Genetically Modified Organism (GMO): Prospect and Challenges in Bangladesh

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Abstract

Genetically modified organisms (GMOs) are organisms that have been altered using genetic engineering methods. Although genetic engineering is a common and essential practice in biotechnology, its specific use in crops is controversial. The key steps involved in genetic engineering are identifying a trait of interest, isolating that trait, inserting that trait into a desired organism, and then propagating that organism. Methods for genetic manipulation have rapidly improved over the last century from simple selective breeding, to inserting genes from one organism into another, to more recent methods of directly editing the genome. The most commonly used of genetic engineering product are insulin for human diabetes in case of human. During 2013 Bangladesh release three Bt Brinjal varieties for commercial cultivation which are BARI -1, BARI Bt Brinjal-2 and BARI Bt Brinjal-3 that resistant to pod borer. Bangladesh Rice Research Institute (BRRI) collaboration with Banghabandhu Sheikh Mujubur Rahman Agricultural University (BSMRAU) release first GM rice BRRI dhan-62 which is zinc rich during 2013. After BRRI dhan-62, BRRI release GM variety BRRI dhan-86 during 2017 using anther culture which is on of the biotech tools. Golden rice enrich with vitamin A, Bt tobacco with fine quality fiber with higher yield and late blight resistant potato develop through genetic engineering tools are under field testing. Among the Asian countries Bangladesh first release GM crop and Bangladesh is 29th country where government gives approval of GM crop/food.

1. Introduction

Genetically modified Organism (GMO) is basically an organism (plant, animal or microorganism) created by application of bio-technology which is such a technology by the application of which a new genetically characterized organism is created by introducing a new character or genetic carrier or gene in any organism found from that organism or from any wild species thereof or from completely different type of organism. The term GMO or LMO (Living Modified Organism) are used interchangeably to denote the same thing pertaining to modern biotechnology.

Scientists first discovered in 1946 that DNA can be transferred between organisms (Clive 2011). It is now known that there are several mechanisms for DNA transfer and that these occur in nature on a large scale, for example, it is a major mechanism for antibiotic resistance in pathogenic bacteria. The first genetically modified (GM) plant was produced in 1983, using an antibiotic-resistant tobacco plant. China was the first country to commercialize a transgenic crop in the early 1990s with the introduction of virus resistant tobacco. In 1994, the transgenic 'Flavour Saver tomato' was approved by the Food and Drug Administration (FDA) for marketing in the USA. The modification allowed the tomato to delay ripening after picking. In 1995, few transgenic crops received marketing approval. This include canola with modified oil composition (Calgene), *Bacillus thuringiensis* (Bt) corn/maize (Ciba-Geigy), cotton resistant to the herbicide bromoxynil (Calgene), Bt cotton (Monsanto), Bt potatoes (Monsanto), soybeans resistant to the herbicide glyphosate (Monsanto), virus-resistant squash (Asgrow) and additional delayed ripening tomatoes (DNAP, Zeneca/Peto, and Monsanto) (Clive 2011). A total of 35 approvals had been granted to commercially grow 8 transgenic crops and one flower crop of carnations with 8 different traits in 6 countries plus the EU till 1996 (Clive 1996). As of 2011, the USA leads a list of multiple countries in the production of GM crops. Currently, there are a number of food species in which a genetically modified version exists (Johnson 2009). Some of the foods that are available in the market include soybean, canola, potatoes, eggplant, strawberries, corn, tomatoes, lettuce, cantaloupe, carrots etc. GM products which are currently in the pipeline include medicines and vaccines, foods and food ingredients, feeds and fibres. Locating genes for important traits, such as those conferring insect resistance or desired nutrients-is one of the most limiting steps in the process.

In the context of Bangladesh, GM crops and foods are highly debated issue over the last few years. This issue at first drew the attention of Bangladeshi people after the agreement between Monsanto and Grameen Bank in 1998. After many days on 30th October 2013 Government by a notification approved to cultivate then, Bangladesh becomes the first in South Asia to grow a GM food crop (Daily Star. 2013). The promoters of GM crops or foods argue that, Bangladesh's population is increasing rapidly but cultivable land is decreasing @ 1% per year, agriculture is also threatened by adverse impacts of climate change (i.e. salinity, drought, flood, storm), insects and diseases. So high yielding GMOs (e.g. Golden Rice, Bt. Brinjal and GM Banana) will be the miracle solution to meet demands of food production and nutrition. On the other hand, environmentalists allege that, some international companies are trying to deprive Bangladesh from her rich variety of agricultural crops by appropriating and displacing them by introducing their own GM crops, which would make Bangladeshi farmers permanently dependent on them for seeds. Some GM crops may have higher output, but their long term safety for human health, environment and preservation of biodiversity, and their long term viability for the farmers are yet to be firmly established. Eco-feminists are also committed not to sacrifice their seed and food sovereignty for corporate control and profits, as women are primary food-growers and food-givers claim that, alternative lies in women's hands and minds and demands a paradigm shift from monocultures to diversity and from chemicals to organic.

However this study have been taken with the respect of following objectives

- ✓ To review the present senario of GMO crop in Bangladesh.
- ✓ To clear the concept of people who are very worried about genetically modified foods and
- ✓ To brought out the answer are genetically modified crops/food are safe for consumer?

2. Material and Methods

This paper is absolutely a review paper. The title is selected with the consultations of my major professor. All data and information used in this paper are taken from secondary source. I have collected the data and information from different books, journals, newsletters, training class and internet. For these purpose, I went BARI, BRRI, BARC and SID library and BSMRAU also. I visited different websites through internet. Collected data are then compiled and the paper is prepared.

3. Results and Discussion

3.1 What is Genetic Engineering?

The nucleus contains chromosomes and these chromosomes are made from DNA and DNA is the genetic code. Everyone has got their own gentic code. The genetic code carries information that makes our body what it is and scientists have now found a way to change our genetic code. This is called Genetic Engineering.

3.2 What is GM crops/food?

According to 'World Health Organization'

Genetically modified (GM) foods are foods derived from organisms whose genetic material (DNA) has been modified in a way at does not occur naturally, i.e. through the introduction of a gene from a different organism.

GM crops are described by many different names-

Genetically Engineered crops (GE)

Transgenic or Biotech crops

Genetically Modified Organism (GMO)

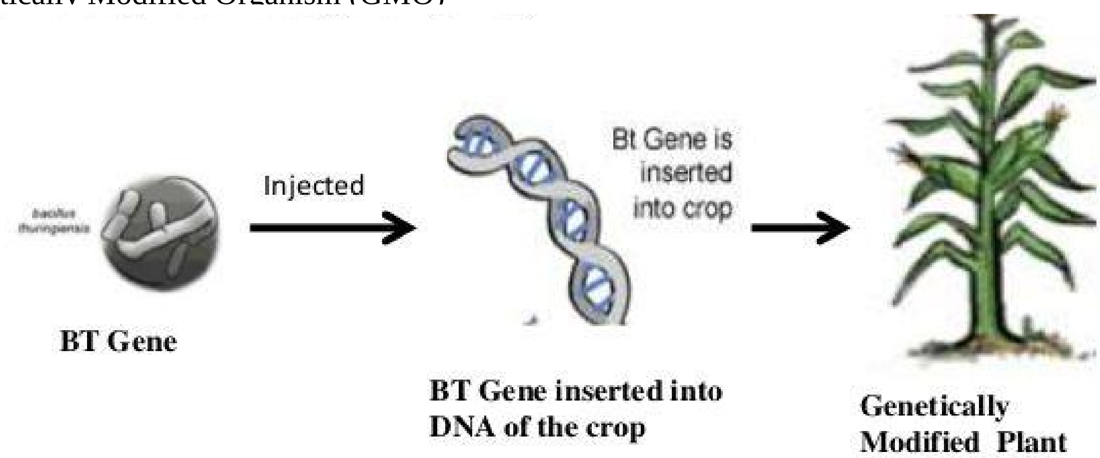

Figure 1. Simplified figure how Bt gene insert into plant?

3.3 What is DNA?

The DNA stands for de-oxy ribonucleic acid. It is a genetic a material of all organism. It is poly ribo nucleotide chain joining each other. It stored genetic information. James and Francis Watson received noble prize for discovery of the structure of DNA. It is second most important discovery in Biology just behind the Charls Darwin.

3.4 Genes

A segment of DNA which express a specific trait. For each traits at least one gene responsible. More precisely, gene is that segment of DNA that encode a single polypeptide, protein or RNA molecule

3.5 What is gene staking?

Gene stacking – also known as **gene pyramiding –** is the process of including more than one transgenic event in one plant to produce stacked traits, stacked transformation events, or a stacked genetically modified organisms (GMO).

The cultivation of stacked GMOs has risen rapidly since they were first approved, and to date they were grown on 51 million ha in 2014, about a quarter of the total area under GM crops worldwide, and are set to become increasingly common.

3.6 Genetically Modified Organism (GMO) global scenario.

The year 2016 was momentous since for the first time, Nobel Laureates released a statement in support of biotechnology and condemned critics in their critical stance against the technology and Golden Rice. The UN FAO, IFPRI, the G20 countries and other like-minded bodies, guided by 2030 Agenda for Sustainable Agriculture committed to eradicate hunger and nutrition in 15 years or less. More importantly, the US National Academies of Sciences, Engineering, and Medicine published a study of 900 research studies on biotech crops since 1996 and found that genetically modified crops and conventionally-bred crops have no difference in terms of probable risks to human health and the environment. Biotech crops now have an unblemished record of safe use and consumption for over 20 years. Future generations can benefit more from wide choices of biotech crops with improved traits for high yield and nutrition that are ideally safe for consumption and the environment. At the beginning of the third decade of commercialization of biotech/GM crops in 2016, 26 countries grew 185.1 million hectares of biotech crops predominantly with agronomic traits in the four major biotech crops of soybean, maize, cotton, and canola. The accumulated hectarage (planted since 1996) surged to a record 2.1 billion hectares or 5.3 billion acres. Of the total number of 26 ountries planting biotech crops, 19 were developing countries and 7 industrial countries. The ncrease between 2015 and 2016 of 3%, is equivalent to 5.4 million hectares or 13.3 million acres. Developing countries grew 54% of the global biotech hectares compared to 46% for industrial countries. Soybean occupied 50% (91.4 million hectares) of the global biotech crop hectarage, 1% below the 2015 area. Herbicide tolerance has consistently been the dominant trait with 47% of the global hectarage, but is slowly declining over the years with the increasing prominence of the stacked traits. Stacked traits increased from 58.5 million hectares in 2015 to 75.4 million hectares in 2016 – an increase of 16.9 million hectares or 41%. Based on the total global crop hectarage, 78% of soybean, 64% of cotton, 26% of maize and 24% of canola were biotech crops in 2016. The latest data for 1996 to 2015 showed that biotech crops contributed to Food Security, Sustainability and Climate Change by:increasing crop production valued at US$167.8 billion; providing a better environment, by saving 619 million kg a.i. of pesticidesin 1996-2015; in 2015 alone reducing CO2emissions by 26.7 billion kg, equivalent to taking ~12 million cars off the road for one year; conserving biodiversity in the period 1996-2015 by saving 174 million hectares of land (Brookes and Barfoot, 2017); and helping alleviate poverty for up to 16.5 million small farmers, and their families totaling >65 million people, who are some of the poorest people in the world. Biotech crops can increase productivity and income significantly and hence, can serve as an engine of rural economic growth that can contribute to the alleviation of poverty for the world's small and resource-poor farmers. Biotech crops can contribute to a "sustainable agriculture". Predictions made by James, C. (2015) that the slight decline in biotech crop area in 2015 due to the low global commodity price would immediately reverse once crop prices revert to higher levels was achieved – this is contrary to propaganda from critics that biotech crops is failing farmers.

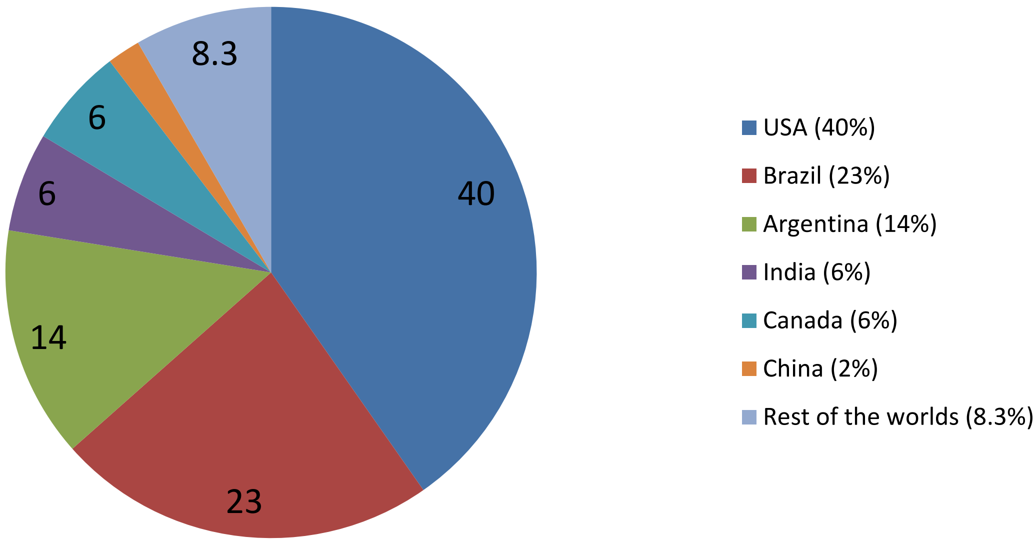

Figure 2. GM production of top sixes countries

Sources: Calculation based on ISAAA (2014). Special Brief 46-2013 Executive Summary, Global Status of Commercialized Biotech/GM Crops: 2013

http://www.isaaa.org.resources/publication/briefs/46/executivesummary/

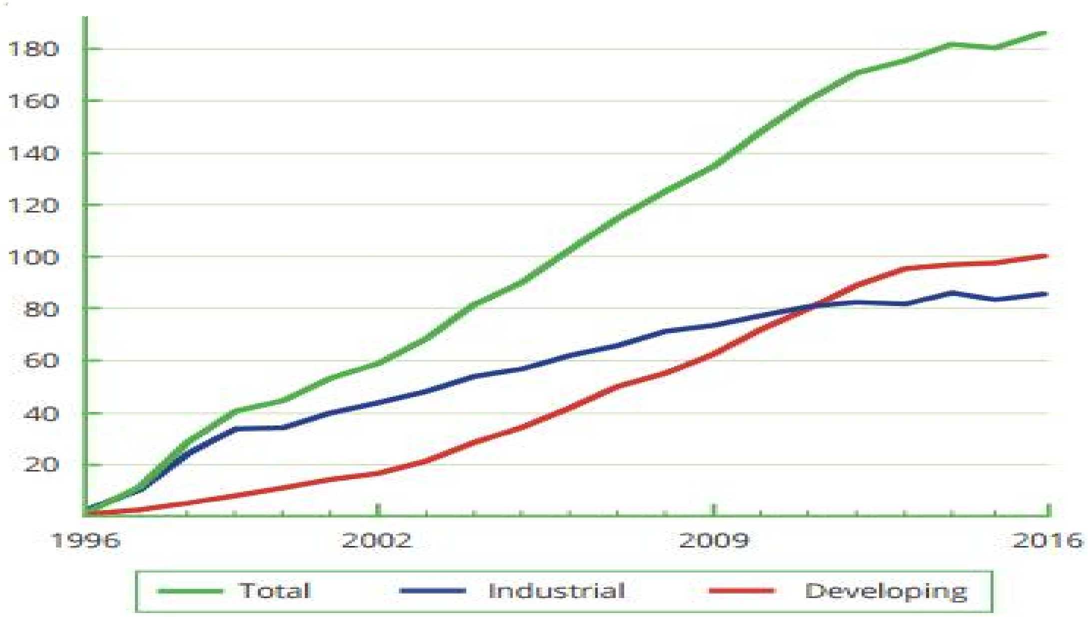

Figure 3. Global area of Biotech Crops, 1996-2016; Industrial and developing countries (Million hectares). Source: ISAAA 2016

Brookes and Barfoot (2017, Forthcoming) revealed that by using biotech crops, environmental footprint from agriculture was reduced over the last two decades by 619 million kgs of active ingredient. In 2015 alone, there was a slight decline in the amount of pesticide applications compared to 2014, due to reduced planting of maize and cotton in 2015.

Table 1. Reduction in Pesticide and Environmental Impact Quotient*

	1996-2014	**1996-2015**	**2014 alone**	**2015 alone**
Reduction in pesticides (million kgs actives ingredients, a.i.)	583.5	619	40.4%	37.4%
Pestiside saving	8.2%	8.1%	6.4%	6.1%
Reduction in (EIQ)**	18.5%	19%	17.6%	18.5%

**Environmental Impact Quotient (EIQ) = a composite measure based on the various factors contributing to the environmental impact of an individual active ingredient.
*Brookes and Barfoot, 2017.

3.7 Impact of GMO adoption

On average, GM technology has increased crop yields by 21% (Figure 2). These yield increases are not due to higher genetic yield potential, but to more effective pest control and thus lower crop damage (Qaim 2003). At the same time, GM crops have reduced pesticide quantity by 37% and pesticide cost by 39%. The effect on the cost of production is not significant. GM seeds are more expensive than non-GM seeds, but the additional seed costs are compensated through savings in chemical and mechanical pest control. Average profit gains for GM-adopting farmers are 69%.

Figure 2. Impacts of GM crop adoption.

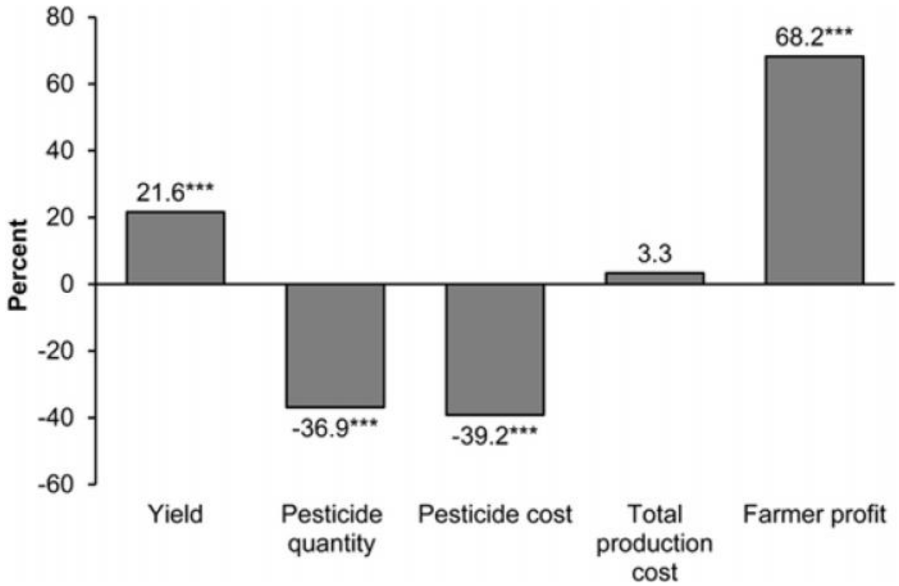

Figure 4. Impact of GMO crop adoption global scenario.

3.8 GMO Maize in the world

For example, a 2014 meta-analysis by two Germans scientists of all GMO crops found, "On average, GM technology adoption has reduced chemical pesticide use by 37%, increased crop yields by 22%, and increased farmer profits by 68%" (Wilhelm. 2014) It also found that yield and profit gains were higher in developing countries, which the New York Times did not mention in its analysis. A 2015 review by PG Economics, an industry-focused consultant firm, found that GMO crops provided economic benefits of $133.4 billion from 1996 to 2013, with roughly half of the gains going to farmers in developing nations. About 70 percent of the economic benefits were attributed to yield and production gains while the remaining 30 percent came from cost savings.

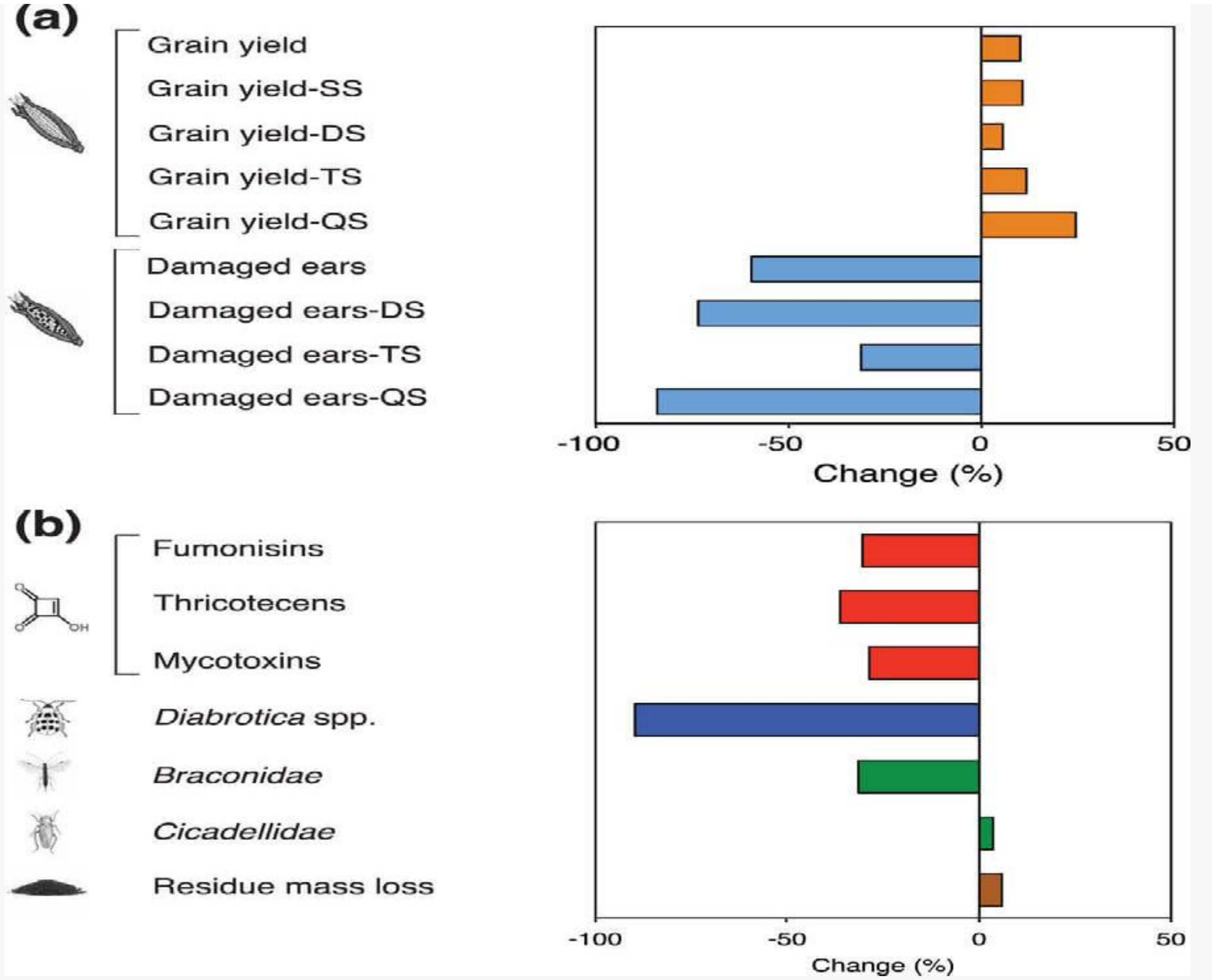

Figure 5. Effects of GMO corn on: grain yield and damaged ears (a), grain quality (toxins), target pest non-target insects, and residue mass loss."Response ratios. Effects of GE maize hybrids on the significant traits: grain yield and damaged ears (a), grain quality (fumonisins, thricotecenes, mycotoxins), target (*Diabrotica* spp.) and non-target (*Braconidae*, *Cicadellidae*) organisms and residue mass loss (b). The response ratio was calculated as the mean percentage of change for the weighted Hedge's *g* (g+) values different from zero between the GE hybrids and their isolines. SS = single eventhybrid; DS = double stacked hybrid; TS = triple stacked hybrid;QS = quadruple stacked hybrid." (Elisa *at al* 2018)

3.9 Biotech crops mitigate climate change with savings of 23.9 billion kgs of CO2

Conventional breeding is losing the battle against climate change. The rate at whichtemperatures across the globe are increasing and the frequency of climate-change related stresses occur are outpacing the speed at which new adapted crop varieties are developed and deployed. Biotech crops contribute to a reduction of greenhouse gases and help mitigate climate change by permanent savings in carbon dioxide emissions. This is achieved through reduced use of fossil-based fuels associated with fewer insecticide and herbicide applications and reduction in farm operations such as ploughing in no-till agriculture associated with the use of herbicide tolerant crops.In 2015 alone, a total savings of 26.7 billion kgs of CO2 was realized – a slight reduction (1.1%) from 27 billion kgs in 2014 (Table 2). It is noteworthy that reduction due to ploughing/tilling contributes greatly to reduced CO2 emission. Tilling mechanically turns over and breaks up soil to prepare for planting. It incurs the use of fossil fuels and at the same time leaves soil vulnerable to erosion and contributes to increased pollution and sedimentation in streams and rivers and loss of land to desertification. According to the World Wildlife Foundation, half of the topsoil on the planet has been lost in the last 150 years.

Table 2. Saving on CO_2 Emission Equated with Number of Cars off the Road*

	2014 alone	**2015 alone**
Saving CO_2 emission due to reduce used of fossil based fuels (Billion kgs)		
a. Due to reduced insecticide and herbicide sprays	2.20	2.80
b. Due to reduce ploughing	24.80	23.9
Total CO_2 emissions	27.0	26.7
Reduction in number of cars off the road (million)		
a. Due to reduced insecticide and herbicide sprays	0.97	1.25
b. Due to reduce ploughing	11	~11(10.06)
Total cars off the road	12	~12(11.9)

*Brookes and Barfoot, 2017

Less tilling results in less erosion, more water retention, and fewer greenhouse gas emissions due to fewer trips across the fields and lowered fuel costs as well as decreases machinerymaintenance costs. Reduced CO2 emissions from biotech crops in
2015 can be equated to removal of ~12 million cars, similar to 2014.

3.10 Developing Country Experiences

3.10.1 Bt cotton adoption in India

Cotton is a very important crop for India. However, due to the high incidence of pests, especially the cotton bollworms, India falls short of the world's average yield of cotton by 48%, an equivalent of 280 kg/ha[2]. Indian farmers often lose up to 50-60% of their crop to the cotton bollworm. With the commercialization of Bt cotton in India in 2002, the cyclic infestation of bollworm has been suppressed.

In 2016, India has become the top producer of cotton globally. Indian farmers planted biotech cotton on 11.2 million hectares, followed by China and USA.[2] 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. The single gene hybrids have achieved a near phasing out because of the dual gene cotton hybrids which provided additional protection to various insect pests. Dual gene hybrids have also helped cotton farmers to earn a higher profit through cost savings associated with fewer sprays and increased yield of 8-10% higher than single gene IR cotton hybrids.

Fourteen studies on the impact of Bt cotton were conducted from 1998 to 2013. The results showed that yield increased by about 31% and insecticide spraying reduced by 39%, which translate to 88% increase in profitability (US$250/ha).

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

3.11 Methods of Trait Introduction in GM crop

- *Agrobacterium tumefaciens*-mediated plant transformation
- Chemically mediated introduction into protoplasts and regeneration
- Direct DNA transfer system
- Electroporation

- Conventional breeding - cross hybridization and selection involving transgenic donor(s)
- Microparticle bombardment of plant cells or tissue
- Pollen-tube pathway (PTP)

3.12 Commercial GM Traits List

- Abiotic Stress Tolerance
- Altered Growth/Yield
- Disease Resistance
- Herbicide Tolerance
- Insect Resistance
- Pollination control system

Table 3. Some trait of crops which already used in commercially and their advantages are given below

Trait	Advantage	Sample Product
Pest-Resistance	Less damage by insect, virus, bacteria, etc.	Corn
Herbicide-Resistance	Herbicides will kill only weeds, not corps	Cotton
Delayed Ripening	Can be shipped with less damage	Tomato
Miniature Size	Improved eating quality	Watermelon
Improved Sweetness	Better tasting	Sweet peas
Cole-Resistance	Withstands freezing and thawing	Strawberries
High starch	Absorbs less oil when fried	Potato
Polyester Gene Added	Better fiber properties	Cotton
Growth Hormone Added	Faster growth	Salmon
Hepatitis B Virus Protein Added	May provide immunity to Hepatitis	Banana

Table 4. Countries with GM Crop Approvals

Argentina, Australia, Bangladesh, Bolivia, Brazil, Burkina Faso, Canada, Chile, China, Colombia, Costa Rica, Cuba, Egypt, European Union, Honduras, India, Indonesia, Iran, Japan, Malaysia, Mexico, Myanmar, New Zealand, Norway, Pakistan, Panama, Paraguay, Philippines, Russian Federation, Singapore, South Africa, South Korea, Sudan, Switzerland, Taiwan, Thailand, Turkey, United States of America, Uruguay, Vietnam	Total 36 countries approved and cultivate GMO in the world.

3.13 Bangladesh situation and prospects

Bangladesh releases first genetically modified crop to farmers 2013(Daily star, 30 October, 2013).With the release of BARI Bt Brinjal-1, Bangladesh has become the 29th nation to grow genetically modified (GM) crops. During the year 2013 after realizing BARI Bt Brinjal-1 same year BARI Bt Brinjal-2, BARI Bt Brinjal-3 and BARI Bt Brinjal-4 released following approval from the government's biosafety regulator. Although environmentalist groups say the government has released the seeds hurriedly and without enough research. Bt gene inserted in locally produce brinjal through genetic engineering procedure. The vegetable has been modified to be resistant to its most common pest, Fruit and Shoot Borers, which can devastate 50-70 percent of a crop. Now Bangladesh Agricultural Research Institute (BARI) has begun distributing the seedlings of four types of genetically modified brinjal seedling. Doubling of acreage from 12 hectares in 2014 to 25 hectares in 2015, the International Service for the Acquisition of Agri-biotech Applications (ISAAA) credited the success to Bangladesh(ISAAA 2014).

Table 5. History of Genetically Modified Crops (GMO) development in Bangladesh

GMO Crop	Organization	Year of release	Comments
BARI Bt Brinjal-1	BARI	2013	Cultivating by farmers
BARI Bt Brinjal-2		2013	Cultivating by farmers
BARI Bt Brinjal-3		2013	Cultivating by farmers
Late blight resistant potato	BARI	Waiting for release	Field testing
Bt cotton	CDB	Waiting for release	Field testing
BRRI dhan-86	BRRI	2017	Seed multiplying, with half a tonne of extra yield potential per hectare over most popular variety BRRI dhan-28
BRRI dhan-62	BRRI and BSMRAU	2013	zinc-rich rice variety with 19 mg/kg of the micronutrient
Golden rice	BRRI	Waiting for release	Vitamin A riches

Daily star 2013, Daily star 2015, Daily star 2016, Daily star 2017

Inspired by the success of the country's first commercially released biotech crop Bt Brinjal in 2013, Bangladesh is now field testing three more crops developed through applications of agro-biotechnology. Late blight resistant potato from BARI, Bt Cotton from Cotton Research and Development Board and golden rice from Bangladesh Rice Research Centre (BRRI). The ISAAA a non-profit international organisation that keeps watch on production and expansion of biotech crops worldwide. The ISAAA, governed by an international board of directors, is composed of three centres: the AfriCenter in Nairobi, Kenya; AmeriCenter, Ithaca, New York; and the SEAsiaCenter in Los Baños, the Philippines. The ISAAA report said, “Success with has led Bangladesh to prioritise the field testing of a new late blight resistant potato [an important crop occupying 0.5 million hectares in Bangladesh] which could be approved as early as possible during 2018.” (Daily star 2016). Bangladesh is now a potato exporting country. After releasing GM potato (i,e late blight resistant potato) amount of export would be 10 times more than present quantity(Daily star 2016). Farmers in Bangladesh spend up to Tk 100 crore a year in spraying 500 tonnes of fungicide to protect this major tuber crop. GM potato will increase farmer's income reducing pesticide cost. Importantly, seed (Bt Brinjal) is now being multiplied to meet the growing needs of substantially more farmers in 2017-18.

3.14 Status of Bt Brinjal in Bangladesh

In the last three years, Bangladesh cautiously advanced the commercial planting of / eggplant from two hectares planted by 20 farmers in 2014, the first year of commercial planting, to a remarkable 700 hectares planted by 2,500 farmers in 2016. is the country's first genetically modified crop that protects brinjal from the deadly fruit and shoot borer (FSB). The fruit and shoot borer (*Leucinodes orbonalis*) is one of the major insectpests of brinjal, which causes losses of up to 70% in commercial plantings. The winter season of 2016 was the turning point for large scale adoption of in Bangladesh. Smallholder brinjal farmers who cultivate brinjal on approximately 50,000 hectares in summer, winter and spring seasons increased planting of to 700 hectares in 2016, a 28-fold increase over 2015 (Table 27). Brinjal farmers in Bangladesh could choose from four varieties popularly known as Bt Uttara, Bt Kazla, Bt Nayantara and Bt ISD-006 approved for commercial cultivation in four major brinjal growing regions: Gazipur, Jamalpur, Pabna and Rangpur.

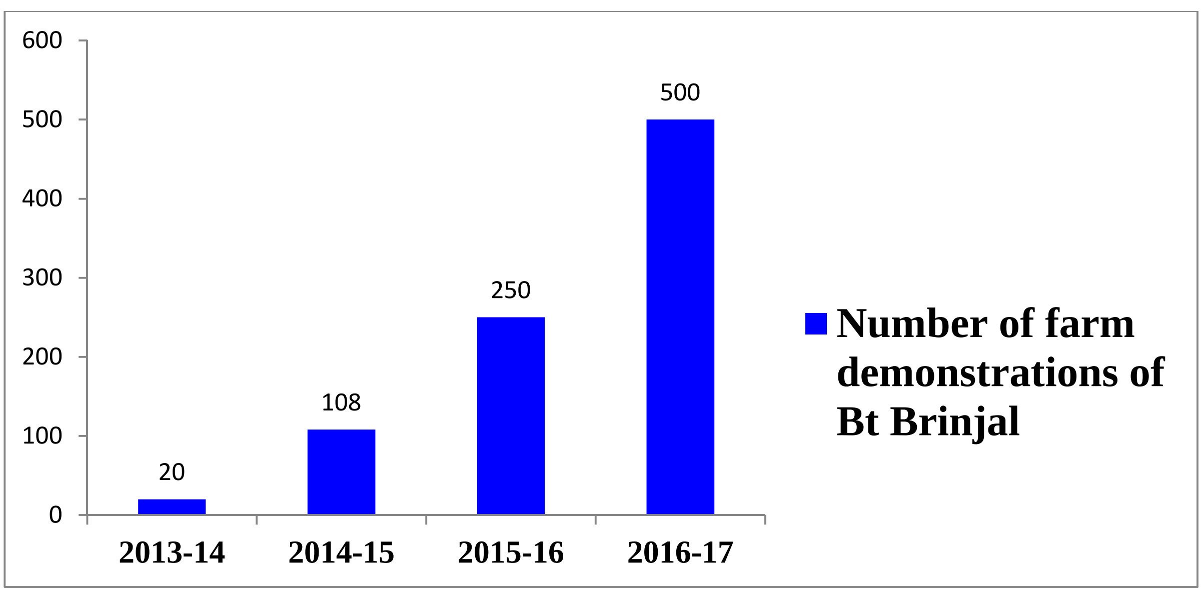

Figure 6. Number of farm demonstrations conducted by by Bangladesh Agricultural Research Institute(BARI) and Department of Agricultural Extension (DAE) of Bt Brinjal

The majority of farm-level plantings of in 2014 and 2015 were part of the farm demonstrations closely monitored and executed by the Bangladesh Agricultural Research Institute (BARI) and the Department of Agricultural Extension (DAE) of the Government of Bangladesh. These farm demonstrations commenced in 2013-2014 starting with 20 farm demonstrations and have increased to 500 for 2016-2017 (Figure 7).

Table 6. Adoption of Bt Brinjal in Bangladesh

Year	Adoption of Bt Brinjal (ha)	Total brinjal area (ha)	Nos. of Bt Brinjal farmers	% Adoption
2014	12	50,000	120	<1
2015	25	50,000	250	<1
2016	700	50,000	2500	2

Sources: Analysized and compiled by ISAAA, 2016

Farmers' opinion of growing based on data collected and analyzed during the field demonstrations in 2014 and 2015 by BARI and DAE concluded that farmers' preference of growing because: – Farmers need not undertake sorting of infested/non-infested brinjal fruits as varieties were free from infestation of the fruit and shoot borer; – The cost of production of was significantly lower due to almost no applications of insecticides for control of the fruit and shoot borer; and, – Farmers obtained higher gross margin due to the bounty of additional fresh healthy brinjal fruits resulting in higher marketable fruits.

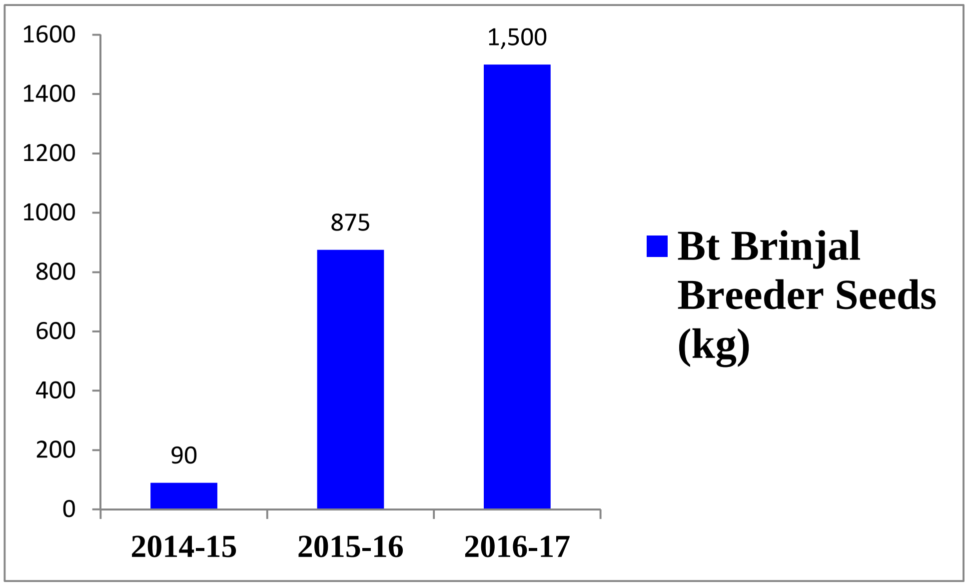

Figure 7. Bt Brinjal Breeders Seeds (kg) Production by Bangladesh Agricultural Research Institute (BARI)

Thus, in response to the growing interest by smallholder farmers in , the Bangladesh Agricultural Research Institute (BARI) produced breeder seeds of varieties namely BARI Bt begun-1 (Bt Uttara); BARI Bt begun-2 (Bt Kajla); BARI Bt begun-3 (Bt Nayantara); BARI Bt begun-4 (Bt Iswardi or ISD006). In total, BARI produced 90 kg of breeder seeds in 2014-15, 875 kg in 2015-16 and around 1,500 kg in 2016-17 (Figure 8). In 2016, the Government of Bangladesh made

3.15 Late Blight Resistant Potato

Potato, an important crop in Bangladesh, is grown on over half a million hectares producing 8.9 million tons of potato annually. The average potato yield in Bangladesh is about 19 tons per hectare, significantly lower than world average due to heavy infestation of late blight disease. Farmers in Bangladesh spend US$60.35 (Bangladeshi Takka 5,000) per hectare annually to apply 400-500 metric tons of fungicide to control late blight disease. In order to control late blight disease, BARI's Tuber Crop Research Center in collaboration with ABSP-II has developed a late blight resistant (LBR) potato variety namely BARI Potato-8 popularly known as Diamant by introgressing RB gene sourced from Solanum bulbocastonum in 2007. BARI has conducted backcrossing, contained and confined multi-location field trials of LBR potato over the last several years (Table 7).

Table 7. Cronologically Development of LBR potato in Bangladesh, 2008 to2016

Years	Nos. of LBR Potato Clones	LBR Potato Trial	Locations	Status
2008-09	>300	CFT	2 Locations	87 hybrids
2009-10	87 hybrids	CFT	2 Locations	Selection completed
2010-11	10 clone	MLT under CFT	2 Locations	8 hybrid clone
2011-12 2012-13	8 clone	MLT under CFT	6 Locations	6 hybrid clone
2013-14	6 clone	MLT under CFT	6 Locations	6 hybrid clone
2014-15	6 clone	Regulatory trial under CFT	6 Locations	1 hybrid clone
2015-16	1 clone	Regulatory trial under CFT	6 Locations	Trial complete

Source: BARI; Analyzed by ISAAA 2016

BARI has also carried out the food and feed safety studies including compositional, toxicological and environmental risk analysis as per the regulatory guidelines including Bangladesh Guidelines for Food Safety Assessment of GM Plant and the Guidelines for Environmental Risk Assessment of GM Plants. In December 2016, BARI prepared and submitted a biosafety dossier on LBR potato for its commercial release to the National Committee on Biosafety (NCB) of the Ministry of Environment and Forests (MOEF) in December 2016. Simultaneously, BARI's Tuber Crop Research Center started a collaborative research project to develop a late blight resistant potato variety using multiple gene technology in collaboration with Michigan State University (MSU) in October 2015. It is expected that the National Committee on Biosafety of MOEF of the Government of Bangladesh will consider approval of the commercial release of the first generation LBR potato expressing RB gene sometime in 2017 (Ahmad, 2016).

3.16 Biotech Cotton in Bangladesh on trial.

Bangladesh is the second largest importer of cotton fiber and uses approximately 4 to 4.5 million bales of cotton to spin products for the textile sector. Domestic raw cotton production is abysmally low, with an annual production rate of 150,000 bales from a total cotton area of 40,000 hectares planted by 70,000 farmers. Bangladesh can only meet 2-3% of the total raw cotton demand of the textile sector and hence relies heavily on imported raw cotton and fibers from India, USA and Uzbekistan. The Cotton Development Board (CDB) of the Ministry of Agriculture estimates that the demand for cotton fiber will increase by three-fold from 800,000 tons in 2014 to 2,500,000 tons by 2020 driven by the global demand for clothing and textiles manufactured in Bangladesh (Uddin, 2014). In order to increase the domestic supply of raw cotton, the Government of Bangladesh has made a commitment to increase cotton production by introducing new and improved varieties of cotton hybrids and genetically modified Bt cotton. Neighboring countries including India, China, Myanmar and Pakistan have already introduced Bt cotton and significantly increased cotton production in the last couple of years. In recent years, the Cotton Development Board has field tested single gene Bt cotton hybrid sourced from Chinese Hubei Seeds in 2015-16. Bangladesh began greenhouse trial of a genetically modified (GM) cotton variety imported from China. The GM cotton seeds imported from Hubei Provincial Seed Group Company are infused with genetic traits taken from a soil-dwelling bacterium - Bacillus thuringiensis (Bt) - that effectively fights bollworm, a harmful caterpillar responsible for damaging cotton yields. Bangladesh Agricultural Research Institute (BARI) provided greenhouse facilities to CDB for the GM cotton trial. BARI Biotechnology Division has complete greenhouse trial completes successfully by December 2015. Than Bt cotton began to a field trial within the BARI compound next season and then trials for its adaptability was begin at a regional level in the following season(Daily star,2015). Within three years regional yield trial will be complete. Bt cotton has the potential to increase the yields up to 20 percent and enhance fibre quality of cottons as those are not attacked by the bollworms. Probably farmers will get Bt cotton after seven months when the National Committee on Bio-safety (NCB) gave approval for this GM variety. CDB set a target to increase annual cotton production to one million bales in the next five years. Officials said introduction of Bt cotton would help reach that target easily as well as helping save the money spent for costly imports.

3.17 Flavr savr tomato

In our country flavr savor tomato introduce by the company Monsanto. According to the name of scientist Flavor savor its name is Flavor savor tomato. Now in super market these tomatos are found. Through genetic engineering, to slow down the ripening process of the tomato and thus prevent it from softening, while still allowing the tomato to retain its natural colour and flavor.[3] The tomato was made more resistant to rotting by adding an antisense gene which interferes with the production of the enzyme polygalacturonase. The enzyme normally degrades pectin in the cell walls and results in the softening of fruit which makes them more susceptible to being damaged by fungal infections. The intended effect of slowing down the softening of Flavr Savr tomatoes would allow the vine-ripe fruits to be harvested like green tomatoes without greater damage to the tomato itself. The Flavr Savr turned out to disappoint researchers in that respect, as the antisensed PG gene had a positive effect on shelf life, but not on the fruit's firmness, so the tomatoes still had to be harvested like any other unmodified tomatoes. An improved flavor, later achieved through traditional breeding of Flavr Savr and better tasting varieties, would also contribute to selling Flavr Savr at a premium price at the supermarket.

The FDA stated that special labeling for these modified tomatoes was not necessary because they have the essential characteristics of non-modified tomatoes. Specifically, there was no evidence for health risks, and the nutritional content was unchanged. (Weasel, 2009)

3.17 Example of how Bt Brinjal, Bt Cotton, Bt Soyabean develop?

Bt stand for the name of the Bacteria from which it isolated is *Basillus thurengiensis*. It contains Bt gene or *Cryo* gene. The Cry gene name as it synthesized crystal protein. The characteristics feature of crystal protein dissolved in alkaline P^H. If it dissolves it become toxic. The Lepidoptera caterpillar gut region is alkaline condition. The plant has no alkaline condition in physiological process. When the larvae feed leaves as well as they feed crystal protein, crystal protein dissolved in gut of larvae and become toxic. As a result epithelial cell of gut region perforated and larvae get killed.

3.18 First biotech rice/GM rice in Bangladesh

Bangladesh Rice research institute release first biotech rice during 2017 (Daily Star 2017). It got release as the name BRRI dhan-86. Anther culture which is frequently used as biotech tools is applied to develop this rice variety. This anther culture, applied for the first time in rice science in Bangladesh, is a biotech plant culturing technique where immature pollens are made to divide and grow into tissues either on solid and liquid medium. BRRI breeders developed that the new variety, with half a tonne of extra yield potential per hectare over the country's most produced rice variety BRRI dhan-28, is derived from Iranian rice variety Niamat through application of a biotech tool called anther culture.

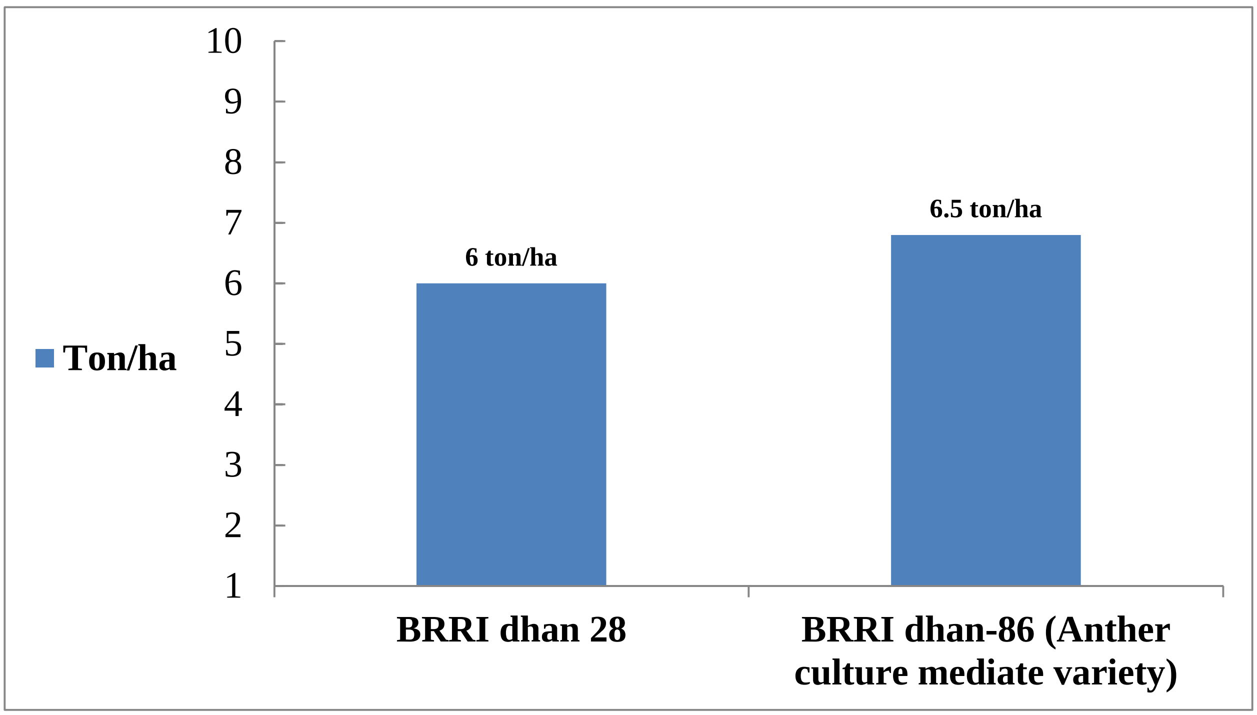

Figure 8. Anther culture mediated first biotech variety develop by BRRI with 0.5 ton extra yield.

The scientists at the Bangladesh Rice Research Institute (BRRI) have also developed a new rice variety with the highest ever zinc (27.6 mg/kg) content. In 2013, Bangladesh released the world's first biofortified zinc-rich rice variety BRRI dhan-62 with 19 mg/kg of the micronutrient. Since then countries scientists at BRRI and Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) have, so far, developed six zinc-rich rice varieties with the richest in zinc content (Daily Star 2017).

3.19 Second GM rice ready for release (Golden Rice)

Rice is a globally major staple food. It is also a main staple food in Bangladesh. Vitamin A deficiency is a problem in developing countries. Plants synthesize provitamin A carotenoids, such as -carotene, which are converted to vitamin A in the human body. Natural sources of -carotene include green leafy vegetables, yellow vegetables, and broccoli. However, when these vegetables are cooked or processed, their nutritional levels decline.

Rice does not contain any beta carotene. Dependence on rice as the predominant food source, therefore, necessarily leads to Vitamin A deficiency (VAD), most severely affecting small children and pregnant women. According to World Health Organisation (WHO 2010) global database on vitamin A deficiency, one in every five pre-school children in Bangladesh is vitamin A-deficient. Among pregnant women, 23.7 percent suffer from the deficiency.

Meanwhile, scientists at the Bangladesh Rice Research Institute (BRRI) told The Daily Star that on completion of a successful trial of the genetically engineered Golden Rice at the transgenic screen house of BRRI, they have taken the biotech rice GR-2 E BRRI dhan-29 to confined field trials late last year.

As follow-up steps, open-field and multi-location trials would be conducted, setting into motion the last stage for its release to the farmers.

Along with two other rice varieties (IR-64, a variety developed by the International Rice Research Institute, and RC-28, a Filipino variety), BRRI dhan-29, one of Bangladesh's most productive rice varieties, has been genetically engineered to have producing beta carotene (also known as pro-vitamin A). This has been widely publicized as Golden Rice for its yellowish colour.

Consumption of only 150 gram of Golden Rice a day is expected to supply half of the recommended daily intake (RDA) of vitamin A for an adult. People in Bangladesh depend on rice for 70 percent of their daily calorie intakes.

Normal rice Golden rice

Figure 9. The colors of normal rice and golden rices which contain β-carotene.

Therefore it was necessary to use recombinant genetic techniques, not conventional breeding, to develop a rice endosperm that would produce carotene. The entire -carotene biosynthesis pathway (three genes on three vectors) were transformed into rice endosperm using Agrobacterium. The result were yellow endosperms and gained the name Golden Rice. The yellow color was from the -carotene formed in the endosperm (8). By 2002, Beyer et al. had refined the technique and were able to transform the -carotene biosynthesis pathway by either single- or co-transformations of cDNA constructs. They used 2 genes from daffodil *Narcissus psuedonarcissus* and 1 gene from a bacterium *Bacillus thurengiensis* (11). The resulting Golden Rice yielded 1.6 – 2.0 μg -carotene/g of dry rice. There have also been considerations for crossing Golden Rice with a rice producing high iron because -carotene helps increase the bioavailability of iron (11). At this point, Golden Rice is a good resource for a supplementary source of -carotene and subsequently, vitamin A.

3.20 Future directions for the creation of GMOs in Bangladesh

Humans' ability to modify crops for improved yields and nutrients in a given environment is a keystone of agriculture. The technological advancement from selective breeding to genetic engineering has opened up a large realm of possibilities for the future of our food. As techniques for genetic engineering, such as new RNAi- and nuclease-based technologies that allow for direct modification of the genome, steadily improve, our ability to create new GMOs will also grow. As our scientific capabilities expand it is essential that we discuss the ethics and ideals surrounding GMOs so that we may effectively and safely use this technology in a way that is acceptable to the public.

3.21 Advantages of GMOs:

- ✓ Saves the use of toxic chemicals. GM crops can be made resistant to pests, so pesticides do not need to be sprayed on them. This is also better on the environment!
- ✓ Prevents wasted crops. If pests cannot eat the crops, nothing goes to waste. Therefore farmers make more money!
- ✓ It could potentially solve hunger. Many people agree that there is not enough food in the world to feed everybody. As genetically modified foods increase the yields of crops, more food is produced by farmers.
- ✓ We can begin to grow foods in different conditions. For instance. Straw berries can be genetically engineered to grow in frosts. Other foods that grow in cold climates could be engineered to grow in hot climates (such as African where much of the continent does not have enough food).

3.22 Disadvantages of GMOs:

There have been numerous criticisms leveled at genetically modified produce and it is important that we as the consumer are informed about the possible drawbacks of a product.

Changing plant may have lasting effects on other organisms in the ecosystem. The change in a plant may cause it to be toxic to an insect or animal that uses it as its main food source.

Due to the widespread use of insect resistant genes in crops the insects may become resistant to the genetic modifications. This world causes a widespread loss of crops and plants that have the natural immunity leading to a loss in biodiversity.

Breeding and cross pollination across unintended species could occur resulting in things such as insect resistant weeds.

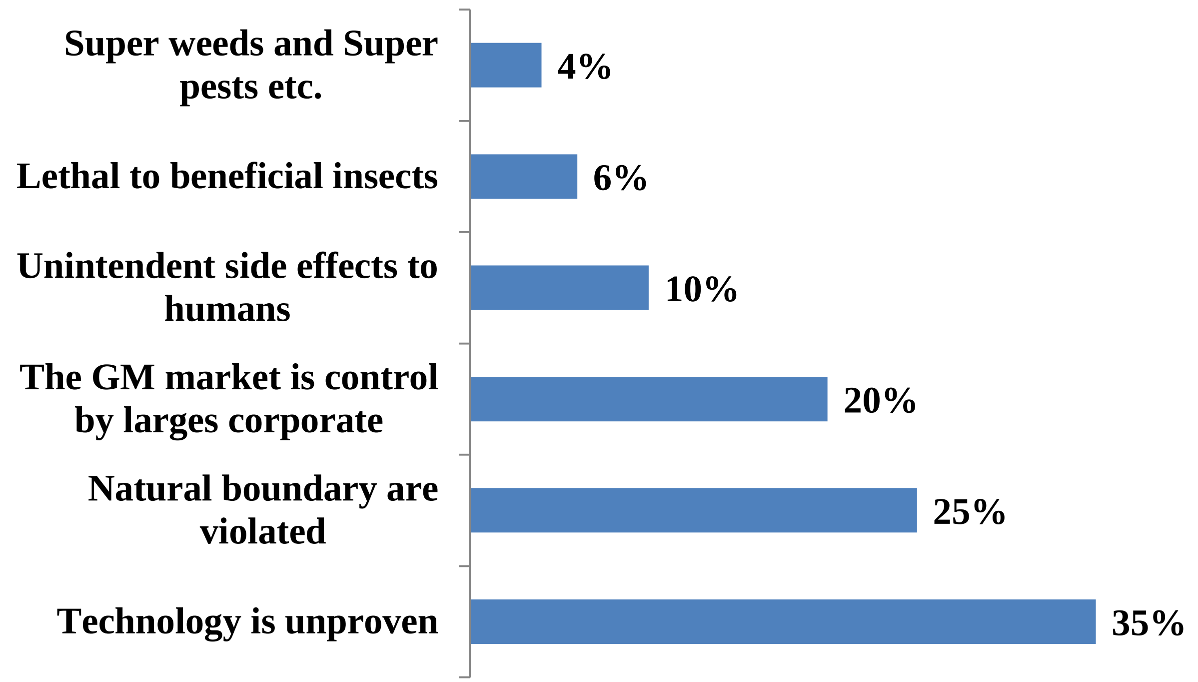

Figure 10. Predominant disadvantages of GMOs

Genetic modification can also make it difficult to know what you are eating, as a plant could contain animals products via genetic engineering. This could cause issues for those with dietary restrictions and religious commitments.

Unintendent side effects to humans, Allergic reactions, Infertility, Birth defects, Lethal to beneficial insects, Super weeds and Super pests etc.

4. Conclusions

1. Present status of GMO crop is satisfactory considering among South Asian countries but not up to the level comparing population growth. Bright scopes are waiting to utilize GMO to meet country demand.

2. The concept of the consumer is not clear about GMOs. Scientist communities especially agro knowledge based society should give effort to remove fear facto of consumer about GMO.

3. Genetically modified organism (GMO) foods are feared and hated by environmentalists and the public alike. Yet the scientific assessment of GMOs is remarkably different. Every major scientific evaluation of GMO technology has concluded that GMOs are safe for human consumption and are a benefit to the environment.

5. Recommendations

I agree with the use of transgenic crops. I think that they should be used, because the new organisms have some benefits that can be very useful.

For example, Golden Rice helps people who eat rice, but don’t get enough vitamin A. Also, there are crops that are resistant to herbicide, which saves farmers time and money.

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