Impact of Genetically Engineered Crops on Agri-products Sustainability in India: Challenges, Action and Expectation

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Abstract: *With the advent of recombinant DNA technology in Agriculture the crop improvement entered a new realm. Recombinant DNA Technology has seen as a potent tool for enhancing a crop productivity and food quality and therapeutic medicines productions. These agriculture advancement are important for maintaining the global production of sufficient agri-based products in sustainable manner to face with globally increasing human population. Recently, Indian farmers have planted 11.6 million hectares Bt cotton and produced 6.51 million tons of cotton fiber, which is 95% of the total 12.2 million hectares of cotton in the country. Resistance to herbicides insects and viruses have been genetically engineered into a few crops globally like corn, cotton and soybean. The transgenic plants reduce pesticides application so that they are suitable for organic farming. Scientists have traditionally cultivated fields to disrupt weeds to reduce its ability to absorb water. The Development of Genetic Engineering (GE) in agriculture could affect farm structure, labor dynamics & community viability. Public and private research organizations should allocate sufficient resources to monitor and assess the substantial environmental, economic and social effects of current and emerging agricultural technology. Furthermore, scientific support should be focused on expanding the preview of GE technology in transgenic crops development. The information presented in this review addresses questions about the recent advances on Genetically Engineered Crops. No single technology can solve all the problems, but a combination of transgenic technology, organic farming, marker assisted breeding and traditional practices would markedly improve crop yields.*

Keywords: Transgenic crops, sustainable agriculture, organic farming, markers etc**.**

Introduction

Amid late years there has been an impressive progression of Science and Innovation for utilizing present day Biotechnological tools for the generation of foods, feeds, and drugs. These incorporate the development of genetically engineered (GE) crops, use of genetically modified organisms (GMO), especially recombinant bacteria. The improvement of genetically engineered crops have focused transcendently on enhancing conventional pest control methods. Research valuation shows that these GE crops by and large convey imperative financial and some ecological advantages over their traditional product options. In any case, initial evidence specifies that current GE crops won't cultivate practical editing frameworks aside from the negative natural and social criticism properties. Moreover, it has been accounted that some seed and chemical farms focused on development and promotion of sustainable agricultural systems. According to Genetic Engineering Approval Committee (GEAC), GE crops foster agricultural sustainability by boosting financial performance and trending to key environmental challenges.

In 2002, India has endorsed for Bt-cotton (*Bacillus thuringienesis*) hybrids for commercial cultivation by GEAC and Ministry of Environment and Forests (MoEF), Government of India (GoI). According to Department of Biotechnology (DBT), GoI has recommended a data on bio-safety of Bt-Cotton such as toxicity, allergenicity, impact on non-target beneficial organisms, pollen flow etc.
The practice of Bt cotton has brought about a 24% increase in yield per acre, and a gain of 50% in profit to small holders. There is a surge of studies indicating positive impacts of Bt-technology (Qaim, 2003; Kathage, 2012). According to GEAC study which is related to the cotton-growing regions of India and scrutinize short-term impacts of the technology in terms of reduced pesticide expenses, increased yields, improved health outcomes, increased farmers' net income and improved rural economy. Currently, GE crops are commercially grown by 8 developed and 19 developing countries on 175.2 million hectares area (James, 2013).
Across the globe, these crops are now cultivated on an area of 181.5 million hectares (mha), which is more than the aggregated arable land area of India. Currently, USA is the largest producer of GE crops in the world. USA has already derestricted some petitions of various crops like corn, cotton, tomato, soybean, canola, potato and sugar beet. Among other North American countries, Canada is the fifth largest (11.6 mha) adopter of GE crops, viz. canola, maize, soybean and sugar beet. Brazil (42.2 mha) and Argentina (24.3 mha) in South America are the second and third largest GE crop growing countries in the world, respectively. Africa's share is less than 1.6% of the world's total area under GE crops. Though, field trials of several GE crops are under way. Maize is the only GE crop grown in five European countries (around 0.15 mha) (Giri & Tyagi**,** 2016).

The expanded yield, reduced cost of production, and higher net returns per hectare are the major drivers of widespread adoption of GE crops by farmers (Pray *et al.*, 2001, Subramanian *et al*., 2010). Now Indian Agriculture is facing a dual problem whether to increase the crop productivity at the cost of environmental pollution or sustaining the current level productivity ensuring peripheral conservation of natural resources. India, which has 91% of its cotton area under GE varieties, and allocates substantial resources to agricultural biotechnology is giving mixed signals on the regulation and use of other GE crops (Bagla, P., 2012) (**Table-1**). This paper considers the contribution of GE crops in relation to specific sustainable development goals towards the agri-crops.

Table No. 1- Time line of GM Crops in India

2002	Bt Cotton released in India
2006	GM crops cultivation reached 100 mha worldwide. Bt cotton II released in India for controlling *Spodoptera* & *Helicoverpa*
2009	GEAC recommended commercial release of Bt Brinjal Event EE-1
2010	Govt. of India imposed moratorium on Bt Brinjal Event EE-1
2014	Bt Brinjal released in Bangladesh
2015	Transgenic Maize grown in 67000 ha in India
2017	Enhanced production of Bt Cotton in India

Generation of GE Crops

In order to generate GE crops, Agronomist has regenerated transgenic crops by introducing new traits genes. In addition, transferred gene is expressed and inherited for crop product optimization. Generally speaking, there have been using three generation for modification of transgenes in the agri-crops.

First Generation

The first generation of GE crops were primarily aimed to increasing farmers net results through savings in production costs, reduction of chemical use, increase flexibility in crops planted and in the same cases, yield advantages. Input traits such as pest resistance and herbicides tolerance represented the first generation. The new wave of the agricultural biotechnology has offered advantages to farmers in the production phase without changing the final product.The first generation of GE crops, mainly soybeans, canola (commonly known as rapeseeds), corn (maize) and cotton, was approved for commercialization in 1996. Another characteristics of the GE crops from the first wave was that they were not directly used as foods. Examples of such crops are herbicide resistant soybean, insect resistant maize, and herbicide and insect resistant cotton.

It can be considered a success with upwards of 167.2 million acres being planted worldwide in 2003. However, despite genetically modified corn and soybean being an intrinsic part of the US food supply, making up 45% and 85% of US acreage planted in 2004, respectively. Agricultural biotechnology has lost momentum in recent years with fewer new products being brought to the market, as evidenced by reduced field testing (Stewart *et al*, 2005). Additionally, in spite of highly touted environmental benefits, the first generation plant biotechnology had not received high levels of public support, nor had it promoted to great public concern, mainly due to the general public not being aware that products of agricultural biotechnology were present in their food (Shanahan *et al.*, 2001; PEW, 2003).

Second Generation

Scientists have been pursuing many avenues to produce the second generation of GE crops which may provide more benefits to producers and some tangible benefits to consumers. Examples of such crops include rice with a higher level of beta-carotene, tomatoes with higher levels of carotenoids, maize with increased vitamin C, soybean with improved amino acid composition, and potatoes with higher calcium content (Lusk and Jason, 2003).

A second wave of GE crops, referred to as value-enhanced crops, includes those plant varieties that have one or more output characteristic modified. These crops have potential to provide momentum to the agricultural biotechnology industry and to enhance productivity worldwide (USDA site, 1999). The second generation of agricultural biotechnology concerned about the product quality characteristics such as having better taste, more nutritional content, and having longer shelf life. Despite the obvious promise, these products have yet to make significant way inroads into the market. Calgene's Flavr Savr tomato, which should provide better tasting tomatoes by increasing their shelf life, ultimately could not be kept on grocer's shelves due to marketing and transportation problems.

Third Generation

Third generation crops are only grown on small scales, their 'first generation' counterparts (plants modified to improve the original crop) are rapidly being adopted across the world. The another objective may be to create "pharma-plants" to help produce active pharmaceutical products.

Fears about food safety, environmental safety, and loss of overseas sales have hindered GE crops. But studies show such fears are largely unfounded. Attitudes to GE crops may now be changing, as policymakers recognize that science, technology and innovation can drive economic development.

The process by which GE crops are formed known as genetic engineering. Genes of commercial interest are moved from one organism to another. Currently there are two primary methods exist for introducing transgenes into plant genomes (**Figure 1**). The first encompasses a device called a 'gene gun'. The DNA to be introduced into the plant cells is coated onto minute particles of gold or tungsten. These particles are then physically shot onto plant cells and incorporated into the genomic DNA of the recipient plant. The second method uses a bacterium to introduce the genes of interest into the plant DNA.

The most widely used technique for delivering exogenous DNA is microparticle bombardment. The technique was developed in the late 1980s by Sanford (Sanford, 1990). Naked, engineered DNA is coated on gold or tungsten microparticles, which, in turn, are delivered at high velocity into targeted tissues, such as embryonic tissues from the seed or meristems, propelled by pressurized helium. There are other ways to deliver DNA into plant cells, including electroporation (letting the negatively charged DNA move down an electric potential gradient) into protoplasts, microinjection, chloroplast transformation, silicon-carbide slivers, mesoporous silica nanoparticles, etc. (Barampuram & Zhang, 2011). However, particle bombardment remains more effective at transferring large DNA fragments even whole chromosomes simultaneously (Schmidt *et al.*, 2008).

The intraspecific polymorphism of the markers may be significant for marker assisted selection, since breeding programs might have to use some form of monitoring of allelic richness. The molecular basis of the cultivated cotton are reduced, but can be amplified by landraces or exotic germplasm introduction (Hintum *et al.*, 2010). The markers selected in the present study may be used to monitor genetic diversity among Brazilian or foreign genotypes and their crosses, as well as to select the most distant parental crosses that could foster genetic variance and, consequently, genetic gains, reported for cotton by Gutiérrez and his coworkers 2002.

Bt-cotton technology was first developed and commercialized by Mahyco-Monsanto Biotech. The technology comprises of isolation of a gene cry1Ac from a soil bacterium and its infusion into the cotton genome through genetic engineering offers protection against all the major species of Indian bollworms- *Helicoverpa armigera* (Old world bollworm), *Pectinophora gossypiella* (Pink bollworm), *Earias vittella* (Spotted bollworm) and *E. insulana* (Spiny bollworm) (Manjunath, 2009).

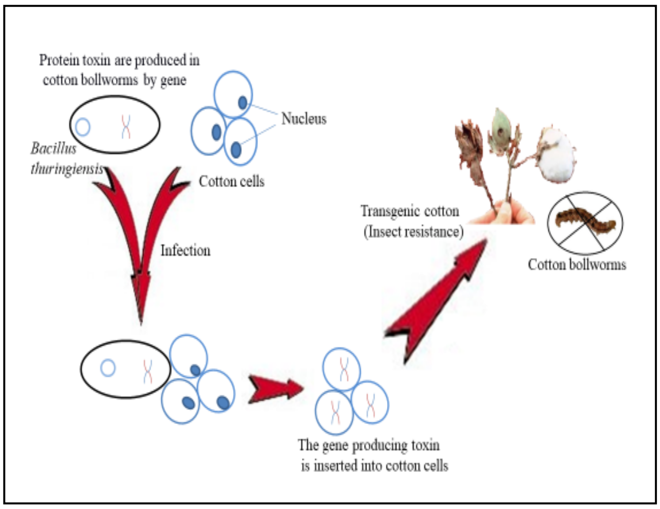


Figure 1: Production of insect resistance toxin

Bt-technology has perceived an impressive adoption rate and emerged as one of the fastest adopted crop technologies in the history of Indian agriculture. Within a decade after release, area under Bt cotton has increased remarkably at the rate of 90% per annum; it occupied 91% of total cotton area (12.2 m ha) in the country by 2011–12. The 91% adoption rate in India is fairly comparable with other mature biotech cotton markets like Australia (99.5% adoption), USA (94% adoption) and China (80% adoption) (James, 2012). It is worth noting that Bt-cotton has not only replaced non-Bt cotton, but also led to an increase in overall area under cotton cultivation from 8.44 mha during triennium ending (TE) 2002–03 to 11.8 mha during TE 2012–13, at an annual growth rate of 4.83% (Srivastava & Kolady, 2016).

Regulation of GE crops

The approaches concerned by governments for the regulation of genetic engineering to assess and manage the risks associated with the development and release of genetically modified crops. There are differences in the regulation of GE crops among countries with some of the most marked differences occurring between the USA and Europe. Regulation varies in a given country depending on the intended use of each product. For example, a crop not intended for food use is generally not reviewed by authorities responsible for food safety (Wesseler, *et al.*, 2011; Beckmann, *et al.*, 2011).

Biosafety concerns about GE crops are addressed by strict national and international policies and devoted regulatory bodies for research, evaluation and safe use across the world. The first set of guidelines related to agri-biotech products was enacted under the Environment Protection Act (EPA), 1986 by the MoEF and stated to as Rules 1989 which provided “rules for manufacture, use, import, export and storage of Genetically Engineered Organisms or Cells.” Later along in 1990, the DBT developed the rDNA Guidelines (amended in 1994) introducing measures for research and development of GE crops, their large-scale manufacture, release as well as testing in soil for field scale evaluation.

In 1998, DBT introduced guidelines for biotech plant research which involve guidelines for import and shipment of GE plants for research purpose. EPA rules in India are enforced by both MoEF and DBT through various authorised bodies. Institutional Bio-safety Committee (IBSC), which became the first body to review agri-biotech applications for approval. After approval of GE product applications, it was then considered by a Review Committee on Genetic Manipulation (RCGM) for monitoring field trials and recommendations to the statutory body GEAC for approval.

The Cartagena Protocol on Biosafety (Heinrich, 2002). which was negotiated under the auspices of the Convention on Biological Diversity (CBD, Rio de Janeiro, 1992), was adopted on 29 January 2000. It arrived into force on 11 September 2003, 90 days after the fiftieth instrument of ratification was established. As of 31st December 2004, 111 countries, together with the European countries, had agreed to it. The Protocol entered into force at a critical time in trade policy, with growing tensions around the obstructive trade command applied by certain countries on agro-biotechnology [Mackenzie, *et al.*,2003]. It provides the ground for the Protocol to be conceived as an instrument primarily concerned with the conservation and sustainable use of biological diversity, more than with international trade. The Protocol does not cover consumer products derived from “living modified organisms” such as corn flakes, flour, starch, seed-oil, tomato paste or ketchup.

Positive Impacts of GE crops

For the development of improved food materials, GE has to allow a much wider selection of traits for improvement. It does not just apply to pest, disease and herbicide resistance but also potentially drought resistance, improved nutritional content and improved sensory properties. It allows greater precision in selecting characteristics and reduces risk of random occurrence of undesirable traits (wiseGEEK,2017). These advantages could in turn lead to a number of potential benefits, especially in the longer term, for the consumer, industry, agriculture and the environment is to improved agricultural performance with less labour and cost input. The following attributes for the beneficial uses of transgenic crops are as following:

(1) **Better Pest and Disease Resistance**: Those crops which modifies genetically can produce varieties that are more resistant to pests and diseases, reducing losses and dependence on pesticides. For example, a resistance given by gene to a mycological infection in a wild plant can be introduced into a food plant that lacks this safety. The crop is then less responsible to this disease.

(2**) Improved Stress Tolerance:** Genes that give greater tolerance of stress, such as drought, low temperatures or salt in the soil, can also be implanted into crops. This can be extend their range and open up new areas for food production (*e.g.* drought, salinity, etc.) in a near future (*Scott, et al.,* 2016).

(3**) Faster Growth**: Crops can be transformed to make them grow quicker, so that they can be cultivated and harvested in areas with smaller growing seasons. This another time can outspread the range of a food crop into new areas or possibly allow two crops in areas where only one is presently practical.

(4) **More Nutritious Crops**: Plants and animals can be built to produce higher amounts of essential vitamins and minerals, such as Copper, Zinc, and iron taking care of sustenance issues in a few segments of the world. They can likewise be adjusted to change the amounts of protein, sugar, and fats that they hold. This could lead to the production of nutrition designed unequivocally for a healthy diet.

(5) **Production of Medicines and Vaccines by Crops**: It may be possible to have plants and animals produce useful medicines and even vaccines, so that prevention and treatment of human diseases in some places can be accomplished cheaply and proficiently through the diet.

(6**) Resistance to Herbicides**: Crops can be modified to be resistant to specific herbicides, making it much easier to control troublesome weeds. Farmers can merely apply the weed killer to a crop field, killing the undesirable plants and leaving the food crop unaffected. For example, GE oilseed rapeseed - the source of canola oil is resilient to one chemical that's widely used to control weeds.

(7) **Better Tasting Foods**: Foods can be engineered to taste better, which could encourage people to eat more healthy foods that are currently not popular because of their taste, such as Broccoli and Spinach. It may be possible to insert genes that grow more or different flavors as well.
It has the ability to grow crops in previously inhospitable environments (eg. *via* increased ability of plants to grow in conditions of drought, soil salinity, extremes of temperature, consequences of global warming, etc.) Improved sensory attributes of food (e.g. flavour, texture, etc) (Farnham,1999).

Other benefits of transgenic plants

Important advantage of GE food is its enhanced ability to withstand long-distance transportation. The GE crops are picked, when still green are allowed to ripen during transportation, therefore yielding a longer shelf life. Even with prolonged shipping and storing periods, the product reaches its destination without spoiling. According to the manufacturers of these GE crops, using these seeds will yield a number of benefits, including increased yields and decreased costs. They push GE crops as a second "Green Revolution" in a World, with billions of hungry mouths to feed.

Negative Impacts of GE crops

Even with the several benefits of GE foods, the quantity of hazard involved with introducing GE crops into the environment as well as in humans. The usage of genetically modified plants and animals has already become common place in today's society without many people being aware of it. The deficiency of consumer consent in the choice to eat genetically modified foods creates an ethical dilemma. One of the biggest complaints to genetically modified foods is their unintended potential for harm, not only to humans who eat the products but also to other organisms that may consume the crops. Various genetically modified foods, for example, consist genes that increase resistance to certain antibiotics (Klümper, & Qaim, 2014). If this property were transferred to a person eating the food, antibiotics might not have the normal effects against infection. The risks have to be viewed in the long-term perspective beyond the immediate benefits of the products like the ones listed following:

(1) **Unexpected Side-Effects**: Some of the effects of genetically engineered food on human health may be unpredictable. The various chemical compounds present in foods behave in extremely complex ways in the human body. If the food contains something not normally present in the human diet, it is hard to tell what its special effects may be over time. Though GE foods are rigorously tested, there may be some subtle, long-term effects that cannot be detected yet.

(2**) Problems with Labeling of GE Food**: It may not be clear to customers exactly what they are eating when they purchase GE foods. Not all countries have a necessity to label food, or ingredients, as genetically modified, and even where such foods are clearly mentioned. People with an allergy to a specific ingredient may be surprisingly affected by a GM food that contains that substance.

(3**) Reduced Species Diversity**: Genes familiar with make crops harmful to specific insect pests may kill other, beneficial insects, with effects on higher animals furthermore to the food chain. This could lead to reduction in biological diversity. (Example GM crops, such as soybean, maize, canola, tomato, cotton, etc.)

(4) **Ecological Damage**: It is possible that genes for resistance to insect pests, diseases and herbicides might spread to native plants. Pollen from GM crops could be transferred by insects or wind to wild plants, impregnating them and creating new modified plants. This could lead to herbicide-resistant weeds and to the uncontrollable spread of plant species usually kept in check by natural predators and diseases. This might damage gentle ecosystems.

(5) **Effects on Non-GE Crops**: Pollen from genetically modified crops can also spread to fields covering

non-GM crops. This can result in allegedly non-GE foods actually containing material from genetically engineered crops . Another problem may be a hiding of the difference between foods that have been modified and those that have not, causing problems for consumers.

(6) **Over-Use of Herbicides**: The planting of herbicide-resistant crops might encourage farmers to use weed killers more freely, since they could then be applied indiscriminately to crop fields. As a result, the excess could be passed away by rainfall to pollute rivers and other waterchannels. The chemicals might poison for fish and other wild animals and plants, and could get into human drinking water as well.

(7) **The Benefits May Not Be Available to Everyone**: The potential to end poverty and malnutrition may not be realized if patent laws and intellectual property rights lead to genetically engineered food production being monopolized by a small number of private companies. The holders of the rights to produce GM foods may be disinclined to allow access to technology or genetic material, making countries in the emerging world even more dependent on commercial nations. Commercial interests may override worthy and potentially achievable goals, limiting the benefits to the world as a whole.

Challenges, action and expectation

The world's population continues to grow and over the next 40 years, agricultural production will have to increase by some 60%. Meanwhile a quarter of all agricultural land has already suffered degradation, and there is a deepening awareness of the long term consequences of a loss of biodiversity. The global pattern of food consumption too is changing with rising affluence fuelling a greater demand for food.
GE crops has attracted the closest attention, it has only one of a clutch of new breeding technology to have been developed in recent decades. The need to increase agricultural productivity and efficiency in developed as well as in developing countries is now widely accepted. To confront these challenges successfully will require policies and actions that capitalize on all scientific advances generated in the India and elsewhere.
There are various technology that can transform agriculture including Mobile farm advisory, Crop protection app, Unified payment interface, Advance a farmer fee saving migration water, Sowing app of smallholder farmers and interactive voice response as shown in the given **figure 2**.

The global population is estimated to reach 9.6 billion by 2050 - a more than five-fold rise since 1900. We need to increase our crop production by at least 60% to feed all the extra mouths. GE plants could hold the key to sustained productivity under testing conditions. Since 1996, when GE crops were first grown commercially, their global cultivation had seen an approximately 100-fold jump - making GE crops the most accepted crop technology of today (James, 2014). In the last two decades, almost 28 countries have adopted GE crops.

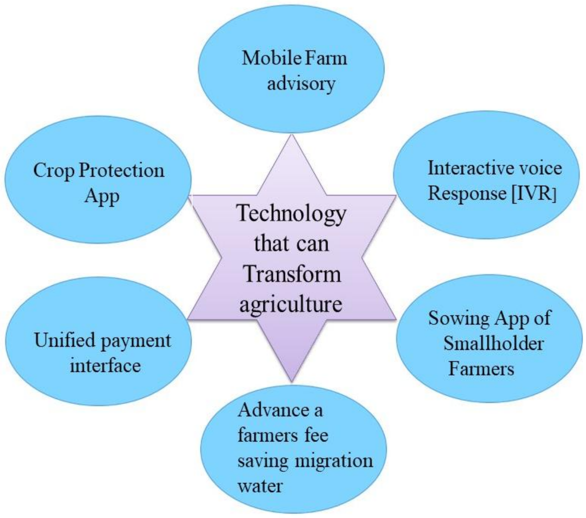


Figure 2: Technology that can transform agriculture

At present, approximately 18 prime crops are at various stages of development and/or field trials in India. These contain brinjal, cabbage, castor, cauliflower, chickpea, corn, cotton, groundnut, mustard, okra, papaya, potato, rice, rubber, sorghum, sugarcane, tomato and watermelon (Malik Zainul Abdin *et al.*, 2017). These crops have been targeted for improvement in different traits, which favorably include resistance to insect pests, viral and fungal diseases, tolerance to pesticides, nutritional enhancement, male sterility and tolerance to drought/soil salinity.
The report proposes that farmers register their crop and acreage sown with the nearest APMC (Agricultural Produce Marketing Committees) market. In case of falling the price, they would be entitled to the difference, up to certain percentage so that the quantum of subsidy is in accordance to the restrictions imposed by the World Trade Organization (WTO) (Chand *et al.*, 2015).
In a major deviation from the current discourse on GE crops, the report claimed that the farmers in India have "enthusiastically embraced" GE seeds for they need less fertilizer and pesticide. Agricultural experts, on the contrary, are carrying on a sustained campaign against GE crops observing that they are not a sustainable pest control strategy. In fact, they are adding to the pest problem. According to the report by March 2020, the government wants at least two-thirds of the states to have digitized and updated data on land ownership and liberal land-leasing laws in place that protect both the owner and the tenant. However, the project related to computerization of land records has not worked as per expectation and it also remains underfunded.

Challenges for Organic Agriculture

The lack of an organic policy for the domestic market and import is the biggest challenge. In the absence of regulation on labelling standard for organic production and logo, it is not possible to distinguish an organic product from a conventional product. The Indian government has been undertaking actions to endorse organic farming with the aim to recover soil fertility and help to double the farmers earnings by the year 2022. The study highlights issues faced by organic farmers that are affecting their livelihood and income are as following (**Table 2**):

Table No. 2 The Concept of Agricultural Sustainability

S.No.	Key Points	Challenges
1.	Consumer standards complex	❖ Poor quality ❖ Growers have higher rates of unmarketable blemished product. ❖ Limits sales revenue.
2.	Reduce profitability	❖ Food prices are low and land is expensive.
3.	Organic farming difficulty	❖ Industrial scale farming is difficult
4.	Exclusive organic certification	❖ Not able to justify the expense for organic certification.

Concept of Agricultural Sustainability

Sustainable agricultural production system has guided to their policy work and food supply chain. Three such themes or core aspects can be identified:

a) A clear commitment to environmental protection, in particular reduced emission and increased resource efficiency.

b) A commitment to securing intra- and inter-generational equity, that is meeting at least the basic needs of everyone today and in the future.

c) A realization that sustainability (or sustainable development) involves several dimensions or areas of concern that need to be integrated in all planning and decision-making concerning food production, processing and retailing (Jacobs, M. , 1999; Connelly, 2007).

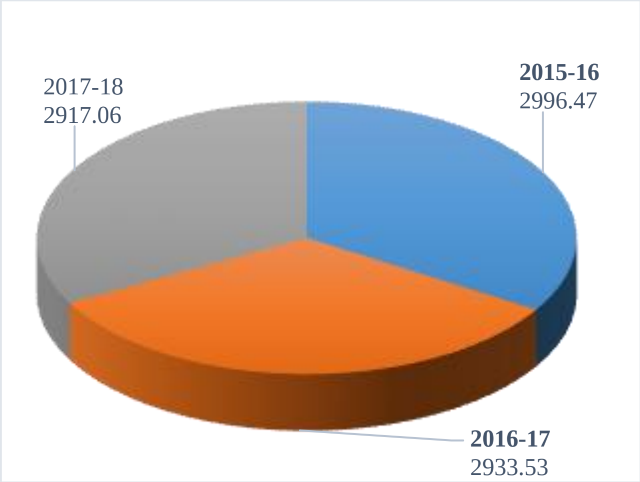
Comparing to the world wide cotton production, the year 2015-16 have yielded 2996.47 lakhs cotton and the year 2016-17 cotton production becomes 2933.53. In **figure 3**, it has been shown that the year 2017-18 net cotton production will be 2917.06. In all these three years, it can be clearly shown that the cotton production increased year after year.

In the year 2015-16, India produced 420.79 lakhs total cotton while in 2016-17, India produced 2933.53 lakhs. Despite the years 15, 16 and 17 respectively, the year 2018 shows the drop down production of cotton i.e. 2917.06 lakhs.

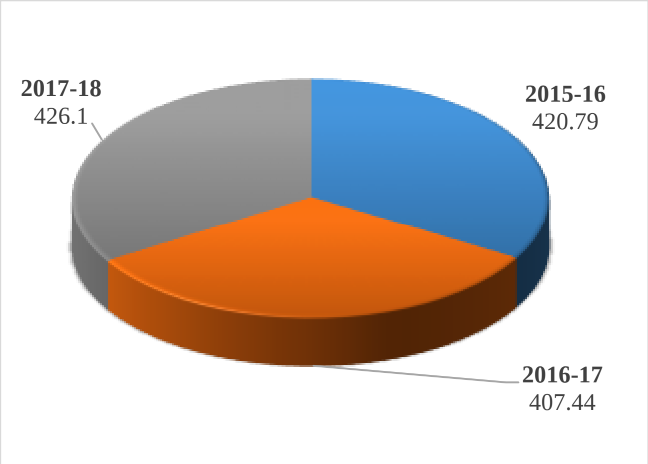
Farming system

Organic farming system in India is not new and is being followed from early time. It is a technique of farming system which mainly aimed at cultivating the land and raising crops in such a way, as to keep the soil alive and in good health by use of organic wastes (crop, animal and farm wastes, aquatic wastes) and other biological materials along with beneficial microbes (bio-fertilizers) to release nutrients to crops for increased sustainable production in an eco friendly pollution free environment.

As per the definition of the United States Department of Agriculture (USDA) "organic farming is a system which avoids or largely eliminates the use of synthetic inputs (such as fertilizers, pesticides, hormones, feed additives etc.) and to the maximum extent viable depend upon crop rotations, crop residues, animal manures, off-farm organic waste, mineral grade rock additives and biological system of nutrient mobilization and plant protection".



(A)



(B)

Figure 3: (A) Worldwide total cotton supply (B) India total cotton supply (In lakh bales 170Kg each).

FAO suggested that "Organic agriculture is a unique production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity, and this is accomplished by using on-farm agronomic, biological and mechanical methods in exclusion of all synthetic off-farm inputs" (Kalainith, 2013).

Molecular pharming is a modern tools that refers to the recombinant expression of pharmaceutically useful proteins in plants. In recent years, plants have become an attractive tool for the production of a wide array of pharmaceutical components. The plants as bioreactors have been use as rapid production of candidate proteins *via* transient expression, obviating the requirement for lengthy transformation and regeneration procedures.

Reasons for Organic Farming

The world's population has been increasing day by day and food scarcity for the world is becoming extremely worst. The need of the hour is sustainable cultivation and production of food for all. The Green Revolution and its chemical based

technology are losing its petition as shares are falling and returns are unmanageable. In spite of diet choices, organic food is the finest choice, and this means embracing organic farming methods. Foods from organic farms are overloaded with nutrients such as vitamins, enzymes, minerals and other micro-nutrients compared to those from conventional farms.
This is because organic farms are accomplished and nourished using sustainable practices. In fact, some past scientists collected and tested vegetables, fruits, and grains from both organic farms and conventional farms.
Some organic farmed foods would have a natural and better taste. The natural and superior taste stems from the well balanced and nourished soil. Organic farmers always prioritize quality over quantity (**Table 3**).

Table No 3: Benefits of Organic Farming summarize as below:

Properties	**Organic**	**Conventional**
Better nutrition	Organic food is much richer in nutrients than the conventionally grown food	Nutrients are comparatively less.
Helps us to stay healthy	Organic foods do not contain any chemical They don't harm humans and environment	Contains chemical
Free of poison	Organic farming avoids these toxins and reduces the sickness and diseases due to them.	It can be revealed by scientific study that a large section of the population fed on toxic substances used in conventional agriculture have dropped prey to diseases like cancer.
Organic foods are highly authenticated	Organic foods undergo a number of quality checks and it contains the labeling present on the top of the product.	Conventional food undergoes quality check as well but they doesn't contain any label present on the products.
Lower prices	They don't require application of expensive pesticides, insecticides, and weedicides, that's why they are cheaper.	They also commercialiased at reasonable prices.
Enhanced taste	They are way tasteful than conventional.	They have less taste.
Ecofriendly	Organic farming does not utilize any harsh chemicals so; the environment remains protected.	The chemicals in conventional farming applied infiltrate into the soil and severely contaminate it and nearby water sources.

Marker Assisted breeding

Marker assisted selection or marker aided selection (MAS) is an unintended selection process where a trait of interest is selected based on productivity, disease resistance, (morphological, biochemical or DNA/RNA variation) linked to a trait of interest (e.g. abiotic stress tolerance, and quality), rather than on the trait itself (Ribaut,. *et al.*, 2001, Hoisington et al 1998). This process has been widely researched and proposed for plant and animal breeding, nevertheless, "breeding programs based on DNA markers for improving quantitative traits in plants are rare" (*Ben-Ari et al., 2012).*

Simple sequence repeats (SSR) markers, also known as microsatellite DNA markers are very valuable for saturation of the huge and complex upland cotton genetic linkage map. Monsanto has invested heavily in development of cotton SSRs and has implemented molecular breeding technologies for the genetic improvement of cotton globally and the acceleration of the integration of biotechnology traits into the most elite upland cotton germplasm in the marketable pipeline. Genomic clones from microsatellite-enriched cotton DNA libraries were sequenced to identify SSR-containing target regions and SSR-containing EST collections were searched (Xiao, J et al, 2009).
Furthermore, the use of distinct multi locus genotypes should ensure variety protection in the world seed market and can be extended to experimental or commercial breeding when maximum genetic distances are required, as in the selection of parents for mapping or for other crossing purposes.

For example, using MAS to select individuals with disease resistance involves categorizing a marker allele that is linked with disease resistance rather than the level of disease resistance. The assumption is that the marker associates at high frequency with the gene or quantitative trait locus (QTL) of interest, due to genetic linkage. MAS can be helpful to select for traits that are problematic or exclusive to measure, exhibit low heritability and/or are expressed late in development. At certain points in the breeding process the specimens are scrutinized to ensure that they express the desired trait. The mainstream of MAS work in the present era uses DNA-based markers. However, the first markers that allowed subsidiary selection of a trait of interest were morphological markers.
The total cotton production of India from the last seven years is given in the respected table which depicts that the year 2011-12, 12.17 million hectares area is covered by cotton

where 36.7 million bales cotton are produced and a yield of 512 kg hectares of cotton (**Table 4**). In all these years, it can be clearly visible that the land covered by cotton is drastically reduced while the yielding of cotton are seemingly increased.

Table No 4: In India Cotton Production (million bales)
*1 bales=170 Kg.

Years	Area (in million hectares)	Production (in million bales)	Yields (in kg/hectares)
2011-12	12.17	36.7	512
2012-13	11.97	37.0	525
2013-14	11.96	39.8	566
2014-15	12.84	38.60	511
2015-16	11.87	33.80	484
2016-17	10.50	35.10	568

To operate novel genes and thereby increasing genetic diversity, all the three current approaches, *namely*, trait introgression *via* marker-assisted selection (MAS), genetic engineering, and *in vitro* mutagenesis, have pros and cons. Transgenics for better cotton fiber quality and other value-added traits have increased much attention in private sector. Number of fiber specific promoters, foreign genes that govern numerous novel properties, such as colour, toughness, and thermal properties have been acknowledged and incorporated into the cotton fiber (Rossbach, *et al*,. 2003; Guo, *et al*,. 2003). However, a practical realization of this approach in routine breeding program is yet to be demonstrated. There is also a renewed interest in chemical mutagenesis and transposon-mediated gene knock-outs as means to obtain single-gene mutants affecting phenotypes of interest, since the prospects of gene identification are high and every gene affecting a trait is potentially a target (Nadeau & Frankel, 2000). A highly saturated marker linkage map is necessary for effective MAS. Both intraspecific meiotic configuration analysis and interspecific linkage analysis indicated that the cotton genome map is ~5000 cM or larger, which is considerably longer than genomes of bread, wheat (3791 cM), soybean (3159 cM), corn (1807 cM), rice (1530 cM), tomato (1472 cM), and barley (1279 cM); A highly saturated genetic map of cotton with a 5,000-cM long genome will require 3,000 DNA markers to map at an average of 1 cM density (He, *et al.*, 2007).

Many industries stand to benefit from additional GMO research. For instance, a number of microorganisms are being considered as future clean fuel producers and bio-degraders. In addition, genetically modified plants may soon be used to produce recombinant vaccines. In fact, the concept of an oral vaccine expressed in plants (fruits and vegetables) for direct consumption by individuals is being examined as a possible solution to the spread of disease in underdeveloped countries, one that would greatly reduce the costs associated with conducting large-scale vaccination campaigns. Work is currently underway to develop plant-derived vaccine candidates in potatoes and lettuce for hepatitis B virus (HBV), Entero-toxigenic *Escherichia coli* (ETEC), and Norwalk virus.

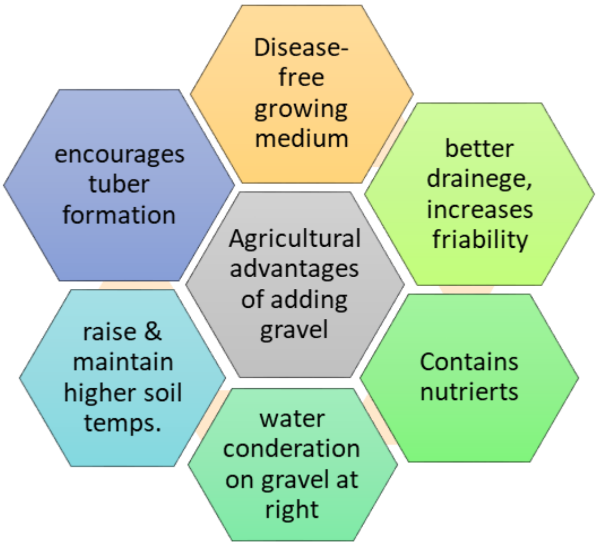


Figure 4: Agricultural advantages of adding gravel

The agricultural advantages of adding gravel can be clearly explained in the above figure. According to the figure, there are numerous benefits related to agricultural gravel i.e. Disease free growing medium, Encourages tuber formation, Raise and maintain higher soil temperatures. Water consideration on gravel at right, contains nutrients and better drainage with increased friability.

Economic impact of GM Crops

Genetic improvement in seeds through modern molecular biology techniques has been carried out mainly by a reduced number of international companies to give these products some characteristics that farmers would take as significantly beneficial for their work and economy because they contain a clearly marked increase in the protection from diseases transmitted by insects and viruses because they are more tolerant to herbicides.

Addressing the Health and Environmental risks of GM Crops

The possible implications and risks of genetically modified food in human health is a matter of concern in many countries and it needs to be addressed (Bolívar Zapata, 2011). In regards to GM foods derived from GMO, most countries considered that specific assessments are necessary and a specific system has been established for the rigorous evaluation of GM organisms and GM foods comparative to both human health and the environment. Similar rigorous evaluations are usually not achieved for traditional foods and crops. Foods resulting from GMO which are currently accessible on the market must have passed severe risk assessments and are not likely to present risks for human health. To date no effects on human health have been

revealed as a result of the consumption of such foods in the countries where they have been approved.
Regarding the health implications of the use of GMO in 2003. FAO pointed out that this topic cannot be addressed in a general way but in a one-by- one manner. It is necessary to study their scope case-by-case to make complete and transparent evaluations. In addition, the FAO maintains that modern biotechnology duly developed could play an important role in agricultural food production and in other areas of human development and that they could even contribute to food security. In 2005, WHO stated that it was necessary to boost improvement in other highly important factors such as infrastructure and access to markets to reach an agricultural growth supported by technology and research.
Another scenario of potential risk is that the inserted gene might disrupt the integrity of existing genomic information in the plant, leading to inactivation or other modulation of endogenous genes. Again, such a disruption might be envisioned to activate (or deactivate) metabolic processes involving product or toxins or their detoxification – in any case by events far removed from the known and intended effect of the inserted gene, and thus confounding our ability to draw a causal connection between the inserted gene and the alleged effect.

Future ambitions

India has the world's fourth largest GM crop acreage currently on the strength of Bt cotton, the only genetically modified crop permitted in the country. The overview of Bt cotton has been both highly successful and controversial. The applications of GM technology already described are not the end of the story, but merely the beginning. Scientists foresee the introduction of many more crop varieties with an innate resistance to plant pathogens obviating the need for chemical spraying. Adaptation to climate change is another looming issue. Asia is predicted to be a major source of future GM products.
The Indian government, for example, has dedicated itself to GM food crops through major scientific investment in rice, maize, rapeseed, soybean, sweet pepper, papaya and wheat variously to increase yield, quality, drought and salinity tolerance, nutritional value and pest-resistance. The Food and Agricultural Organization of the United Nations recently reported that the considerable quantity and variety of GM crops now in the pipeline may be commercialized in developing countries within the next 5 years. At the same time it was also shadowed by controversy, with a tangle of pricing and intellectual property rights (IPR) issues followed by government price interventions and litigation. India has taken only tentative steps towards establishing a strong regulatory system; the Biotechnology Regulatory Authority of India Bill, 2013, which delivered for multi-level scientific assessments and an appellate hearing, has lapsed. Hence, a strong regulatory authority should be recognized.
India's policy has divided into four phases. The first phase proceeds from Monsanto's initial application to introduce Bt cotton, which was rejected, to Mahyco-Monsanto's approval. Here, alliance between Monsanto and various domestic actors, and the discourse on the role of Biotechnology in India were important in influencing policy. The second phase covers the period from the field tests of Bt cotton to the refusal to grant permission for Bt cotton in 2001. The farming of biotechnology by anti-GM networks is seen as a key factor in the policy during this phase. Stage three looks into the Gujarat incidence and the approval to Bt cotton in 2002. The shift in discourse towards farmers and alliances between industry and farmers are focused upon here. The final phase is the approval of several Bt cotton seeds granted in 2005 along with the reversal in allowing Monsanto Mahyco Biotech (MMB) Bt cotton in Andhra Pradesh.

Conclusion

This paper has concentrated on GM technology and important set of policy issues confronting Indian agriculture to come up with recommendations that would help a progressively important role for agricultural sustainability in the future. This technology is likely to yield diversities of crops which can restrict to pest or drought and consequently they will rise yield and improve productivity to combat the food security problems in the developing countries. In addition to the necessity to increase the consumer's acceptance, we must also find ways to make these advanced technologies affordable to poor farmers in the developing world.
Commercialized GE traits are targeted at pest control and when used appropriately they have been effective at reducing pest problems with sustainable advantages to farmers. Although genetic engineering could be used in more crops in novel ways beyond herbicide and insect resistance, and for a greater diversity of purposes. With proper management, Genetic Engineering technology could help address food insecurity by reducing yield looses through its introduction into other crops and with the development of the other yield security traits like drought tolerance. However industry has insufficient incentive to finance enough in research and development for those purposes when firms cannot collect revenue from innovations that cause net benefits beyond the firm. Therefore, the progress of these trials will require greater collaboration between public and private sectors because the benefits spread beyond farmers to the society in general. The implementation of the targeted and tailored regulatory approach to the GE trait development and commercialization that meets human and environmental safety standards while minimizing pointless expenses will aid this agenda.
There is no scientific sign to prove that genetically-modified crops would harm soil, human health and environment. Among the above fascinating and gloomy scenario of GM crops in our agriculture sector, the Govt. should take steps with caution taking into confidence the claims and counter-claims advocated by the stakeholders so that the national interest get prioritized, restoring susceptibility of native varieties from genetic contamination by these novel types and propagating our economic super power status in international import-export trade.

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