their massive investments. But the strong anti-GMO movement in EU has negative impact on the industry leading to a reduction in investments in agricultural biotechnology. Thus consolidation and restructuring in the industry to conserve R&D expenses ensued.

While this is all happening in the West, countries in the East specially the developing countries saw the potentials of transgenic crops and have been increasing investments, notably, China, India and Brazil. Among Asian nations, China that embarked on agribiotechnology way back in the 1980s had the highest R&D expenditures in 2001, which amounted to U$115M, 63% of the total R&D budget for developing countries of U$180 as presented in Table 2 (Clive, 2004). China has approved 31 GM crops for commercialization, which include rice, wheat and corn. Public and private R&D investments in India have been substantial and in 2002 the government allowed the field trials of GM mustard, soybean and corn with R&D funded by contributions from the private (U$10M) and public (U$15M) sectors. Another camp argues that modern science has much to contribute to agriculture and food security. They point out that agricultural biotechnology can lead to improved productivity and is a substitute to the extensive use of agricultural chemicals which is harmful to human health and environment, and in the long term will result to sustainable agriculture. Output traits of crops can be changed that offer product differentiation such as improved durability (shelf life) and nutritional value (e.g. Vitamin A enriched rice) or soybean oil with low unsaturated fat (Elroy, 2001). Looking at the economics of agribiotechnology crops, the use of fewer pesticides translates to less cost to the farmer causing a ripple effect to the wholesaler, processor, retailer and the consumer.

Table 2. Global R&D on Crop Biotechnology, 2001*

Category	R&D Expenditures (M dollars)
Industrial	4,220
Private	3,100
Public	1,120
Developing Countries	180
China	115
India	25
Brazil	15
Others	25
Total	4,400

*Estimates

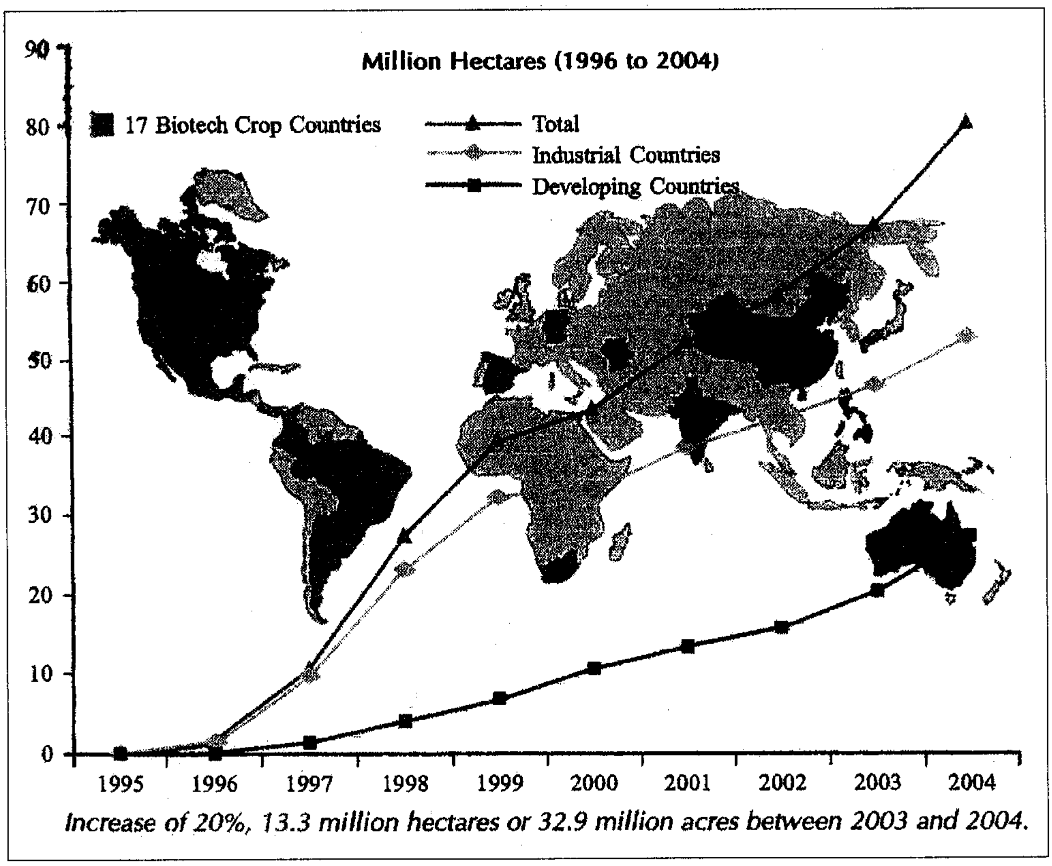
Source: Clive James, ISAAA, Global R&D Expenditures in Crop Biotechnology and Future GM Crop Market, 2004 (http://www.Isaaa.org)

Agricultural Biotechnology in Developing Countries

For the past decade, there has been a dramatic increase in the cultivation of approved biotech crops, mostly crops grown large scale, in terms of acreage from 1.7M has. in 1996 to 81M has. in 2004 with the share of the developing countries continuously on the rise as shown in Figure 1 (Clive, 2004). The area grown to biotech crops in developing countries reached 27.6M has. which accounted for 34% of the total world area in 2004.

In 2003, only 2M farmers grew biotech crops but a year later this increased to 8.15M farmers in 17 countries. More recently the adoption of agricultural biotechnology (e.g. GMO crops) in terms of acreage in developing countries is increasing at a rate three times more than that of the advanced countries. Countries in Asia such as India, China, Indonesia and the Philippines are preparing to commercialize GMOs. As a matter of fact, the percentage increase (35%) in developing countries for 2003-04 is higher than in industrialized countries (13%) (James Clive, 2004). Currently 11 of the 17 coun-

Figure 1. Trend of Global Area Planted to Biotech Crops, 1995-2004



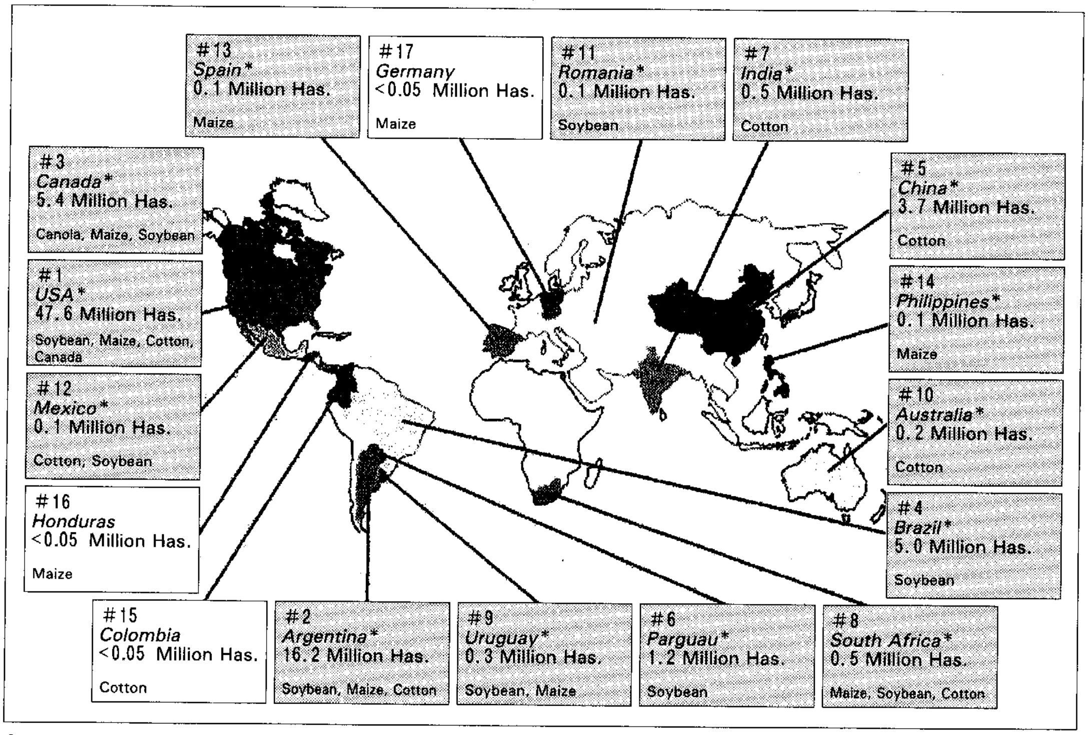
Source: Clive James, Global Status of Commercialized Biotech/GM Crops: 2004, Executive Summary, ISAAA, p.5.

tries that grow biotech crops are developing nations: Brazil, China, India, Mexico, Argentina, Uruguay, Honduras, South Africa, Philippines, Romania and Colombia. Of these three are in Asia: China, India and Philippines (Figure 2).

Agricultural Biotechnology in the North and South: What is the Difference ?

From now on the adoption and commercialization of biotech crops will increase in developing countries basically to meet their domestic food and feed needs, and to provide export earnings (ISAAA, 2004) and many see biotech to be the solution to the pressing problems of hunger, malnutrition and

Figure 2. Biotech Crop Production in the World, 2004



Source: Clive James, Global Status of Commercialized Biotech/GM Crops: 2004, Executive Summary, ISAAA, p.3.

poverty in many nations in the South. Most companies that spend much money on R&D in GMO are from the industrialized county. In the US there is widespread cultivation of GMO cotton, wheat, corn, soybean and canola. These multinationals are the ones introducing the GMO products to other developed countries and developing countries. Even GMO products are becoming global with the increase in their trade and investment. Hence in the West there is strong leadership in the industry, which is economically motivated.

In many developing countries GMOs are seen in light of it providing food security, reducing poverty and malnutrition and promoting sustainability and protecting the environment in the long run. The use of GMO seeds leads to improved productivity to farmers, since the crops will be resistant to pests and diseases; the farmers will be using less pesticide and chemicals which will be better for their health and the environment as well. Moreover, through genetic engineering, more nutritious (e.g., golden rice), vitamin-enriched and higher quality of crops will be produced. Most of the R&D in GMOs are done by biotech companies in DCs and their application really do not suit the most urgent needs of the developing nations (Fresco, 2001). Mostly what these countries grow are GMO soybean, maize and cotton and not the much needed more nutritious, drought resistant, salinity tolerant, etc. homegrown crops. Agricultural biotechnology in Asia, is basically done and extended by public institutions and universities to address the urgent need to improve the welfare of the marginal farmers in the countryside. Biotechnology R&D, particularly GMOs are very costly which firms in developing countries do not have the capacity and the finances to do so. Hence they have to rely on MNCs for transgenic crop input supplies. In case it is developed in the LDC, R&D is usually publicly funded in collaboration with universities and other research institutes and international agencies, and private investment is minimal. The government is obligated to do this to serve the farmers. But then the government should not brush aside the potential health risks of the GMO to individuals and the environment that might be over shadowed in its drive to meet the welfare and economic goals. In advanced and developing countries there are many new GMO products in the pipeline and many more to be field tested and ready for commercial use and will be in the increase in the coming years. In the previous section, we have outlined the technology inherent risks of agricultural biotechnology. In addition to this Lehrer (2000) had presented the technology transcending risk (e.g., more people suffering from poverty). Given this let us see the situation in many developing countries.

In Asia for example, for the past two decades manufacturing has taken over agriculture in terms of contribution to GDP although agriculture still remains an important sector since a majority of the population who live in the rural areas still depend on agriculture for their livelihood. Agricultural biotechnology is seen to have great potentials in solving food and supply security in Asia. Land is scarce in the Asian region that houses 70% of the world population. The agricultural sector has to provide the food needs of an expanding population projected to reach 8 billion by 2025, a majority of whom live in Asia. Constrained by the limitations in the expansion of land for cultivation in Asia, biotechnology can significantly increase production and simultaneously improve food quality for sustainable land use. It can likewise reduce the use of chemicals and pesticides, and develop drought resistant crops that can grow on rain-fed areas. Agricultural biotechnology offers great potentials not only for increasing food and agricultural production but also quality and nutritional improvement, alleviation of post-harvest losses of subsistence farmers specially those in the marginal areas where it is difficult to increase productivity. All in all this can lead to significant welfare changes for the regions concerned, more income for the Asian farmers and lift them from persistent poverty, malnourishment and food insecurity, often the root causes of discontent and insurgency. While there is a need for intensification of agricultural production, sustainable agriculture has to be promoted, not only during technology generation and adoption, but also in the training and education of farmers, extension officers, local community and government officials so as to avoid the adverse impact of past experiences. Poverty has been a push factor for rural-urban migration in seeks of employment. This often leads to problems related to the urban poor. To alleviate this problem then it is likewise important to provide livelihood to the rural agrarian population by uplifting them from subsistence agriculture to agribusiness that can add more value to the agricultural produce. These agricultural goods then can be geared for the domestic or export market. Many developing countries have comparative advantages as far as agricultural production is concerned which can be explored to become foreign exchange earners for the country. Agricultural biotechnology can be an important tool to accelerate development and improvement of the standard of living in Asian countries, especially the developing nations of Asia who do not wish to be left out of the innovation benefits of biotechnology nor be left in a disadvantaged position vis a vis the industrialized countries. With minimal private efforts directed toward agricultural biotechnology; public sector endeavors in the R&D of biotech crops have the interest of the producers utmost in mind more than the consumers. The government looks after the producers welfare due to the deeper socio-economic and political impact of doing otherwise.

The position the people take in the West may has different rationale and justification as that in the developing countries as far as modern agricultural biotechnology is concerned where the socio economic situation and problems are far more pressing and urgent. With the adoption of agricultural biotech crops farmers would stand to benefit from improved productivity and sustainable farming; and the consumers will have access to cheaper and more nutritious crops. In many developing countries where many people have low income, the largest portion of their budget goes to food. But at this point it has to be emphasized that although modern biotech crops can give these benefits to farmers and consumers to meet their urgent needs, care has to be taken that food safety specially in the developing areas be given the utmost importance. Many people in developing countries reside in the non-urban area who have less capability and means to access to information about GMOs. Food safety and health regulations both domestic and international as well as practices should be strictly followed. Public awareness of the food people eat and the potential risk has to be undertaken. Lack of education can be a barrier to consumer knowledge about biotech foods and information dissemination about them is still not in place. Moreover labeling of products with GMOs can be done in urban areas as well as in established retailers but not in the public markets in the rural areas. Against this situation in the developing countries, the role of the public (national) sector is very important proactively to make sure of the safety of food grown commercially.

Regulatory Requirements

To have economies of scale the GMO crops that are commercially grown and traded like corn soybean, cotton, and canola are not what the developing countries would really like to produce. For each of the transgenic crops, government regulatory requirements mandate that the health, environment and safety information be provided which cost U$10M each (FA0, 2004).
In many countries agricultural biotech researches are done by the public sector on crops that would answer the local food and feed needs as well as food security as outlined below.
These crops that range from staples to vegetables and plantation crops (export crops) are traditional and domestic crops that are important for the local people and the local economy. A study of Cohen (2005) of 15 developing countries reveals that most of the R&D on GMOs done in developing countries are conducted by public institutions with public interest in mind. But these GM crops usually remain in the pre-commercial stage due mainly to

Table 3. Homegrown GM crops in the Pipeline, Asia.

Country	Crops in the Pipeline
China	Cabbage, chili, cotton, maize, melons, papaya, potato, rice, soybean, tomato
India	Cabbage, cauliflower, chickpea, citrus, eggplant, mung bean, muskmelon, mustard/rapeseed, potato, rice, tomato
Indonesia	Cacao, cassava, chili pepper, coffee, groundnut, maize, mung bean, papaya, potato, rice, shallot, soybean, sugarcane, sweet potato
Malaysia	Oil palm, papaya, rice
Pakistan	Cotton, rice
Philippines	Bananas, maize, mango, papaya, rice, tomato
Thailand	Cotton, papaya, pepper, rice

Source: Joel Cohen, Nature Biotechnology, Poorer Nations Turn to Publicly Developed GM Crops. Vol 23, No.1, Jan 2005.

the costly regulatory requirements, foremost of which is biosafety. In Brazil for instance cost of compliance per event (the incorporation of foreign DNA to a living plant cell) is U$700,000 for virus resistant papaya and U$4M for herbicide resistant soybean while in Costa Rica it cost U$2.5M for virus resistant rice (Cohen, 2005). But then there is the issue of intellectual property rights. Is it a public good that would free farmers of any patent problem ? R&D on GMOs can amount to U$30M and US$5-6M to meet regulatory requirements. Hence these large capital requirements require huge returns. Does the public sector have enough capacity, resource and will to do agricultural biotechnology to serve the public need ?

Food Supply Chain and Food Safety

The components of the supply chain consist of the following: input suppliers (seed, agricultural chemicals), farmers, wholesalers, processors, the retailers, and consumers. This is a chain of direct in-line functions and implies direct linkage among separate functions. It means that each function is dependent upon the others and the overall chain cannot be stronger than its weakest link. Hence the viability of the food chain rests upon the viability of the other elements of the food chain. There are many participants in each component of the supply chain and the supply chain participants vary in size, level of technological sophistication, management capability and capital intensiveness and ownership depending on the country where they operate. Input suppliers, mostly MNCs and their subsidiaries monopolize the seed market (GMO crops), especially for the terminator seed in developing countries. Farm production units are numerous and scattered of various sizes, structures and composition producing according to their comparative advantage and specialization. Produce of widely dispersed farms goes through the wholesalers to the processors and finally to the retailers. Who among these value creation supply chain participants are the main beneficiaries of the agricultural biotechnology (e.g. GMOs) ? Who among them have to take responsibility for food safety ?

In the introduction of GMOs into the market, the consumers have to see the benefits may it be price, quality, nutrition and of course, food safety, otherwise they would not purchase. The consumers are the driving force behind the entire food system (Neil, 2001). The consumer response can always be positive or negative and the result will be felt in the whole food chain. As mentioned earlier, the viability of food system depends on the viability of each participant. The input suppliers (GMO seed firms), processors, and retailers (and even the restaurants) have to meet the needs and preferences of the consumers, one of which is safe food. Moreover, food chain participants anticipate the consumer's response and adopt strategies accordingly. Nestle of Switzerland says they operate to please the needs of consumers. Hence they sell GMO products where consumers buy them and do not sell where consumers oppose it. Danome, a French company known for its biscuits, yogurt and mineral water abides by the new rules and delivers what the consumers prefer. Albert Heikin in the Netherlands stores only 10 products with GMO out of thousands of product lines it carries. McDonalds decided to cut the use of meat raised with antibiotics since more consumers are demanding safe food. The antibiotics administered to animals might lead to antibiotics resistance to humans so that many people now resort to organic grown products which are carried by 73% of food stores in the US. In Japan, to increase consumer's value, all participants in the value chain are taking every measure of product safety assurance. It has been a concerted effort and responsibility between the value chain participants. Food producers, processors as well as retailers are doing their utmost best: retailers are keen on labeling, disclosure and traceability and the processors try to monitor the raw materials/ingredients they use. One measure taken by retailers is to obtain safety assurance certification in Japan (Japan agricultural standard (JAS)) and oversee the products they will carry. Aeon Co., a large retailer in Japan, sells beef with the JAS mark and provides all the information about the beef, the date of birth, breed, slaughter date, the medicines and feeds. Ito Yokaido Co., a major supermarket operator, puts a seal in the vegetables they sell indicating the website consumers can log on into. But agribusiness outsourcing has been on the rise in recent years. This necessitates a stricter rule of conduct. Japan Tobacco now sells frozen vegetables grown and processed in China. To allay fears of safety for food coming from other countries, the company checks the vegetables they buy from local suppliers for chemical residues and re-check them again before they are shipped to Japan. All product history can be checked in its website. Ajinomoto on the other hand puts the production and processing of frozen vegetables in China under its strict supervision. There are some cases where the processors and retailers take responsibility as well in assuring that the food they offer are safe. These could serve as examples to other supply chain agents in developing countries although the infrastructures are different.

In developing countries this supply chain is undeveloped and still in the developing stage. The industry is not as well-organized as that in the west where countries have advanced and cutting edge technology and national agricultural research system, well placed regulatory framework, intellectual property laws and developed local input market so they can join the gene revolution (FAO, 2004). The suppliers of GMO are a few MNCs which control the seed market. A case in point is the transgenic cotton, Bt cotton (trade name of Bollgard(r), developed by Monsanto, USA) which contains the gene of bacillus thuringiensis that makes it resistant to caterpillar pests and herbicide and insect resistant BT/HT cotton developed in 1997. It was first cultivated in the US, Australia, Mexico in 1996 and since then have been introduced in Argentina, China, Colombia, India, Indonesia and South Africa with Monsanto providing planting materials. However there are domestic companies in India and state-owned enterprises in China that have commercialized the planting of cotton. But majority of the seeds of local crops are developed in public institutions and distributed to small farmers through the extension arms of the government. In developing countries the agricultural biotech industry is still in the infant stage where much of the R&D are done by public institutions to address more pressing needs such as poverty, malnutrition and food security. Price is still a determining factor in the purchase decision of consumers in developing countries with regard to food without much concern about the potential health risks. The food supply chain and the regulatory framework in developing countries are still weak. The pressing concern about transgenic food however is safety. Are they harmful to the health ? There is no scientific evidence that GMO foods are harmful to the health according to the scientific community. But the consumers will decide given all the information whether to buy GMO products or not. This decision will then ripple back to the participants of the food chain. Ordinary consumers are not much informed about GMOs in Asia and for them price is still the determining factor for the purchase.

International Food Safety Regulations

Governments of various countries have regulatory policies, programs and instruments that vary in degree, sophistication and extent. Hence parallel to the national regulatory efforts are international agreements that would bind, attune and govern transnational issues about agricultural biotechnology. In this section we will examine the instruments of governance as far as food safety is concerned. Domestic regulations need to be in harmony with international regulations. Developing countries then that are still trying to strengthen their national regulations can be guided and bound by the international framework. With increasing commercialization and trade of GMOs international agreements to regulate food safety include:

Cartagena Biosafety Protocol
FAO/WHO Codex Alimentarius
WTO SPS Agreement
International Plant Protection Convention

The Cartagena Biosafety Protocol was adapted in 2002. It is an international agreement related to GMOs (or living modified organism (LMO)) and includes setting of standards with regard to international movement, transit, handling, packaging, identification and use of LMOs that can have harmful effects on the conservation and sustainable use of biological diversity and risk to human health (Fresco, 2001). The Codex Alimentarius was an agreement reached in 2003 that sets the principles for evaluating food derived from transgenic crops and guidelines on food safety using GMOs. Standards for risk assessment and labeling are still under discussions (FAO, 2004). The WTO agreement on the Application of Sanitary and Phytosanitary Measures (SPS agreement) was adopted in 1994 and enforced in 1995. The agreement stipulates that countries should retain their rights to ensure that the food, animal, and plant products they import are safe. It states too that countries should use international standards to create their requirements for sanitary and phytosanitary measures (FAO, 2004). The International Plant Protection Convention (IPPC) mandate is to prevent the spread and introduction of plants, and plant product pests and to apply the necessary measures. This applies to GMOs. (Fresco, 2001). Many countries in developing countries in Asia do not have the instruments that relate to food safety of GMOs. Some have food safety measures but none specifically for GMOs although these measures are applied to GMOs as stop gap measures (Glowka, 2003).

Imports of GMOs into EU, Japan and South Korea are strictly regulated. Entry of GMOs into these markets especially EU, which has the strictest instruments on GMOs has caused a lot of trade disputes. In the EU there is mandatory labeling regulation for food and food ingredients with GMOs and a new traceability law has been put in place in 2003. GMO foods, known as Frankenfoods, are not very popular and some EU countries continue to oppose approving new GM crop varieties. Many consumers shun the Franken foods hence producers are pressed to suit the consumers wants. In 2003 to appease the countries that oppose GM food, the new EU Parliament passed new laws that required tracing and labeling of all products with at least 0.9 % GMO ingredients and should be labeled as GM products. This labeling in stores started in April 2004. Labeling will also be required for animal feed and all products containing highly refined soya or corn oil (Financial Times, 2004). Under the new regulation, farmers, manufacturers and distributors need to collect and keep information regarding the origin, composition and sale of GM products for five years (Daily Youmiuri, 2004). EU has the strictest law on labeling in the world. But the traceability requirement does not hold for meat, milk and eggs of animals fed with GMOs feeds. This marked the end of EU's 6-year moratorium on new biotech food thus allowing the GMO insect resistant corn developed by Swiss company Syngenta into the EU market for human consumption. In 2003, the EU Commission enacted rules for GMOs and now that the consumers are sufficiently informed, they can decide if they buy the corn or not. Six years ago the EU gave its consent to some GM crops but Europe remained divided. Hence the moratorium was suggested due to the growing public fear of health and environment risks of GM crops. More investigation on the influence of GMO on health and the environment has come up with no scientific evidence that GMO are harmful but anti-GMO activists claim these can not be said with certainty (Economist, 2004). Hence although the GMOs food may be available in the market, and with the requirement labeling, there is no guarantee that consumers will buy them.

The US has been pro-GMO, being one of the biggest producers of GMO corn and wheat. Prominent agribiotech companies such as DOW, Dupont, and Monsanto are American multinationals. And the US government is putting pressure on many countries to open their market to GMO products. In the United States, there is no specific regulation for GMOs. Rather GMOs are covered by existing laws nor is there a mandatory risk assessment for GMOs (Baumuller, 2003) There is a proposal to mandate companies to provide the information on the safety of the GMOs food before marketing them via the Premarket Notice Concerning Bioengineered Food (Baumuller2003). Unlike in the EU where labeling is required, labeling of GM foods in the US is voluntary as provided by the Voluntary Draft Guidelines of the Food and Drug Administration. China since March 2002 has implemented instruments on GMO safety evaluation, import and labeling. The Biosafety Regulation of GMOs in Agriculture is a regulation to safeguard not only the environment but also health from the research phase to the field trial and to production processing and trade. Also GM soya, canola, tomatoes have to be labeled (Greenpeace, 2003). In India government approval is needed for the import of soya oil and maize. Japan on the other hand has zero tolerance for GMO food. Consumer acceptance of GMO is important when the main concern is food safety, quality and health risk. Safety assessment of all recombinant DNA (rDNA) organisms whose properties have been altered are conducted and has to be approved by the Ministry of Agriculture, Fisheries and Forestry. Just like Japan, Korea bans all forms of GMOs. There is mandatory labeling of GM soybeans, corn, bean sprouts as of 2001, and potatoes in 2002 in Korea. As of 2003, the importation of GMOs for food and feeds and processing into the Philippines needs a permit. Whereas in Thailand there are moves to require labeling of soy and corn products. Thailand has to weigh the potential risks and rewards of GMOs since one of their main exports is agricultural products and their biggest markets include EU and Japan where the consumers are very sensitive to GMO foods. Hence Thailand is caught in a quagmire since it wants to be a regional biotechnology hub in Asia.

Food Safety Measures

Some countries in Asia like India and the Philippines have national biosafety committees which will be responsible for the policies and programs regarding the use of biotechnology, both locally developed and imported biotech products. The committees have to coordinate with the different institutions in the country involved in biotechnolgoy R&D. Other countries have biosafety regulatory and food safety measures although some of these measures do not contain regulation of GMOs. These biosafety and food safety instruments have to be strengthened so as to command the trust of the participants of the food supply chain, the consumers in particular. With the increasing R&D, adoption and commercialization and trade of GMOs from now on, Asian countries are still faced with many challenges offered by: 1. Inadequate understanding of biosafety among the ordinary people; 2. Inadequate well-trained staff who can develop and implement the bio safety regulations: 3. Lack of funding to do the risk assessment; 4. Lack of expertise in the evaluation of risk in the field trials and commercial use of GMOs; 5. Lack of facilities to conduct risk assessment and inadequate institutional capacity. Against this background and given the government policies and biosafety committees to assure food safety, the following steps can be undertaken.

Scientific assessment

Scientific risk assessment of GM crops based on established guidelines as well as in abidance to the Codex principle and market monitoring should be done. There has to be science-based biosafety assessment on a case-by-case basis. Although no harmful effects of GMO for instance have been detected there has to be non-stop evaluation and monitoring to be able to tract the long terms effects. In many developing countries there has been a strengthening of regulatory mechanism to guarantee that consumers and the environment are protected from potential risks. There can be pre and post release assessment on the possible impact on food safety to ensure that toxins are not transferred or created nor allergens are not transferred from one species to another (FAO, 2003). Efforts have to be exerted to direct more international and local grants to food safety risk assessment and monitoring.

Labeling

Labeling may add costs to the firm that will be passed on to the consumer. Due to budget constraints, or no other food alternative or a lack of knowledge of the food labels consumers in developing countries may not always take notice of the food labels. Nevertheless, the public/consumers can be provided all the information about GM ingredients in products and let them make the rational choice.

Education and public awareness

Education of producers, processors, retailers and consumers alike of the potential benefits and risks of biotech crops is important and let them make informed decisions. This could be done using the extension arms of the national and local government in cooperation with community associations in the countryside as well as electronic and print media to disseminate information.

Technical and institutional capacity building

In developing countries there is still the need for capacity building of local researchers and scientists on the pre and post commercialization assessment of the safety of biotech food crops as well as national and local government officials who would be involved in the development, implementation and updating of local food safety programs and regulations.

Regional cooperation

On the regional perspetive, nations in Asia should work together and coordinate their efforts to make sure that the GMOs that are being developed are safe before they are disseminated and commercialized given the fact that these countries more or less grow similar crops and are faced with constraints such as human, financial and institutional capital. Information (data base) sharing is very important as far as risk assessment and analysis are concerned so that they can avoid duplication and save on the cost of risk assessment, which is very costly given the financial constraints.

Conclusion

The adoption of GMO crops and transnational trade in agricultural crops are expected to increase from now, in spite of the intensive debate that surrounds it. The goals, focuses and attitudes towards biotech food (e.g. GMOs) differ between the North and South because the needs and intensity of the food needs for these countries are different. The need for safe food is recognized by the industry, government and consumers and is a basic criterion for global trade. Although there are claims by the scientific community that transgenic crops pose no health hazard we need not be complacent. It is of utmost importance that pre and post commercialization scientific based assessment of the potential risk of GMOs be done on a case to case basis. Developing nations in Asia are starting to adopt GMOs introduced from the industrialized countries and are in the pre-commercial release stage of home grown crops, all in the hope to address urgent needs of poverty, malnutrition and food security which are the root causes of more serious economic, social and political dilemmas. Given this scenario, then there needs to be a proactive approach so that before the full blown adoption and commercialization of biotech crops, guidelines and measures have to be put in place to assure the safety of the food people eat. This can be a taxing and long term task since the food supply chain is still undeveloped unlike in more advanced countries where each supply chain participant takes on the responsibility of food safety within the guidelines set by the national and international regulations. Unlike in Europe, US and Japan, many developing nations have no strict regulatory system on GMOs in place yet. Thus the national governments in developing countries need to put in place the domestic regulatory procedures and institutions in harmony with the global guidelines as set by the Codex alimentarius and the Cartagena Protocol which set the international standards and hence harmonize the risk assessment systems while many developing countries are still in the processes of framing up their guidelines. It is important to enhance public awareness, education and training on biosafety of all supply chain agents. Traditional consumers make the choice of food based on their income, tastes and preferences, and lifestyle as well as the price of the product. Nowadays the purchase decision has become more complicated taking into consideration issues of health, quality and food safety. Hence the preservation of consumer confidence has become very important and has become a prime task of the industry, comprising of the supply chain agents and the government. By supply agents we mean the input suppliers, farm producers, processors, retailers, restaurants that are engaged in value creation to satisfy the expectations of consumers which are different in the advanced countries (North) and developing countries (South). Moreover, labeling, capacity building and regional cooperation are measures that can be undertaken at the domestic and international fronts. Government regulations, taxes, etc. can be put in place to monitor the development and use of biotechnology in all industries to protect the consumers and at the same time giving them freedom of choice. We should support and build upon the achievements of agricultural biotechnology, which can be used for the betterment of our society and environment if guided in the proper direction. Biotechnology can be used as a tool and not as a foe. FAO (2004) further cautions that agricultural biotechnology need not be a replacement for traditional agricultural techniques but rather they should be complementary, specially in times when agricultural biotechnology and traditional breeding methods are unsuccessful. As what Tweeten, a well-known agricultural economist said, science and technology (in agriculture) can be used as a solution to the problem rather than causing the problem.

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