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Review Article: Genetically Modified Crops and Food Security

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Abstract
As the world's population continues to increase there is an increase demands for food which cause major challenges to humankind. Thus food security exists when all people have physical and economic access to sufficient, safe, and nutritious food. Uncertainly, food security does not exist for a major proportion of the world population of around 900 million people are malnourished, implying that they are underprovided with calories (FAO, 2012). Since the total area for planting is maintained as it is we need to find another solution in order to feed ever increasing mouth. Many developed countries have opted to incorporate the genetic engineering to improve their productivity. But how to achieve this goal is debated controversially. In association to this genetically modified (GM) crops are sometimes mentioned for food security. In genetic engineering only the desired traits are inserted to a plant while; with conventional breeding methods, thousands of traits from two crops are combined. This procedure holds a lot for Africa encompasses some of the benefits, Africa stands to derive include, increased food production, improved nutritional and health benefits, improved environmental condition, improved economic benefits and improvement in fruit storage**.** In this review paper some original research papers, reviews, relevant opinions and reports addressing the major issues that emerged in the argue on GE crops, trying to grasp the scientific agreement that has matured since GE plants became widely cultivated worldwide. So far the scientific research conducted has not noticed any significant hazards directly linked with the use of GE crops that have been thoughtfully developed and carefully tested; however, the debate is still strong. Extensive public awareness campaigns are required to address the concerns consumers have about the new technology and to highlight biosafety measures and the benefit of genetically modified crops. Integration of modern biotechnology, with conventional agricultural practices sustainably, can achieve the aim of attaining food security.
Keywords: GM foods, food security, Impacts

1. Introduction

Policymakers of African countries are starting to focus on agricultural innovation as a way to sustain this growth and help spread prosperity. On average, agriculture accounts for 30-40 percent of sub-Saharan Africa's overall GDP and employs 64 percent of the workforce (Juma 2011). According to UN, 1999 by now the world population has reached six billion and the growth rate is increasing at an alarming rate, indicating that by 2030 it will reach 8.1 billion. Currently food insecurity and malnutrition are among the most serious concerns for human health, causing the loss of countless lives in developing countries. To be healthy, our daily diet must include sufficient high quality foods with all of the essential nutrients, in addition to foods that provide health benefits beyond basic nutrition. In general, there are three possible means how GM crops could impact food security. First, GM crops could contribute to food production increases and thus improve the availability of food at global and local levels. Second, GM crops could affect food safety and food quality. Third, GM crops could influence the economic and social situation of farmers, thus improving or worsening their economic access to food. This latter aspect is of particular importance given that an estimated 50% of all undernourished people worldwide are small-scale farmers in developing countries (Borlaug N, 2007).

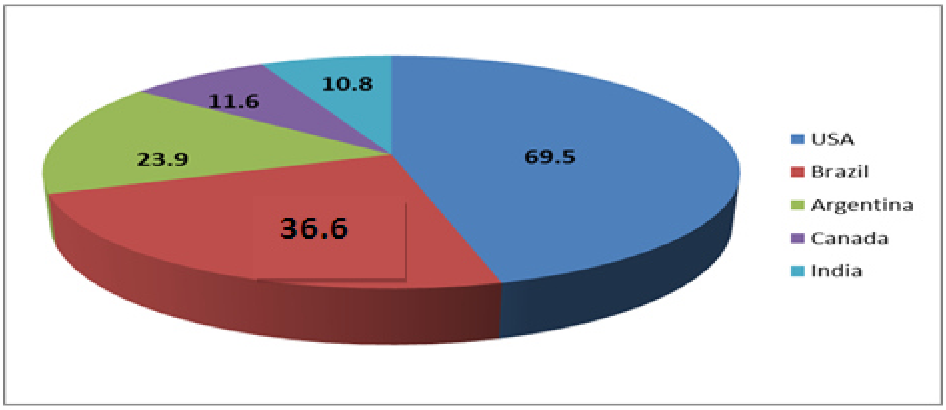
As result of the continuous loss of arable lands and the prevalence of adverse environmental conditions; even maintaining the amount of food per capita what we are getting today will be an escalating job in the future. In order to ensure food security for future generations, the world must produce 50% to 100% more food than at present in spite of the predicted unfavourable environmental conditions (Cohen and Paarl berg .2004).

Nevertheless, conventional plant breeding alone can no longer sustain the ever-rising global food demand. It is the time to encourage sustainable agricultural practices for convalescing crop productivity with the paramount conservation of all available natural resources. Agricultural biotechnology is proving to be a powerful complement to conventional methods for meeting worldwide demand for quantity and quality food. Today we have access to massive gene pools that can be exploited to impart desirable traits in economically important crops with the help of modern plant biotechnological tools. GM crops can help us to meet the demand for high-yielding, nutritionally-balanced, biotic and a biotic stress tolerant crop varieties (FAO, 2001; ISAAA, 2012 and OECD, 2003). While the global area under GM crops continues to expand every year (Thirtle etal. 2003), concerns have been expressed regarding accidental and random pleiotropic effects of these crops on human health and the environment (United Nations ,1999). However, novel foods developed either by conventional or genetic engineering approaches are no different in terms of possible unintended harmful effects on human health and the environment (Ronald, 2011). There is a serious burden on the world to provide food security to all the countries but the question arises that by which technology we can provide food security. The main goal of plant breeders is to develop varieties that express good agronomic traits. However; there is little or no assurance of obtaining any particular gene combination from million of crosses generated by using conventional breeding. With conventional procedure unnecessary genes can be transferred along with desirable genes; or, while one desirable gene is gained, another is lost because the genes of both parents are mixed together and re-assorted more or less randomly in the offspring which hinders the improvements that breeders can achieve.

On the contrary, genetic engineering allows the direct transfer of one or just a few genes of interest between either closely or distantly related organisms to obtain the desired agronomic characters.

Food security has achieved in developed countries by applying technology in their agriculture as they have strong technology and infrastructure. Evidences show that considerable share of GM crops has been grown in developed countries. Similarly, there has been a consistent increase in the number of hectares being planted to GM crops in the developing world in the last few years. A considerable increase in GM crop area was reported in developing countries of Africa, Asia, and Latin America. Although when we talk about developing countries there is a different scenario present here due to they have weak infrastructure and technology that make them difficult to apply technology in their agriculture (Hsu et al., 2005). Application of biotechnology will provide potential contribution to sustainable agriculture productivity and new inputs for resource-poor and small scale farmers (Huang et al, 2002; Morris and Hoisington, 2000; OECD, 2003; Thirtle et al, 2003; Cohen and Paarlberg, 2004). Between 1996 and 2011, the total surface area of land cultivated with GM crops had increased by a factor of 94, from 17000 square kilometers (4,200,000 acres) to 1,600,000 km2 (395 million acres). In 2010, 10% of the world's crop lands were planted with GM crops whereas in 2012, transgenic crops were planted in 28 countries; 20 were developing countries and 8 were developed countries, 2012 was the first year in which developing countries grew a majority (52%) of the total GM harvest. In developing countries about 17.3 million farmers grew GM crops; around 90% were small holding farmers (ISAAA, 2012). Whitman, 2000 reported that presently, up to 85% of U.S. corn is genetically modified as are 91% of soybeans and 88% of cotton (cottonseed oil is often used in food products .

Fig:-1**:** These are the countries that make 90% of the world GM growing areas.



Source: Sheetal ann lamichhane.2014

2. Genetically Modified crops and Food.

Genetically Modified (GM) crops are those organisms that have been modified by the application of recombinant DNA technology or genetic engineering, a technique used for altering a living crop's genetic material. Similarly genetically Modified Food is defined as food items that have had their DNA changed through genetic engineering. Combining genes from different organisms is known as recombinant DNA technology, and the resulting organism is said to be "genetically modified," "genetically engineered," or "transgenic." Unlike conventional genetic modification that is carried out through time-tested conventional breeding of plants and animals with the rapid advances in biotechnology, a number of genetically modified crops or transgenic crops carrying novel traits have been developed and released for commercial agriculture production. These include, herbicide tolerance and insect resistance are the main GM traits that are currently under commercial cultivation, and the main crops are: soybean, maize, canola and cotton.

2.1. Some of GM foods

Genetically modified (GM) foods are thus food items that have had their DNA changed through genetic engineering (Halford, 2003). The most common genetically modified organisms are crop plants. Among crop plants corn has got the gene which is insect resistance and due to this, the farmers do not have to spray pesticides that are harmful to the soil as well as the crop. In addition, soybean is also being modified genetically, so that the farmers do not have to spray insecticides or pesticides. They have been genetically modified to offer improved oil profiles for processing or for healthier edible oils. Likewise, Tomatoes have been modified in order to increase their shelf life while prevent it from rotting while Canola oil has been genetically altered for resistance against pesticides.

2.2 List of some of the genetically modified crop

GM foods description
Rapeseed has been made to be more resistant to pesticides and also free from erucic acid.
Cotton oil can be consumed; cotton is considered as a food and also altered to produce a chemical that kills many pests.
Canola oil was altered to be resistant to pesticides and may be in oil products, baked goods and snacks
Flax altered to resist herbicides, flax is in many products that contain flax oil and seed.
Papaya have been modified to be more virus resistant
Cotton seed oil can be in vegetable oils, fried foods, and oil products that can be consumed.
Tobacco has been altered that contains very little nicotine.

Source: Sheetal ann lamichhane, 2014

3.3. GM technologies and its advantages

In Africa, other countries growing GM crops are South Africa, Egypt and Burkina Faso. Worldwide four countries are principal growers of GM crops: the USA with 47.6 million hectares (59% of global total); Argentina (16.2 million hectares, 20%); Canada (5.4 million hectares, 6%); and Brazil (5.0 million hectares, 6%). Other countries growing GM crops are Australia, China, India, Mexico, Paraguay, the Philippines, Romania, Spain, and Uruguay (ISAAA Report on Global Status of Commercialised Biotech/GM crops: 2009). Other GM maize currently on the market in other countries such as South Africa have better resistance to stem boring insects with a significant reduction in pesticide use. Such varieties include *Bt* maize. Other biotech crops such as insect resistant cotton (*Bt* cotton); insect resistant maize (*Bt* maize) and herbicide tolerant cotton are already helping farmers in other African countries such as South Africa, Egypt and Burkina Faso. In twenty two developed and developing countries the GM crops are commercially cultivated on about 100 million hectares. GM crops and products are mainly produced and exported in the United States of America, Argentina and Canada. Argentina, Brazil, China and India are the leading producers of transgenic crops among developing-countries. In Asian and African countries, insect resistant cotton being the most important commercially produced transgenic crop, while in the Latin American continent, herbicide-resistant soybean followed by insect-resistant corn is predominant which shows the preference of GM crops varies among the developing countries.

The most important advantage of GM food crops is biotechnology can potentially help developing countries to go for such advances as higher yields while shorter growing duration, higher resistance to bacterial and fungal disease, drought tolerance , improves the shelf life of the crop, asking for less chemical fertilizers, advanced pest management, higher drought resistance, and more nutrition availability (Golden rice). As discussed, one potential is that GM technology enables the development of new crop varieties, which have beneficial characteristics for farming. This could be resistance to drought, pests or diseases. In situations of unstable food security, due to bad harvests caused by climate or crop-diseases, GM crops open up opportunities in order to stabilize and ensure food supply for poor subsistence farmers (Egelyng, 2000). Another potential is that some types of GM crops can reduce the use of chemical pesticides and fertilizers, because of their pest resistance with transgenic pesticides. Some crops are made resistant to stress from drought, salt and low pH. This is an important consideration, because chemical inputs are often not available for the subsistence farmers, as the farmers often can afford to none of these inputs (Egelyng, 2000). GM allows crops to be bred by selectively inserting one or more genes into a plant to confer specific advantages. Plants that are resistant to pests and diseases can be produced this way thereby reducing the amount of required insecticide (AFIC, 2004).

The main arguments of GM supporters are safe food security, improved food quality, and extended shelf-life as the reasons why they believe in GM crops which will benefit not only both consumers and farmers, but also the environment (Wisniewski et al., 2002). Belcher et al., 2005 discuss, a critical question is what impact(s) biotechnology companies should take into their account. For instance, the productivity impacts is mainly yield increase, in corn and saving on inputs of chemicals and labour in soybeans the GM technology. Furthermore, the companies claim that GM technology will promote food security while they are also healthier, cheaper, and more stable. However, the nutrients will have more quality and better taste.

The issue is the impact of international regulations on the food situation in the developing countries. As explained by Paarlberg (2002), the most significant factor for keeping GM crops out of the developing world, is the politicization and blockage of national biosafety screening processes. Yet, most of developing countries now have some biosafety regulations and guidelines to with GM crops (Paarl berg, 2002). In these countries, approximately 800 million people remain seriously malnourished, including at least 250 million children

(UNFPA, 2005). So such advantages of tarnsgenic crops would mitigate public hesitation about GM technology (Sharma, 2003). Some also acknowledged the potential of plant biotechnology to improve plant breeding and crop production in developing countries. Finally, the GM technology may require adequate education and training as well. The farmers, especially in the developing countries, have to be willing to adopt the technique and GM crops. The GM technology thus, has great potential in securing food supply for small scale subsistence farmers; however, the technology cannot be transferred to the farmers, without carefully considering the abovementioned aspects (Closter et al., 2004)

2.4. GM crop and its area in various countries

Areas reported in this paper refer to GM crops which are commercialised and grown on a farm-scale basis including areas sown for some experimental purposes as well.

2.4.1. Improvement of GM crops

2.4.1.1. GM Crops development in Sub-Saharan Africa (SSA)

According to the UN conference on Trade and Development (UNCTAD) 2010 report, Africa's capacity to provide food has declined by one-fifth over the past 40 years. This has been proposed as a reason why the continent should adopt genetically engineered crops. .

Within Africa, South Africa was the continent's sole cultivator of GM maize, cotton and soybeans until 2008, when Egypt began growing GM maize, and Burkina Faso started growing GM cotton. Other countries such as Kenya, Tanzania, Uganda, Malawi, Mali, Zimbabwe, Nigeria and Ghana have since allowed the importation of genetically modified food(http://afkinsider.com/92428/why-are-more-african-countries-joining-the-gmo-bandwagon/#sthash.iLx1Ivju.dpuf)

Similarly on other report it was indicated that countries such as Benin, Burkina Faso, Morocco, Senegal, Tanzania, Zambia and Zimbabwe - are known to have conducted field trials. The main GM crops of research and commercial interest in Africa are sweet potato, maize, cotton, soybean, pigeon pea, banana and tobacco (http://www.trust.org/item/20140128102528-5o0u4/?source=hptop). Even though a number of field and laboratory trials executed by various countries of Africa so far only four African countries—Burkina Faso, Egypt, South Africa and Sudan—grow transgenic crops out of a total of 29 worldwide (Juma, C. 2014). Contrasting crops, livestock transgenic research in Africa is also very weak. The policies and legislation in place do not seem to cater for transgenic livestock research and deployment of livestock transgenic animals. Except in Kenya and South Africa, policymakers and lawmakers do not anticipate a role for transgenic livestock research and products in livestock productivity (Romano Kiome, 2015).

The Ethiopian parliament legalized a proclamation stating that genetically modified organisms (GMOs) can be imported if the ministry of environment approves their compliance with bio-safety and public health guidelines in early 2013.The Ethiopian government officials hope that planting GM cotton will achieve higher yields than conventional varieties whereas till now, there are no plans to introduce other GM crops in Ethiopia (http://www.trust.org/item/20140128102528-5o0u4/?source=hptop)

A number of GM varieties have been brought into several SSA countries in the experimental phase, although SSA still lags behind other parts of the world in both the development and commercial release of GM crops. The experience of GM crop adoption in the Republic of South Africa (RSA) provides an example of how small-scale farmers in Africa may benefit from GM varieties, including GM food crops. While no GM variety has been approved in SSA for commercial purposes outside of the RSA, several GM varieties are in field trial or experimental stages (Tables 1, 2 and 3). In combination, political and institutional factors operate to funnel biotechnology development towards the field-testing stage, but prevent it from progressing further. The result is a steady state of continuous CFTs. This suits the interests of public researchers, who are able to 'do science' and generate publishable research, and fits within the often short funding timelines of donors. It allows governments to manage political risks by effectively balancing the demands of pro- and anti-GM lobbies – proponents of GM have a pipeline of technologies, while opponents are appeased by the failure of any to gain approval. In total, these potentially represented 18 crop traits at the CFT or pre-CFT stages of development in Africa. Table 3 summarizes a 2013 review of GM crop development in Africa, excluding previously commercialized Bt and glyphosate resistance traits. Thus before any interventions in the GM crops / foods to African countries time and effort must be devoted to test on farm trials for GM crops / foods be adopted should be under conditions that avoid potential risks. In addition, Policy makers and researchers should carefully assess environmental and socioeconomic risks (such as the major risks to biodiversity, the prospects of insufficient out-crossing distances, the relative absence of clear labeling and other threats to seed purity from adjacent traditional food production) before farmers change their conventional farmingmethods to GM (Azadi & Ho 2010). Crop management traditions, including local adaptation to food security through seed saving cultures of landraces must therefore be maintain and confined in order to avoid genetic loss and transgenic contamination of local seeds. Accordingly those above mentioned countries except Ethiopia are also at an advanced stage of conducting research and field trials with numerous GM crops.

Table 1. Commodities currently at the field trial stage for GM varieties in SSA.

Commodity	Country
Canola	RSA
Cotton	Ghana, Malawi, RSA, Zimbabwe
Maize	RSA
Soybean	RSA
Cowpea	Zimbabwe
Eucalyptus	RSA
Potato	RSA
Strawberry	RSA
Sugar cane	RSA
Sweet potato	Kenya
Wheat	RSA

Source: (FAO, 2009). Note: Although Egypt is excluded from SSA countries, a variety of GM crops are at the field trial stage in Egypt.

Table 2. Commodities currently at the experimental stage[a] for GM varieties in SSA.

Commodity	Country
Cotton	Burkina Faso, Kenya, Tanzania
Maize	Kenya, Nigeria, Republic of South Africa (RSA)
Barley	Kenya, Uganda
Cassava	Kenya, Uganda
Coconut	Nigeria
Cowpea	Burkina Faso, Cameroon
Potato	RSA
Rice	Nigeria
Sesame	Kenya
Sorghum	Kenya, Uganda
Sweet potato	Nigeria
Yam	Nigeria

Sources: FAO (2009); Kimenju and De Groote (2008). [a] The term *experimental stage* is used by the FAO Bio-Dec (FAO, 2009), although its strict definition is not provided. The FAO Bio-Dec classifies stages of GM variety development into experimental stage, field trial, and commercialization, and thus experimental stage is assumed to include all stages preliminary to the field trial, including the on-station trials.

Table 3: Genetically modified crops development in sub-Saharan Africa

Country	**Crop/Trait**	**Status**
Burkina Faso	Cowpea/pod borer resistance	Confined field trials
	Rice/water efficient, nitrogen use efficient, salt tolerant	Laboratory regeneration
	Sorghum/biofortified with iron and zinc	Confined field trials
Ghana	Rice/water efficient, nitrogen use efficient, salt tolerant	Laboratory regeneration
	Cowpea/pod borer resistance	Confined field trials
Kenya	Cassava/mosaic and brown streak resistance	Confined field trials
	Cassava/biofortified with iron, protein and vitamin A	Confined field trials
	Maize/stem borer resistance	Confined field trials
	Maize drought tolerance	Confined field trials
	Sorghum/biofortified with iron and zinc	Confined field trials
	Sweet potato/weevil resistance	Greenhouse containment
Mozambique	Maize/drought tolerance	Stalled: awaiting regulatory framework
Nigeria	Cassava/biofortified with iron, protein and vitamin A	Confined field trials
	Cowpea/pod borer resistance	Confined field trials
	Rice/water efficient, nitrogen use efficient, salt tolerant	Laboratory regeneration
	Sorghum/biofortified with iron and zinc	Confined field trials
South Africa	Maize streak virus resistance	Greenhouse containment
	Maize/drought tolerance	Greenhouse containment
	Sorghum/biofortified with iron and zinc	Greenhouse containment
Tanzania	Maize/drought tolerance	Stalled: awaiting regulatory framework
Uganda	Banana/bacterial wilt resistance	Confined field trials
	Banana/parasitic nematode and weevil resistance	Confined field trials
	Banana/biofortified with iron and vitamin A	Confined field trials
	Maize/drought tolerance	Confined field trials

Sources: Namuddu, A. and Grumet, R. (2013), 'Genetically Modified Crops Under Research in Africa', African

Biosafety Sources: Namuddu, A. and Grumet, R. (2013), 'Genetically Modified Crops Under Research in Africa', African Biosafety Network of Expertise, http://www.nepadbiosafety.net/subjects/biotechnology/gm-crops-under-research-in-africa, and Edmeades, G. (2013), 'Progress in Achieving and Delivering Drought Tolerant Maize', http://www.isaaa.org/resources/publications/briefs/44/specialfeature/Progress%20in%20Achieving%20and%20 Delivering%20Drought%20 Tolerance%20in%20Maize.pdf.as as cited by Bailey et al. (2014).

2.4.2.2. Beneficiaries participation

Participatory evaluation of any new technology that can have possibility to be evaluated at stage being together with end users or relevant stakeholders is mandatory to create awareness. In the same approach Maize is the most important staple food crop and has a critical role for nutrition across the African continent. Consequently, discussion on GMO issues and creation of public awareness on implications must be enhanced (Egziabher 2007). People have the right to participate and contribute to decision-making when it is about their staple crop, grown in gardens and fields, guided by their own traditional knowledge and culture. Administrative coherence and regulatory structures is limited, as could be seen in the operation of extension services in urban areas. Dealing with uncertainties and contradictions are among key areas that need to be addressed. Efficient programmes should be developed to support farmers to improve their responses towards effective seed saving and cropping management. It should however be acknowledged that to orient smallholder producers to meet the demands of consumers will be difficult to achieve in Africa (Mugo et al. 2005) because producers are also the consumers. The most important freedom of choice for farmers in Africa seems to be the ability and right to save and share seeds without risk of contamination by transgenes and to maintain seed availability and exchange as an open system.

2.5. GM area by crop: soybeans and corn

The area development of these most frequent GM crops is specified below.

2.5.1. GM soybeans: mainly herbicide-tolerant

Commercialised GM soybeans were first sown in 1996 in 2 countries, the USA and Argentina and represented respectively 1.6 and 0.8% of their total soybean area. In 1999, GM soybean area represented nearly one third of world total soybean area and nearly 47% of area of countries producing GM soybeans (Table 4). Of the 22 Mio ha, 15 or two-third of total are in USA (51% of US soybeans), 5.5 in Argentina (75% of Argentinean soybean), 1.2 in Brazil (10% of Brazilian soybean) and less than 0.1 Mio ha in Canada and Romania. Almost all GM soybeans are herbicide tolerant (HT).

Table 4. Development of GM corn and soybean area

Mio ha	1996		1997		1998		1999		2000 (e)		GM %('99)	
	C	S	C	S	C	S	C	S	C	S	C	S
USA	0,30	0,40	2,27	3,64	8,66	10,12	10,30	15,00			36%	51%
Argentina	-	0,05	0,07	1,40	0,09	3,43	0,31	5,50			11%	75%
Canada	0,001	-	0,27	0,001	0,30	0,04	0,50	0,10			44%	10%
Brazil								1,18			-	10%
Romania								0,001			-	Nr
South Africa	-				0,05		0,16				5%	-
France	-				0,002		0,000				0,0%	-
Spain	-						0,01				0,2%	-
Portugal	-						0,001				0,4%	-
Total	**0,30**	**0,45**	**2,61**	**5,04**	**9,11**	**13,59**	**11,28**	**21,78**	**10,5**	**22,5**	**28,0%**	**47%**

Source: Commission of the European communities working document rev. 2, 2000

Note:-C=corn &S=soybean

2.5.2. GM corn: mainly insect-resistant

First sowings of GM corn took place in 1996 exclusively in North America, 0.3 Mio ha in USA and 0.001 Mio ha in Canada and represented respectively 1% and 0.1% of their corn area. Similarly, in 1999, GM corn sowings accounted for more than 11 Mio ha and 27% of total GM sowings. With this area, GM corn represents about 8% of world total corn area and 28% of area of countries producing GM corn. Most of the areas are located in USA (10.3 Mio ha or 36% of US corn), 0.3 Mio hectares in Argentina (11% of Argentinean corn), 0.5 in Canada (44% of Canadian corn) and a few thousands hectares in Spain, France and Portugal (Table 4).

Two thirds of corn area or nearly 8 Mio hectares are insect resistant (Bt-corn), about 2 Mio ha is herbicide tolerant corn and around another 2 Mio ha of corn contain both genes. Experts (USDA) do not expect that the development of HT corn will be as fast as for HT soybeans.

Soybeans and corn are well adapted to growing conditions in Northern and Southern America. Thus, they are widely grown in this part of the world, while culture in Europe is limited. The fact that corn and soybeans were the first species for which GM varieties were put onto the market is one basic factor explaining their development on the American continent.

3. Adopting Patterns of GM Crops in least developed countries and Their Implications

Adoption of GM commercial crops and commodities in developing countries in the world indicate that the development and dissemination of GM crops may face great constraints. Only a few developing countries, such as China and India, have the capacity to develop their own GM varieties suitable for their domestic production environment. The adoption of GM crops and commodities in most developing countries relies upon spread out from developed countries, such as the United States; however, these crops are often for cultivation in temperate climates, and are not suitable for the tropical or sub-tropical climate zones of SSA. Most GM crops and commodities adopted in least developed countries (LDCs) were obtained by back crossing varieties initially developed for use in the United States or other early-adopting countries. Three primary GM crops or commodities are cotton, soybean, and maize, and at least one of them has been adopted in Brazil, China, India, Paraguay, Argentina, Mexico, and the RSA (James, 2006).

India cotton is very important crop which contributes 30% of its agricultural GDP. However, due to the high incidence of pests, especially the cotton bollworms, India falls short of the worlds average yield of cotton by 48%, an equivalent of 280 kg/ha(James, C. 2013). Indian farmers often lose up to 50-60% of their crop to the cotton bollworm (Hsiao ping, C. 2005). In 2002, with the commercialization of Bt cotton in India, the cyclic infestation of bollworm has been suppressed. Primarily, India becomes the leading producer of biotech cotton worldwide, which produced 10.8 million hectares, followed by China (4.2 million hectares), USA (3.7 million hectares), and Pakistan (2.8 million hectares) in 2013 (Shetty, PK. 2004). Adoption of Bt cotton started in 2002 with 3 hybrids planted in six Indian states: Andhra Pradesh, Gujarat, Madhya Pradesh, Karnataka, Maharashtra and Tamil Nadu (James, C. 2013). Yorobe *etal,* 2004 reported that there were 1,097 Bt cotton hybrids approved for planting and a total of 10.8 million hectares of Bt cotton plantations in India by 2013 (Table 5). Studies were conducted from 1998 to 2013 on the impact of Bt cotton showed that yield increased by about 31 percent and insecticide spraying reduced by 39 percent, which translate to 88 percent increase in profitability (US$250/ha).

In India, Qaim and Khouser (2013) conducted a study involving 1,431 farm households from 2002 to 2008 to investigate the effect of Bt cotton on farmers' family income and food security. According to the results, the adoption of Bt cotton has significantly improved calorie consumption and dietary quality, leading to increased family income. About 15-20% of food insecurity reduced among cotton-producing households with technology utilization.

Table 5: Development of GM cotton area

Year	Total cotton area (Mha)	Hectarage (Million Has.)
2002-03	7.7	0.05
2003-04	7.6	0.1
2004-05	8.9	0.5
2005-06	8.9	1.3
2006-07	9.2	3.8
2007-08	9.4	6.2
2008-09	9.4	7.6
2009-10	10.3	8.4
2010-11	11.0	9.4
2011-12	12.2	10.6
2012-13	11.6	10.8

Source: ISAAA

5. Conclusion

Genetically-modified foods have vital role in world food security and to help protect the environment by increasing yield and reducing reliance upon chemical pesticides and herbicides. If we want to secure food security in every nation, then we need to encourage GM foods. GM foods might be considered as the logical way of feeding and medicating an overpopulated world (Lesney, 1999) and also benefited the environment. Thus, we must proceed with carefulness to avoid causing unintended harm to human health and the environment as a result of our enthusiasm for this powerful technology.

In this link, we find many argues about genetically modified organisms (GMOs) – that they can be a basis for increasing food production, without expansion of land to cultivation, for instance. Even thought GM crops are not a universal remedy for the problems of hunger and malnutrition; the scientific evidence suggests that GM crops can be an important component in a broader food security strategy. Hence, appropriate policy and regulatory frameworks are required to ensure that the needs of poor farmers and consumers are taken into account and that undesirable social consequences are avoided.

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