Benefits of genetically modified crops, Biosafety concerns and related risks; A South Asian Perspective

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Abstract: Genetically Modified (GM) crops were introduced to agriculture systems in mid-nineties by private sector. The area under these crops has been increasing since then, and currently more than a dozen of GM crops were reported to be grown on nearly 200 million hectares (185 million hectares), spread over 26 countries and 18 million farmers. GM crops were initially successful in industrial countries but trend has shifted now. 100 million hectares were grown in developing countries and 85 million hectares were grown in developed world in 2016 though new countries and crops are added each year to the list leading to increased area in both developing and industrial countries. Among the crops there are staple crops like maize, papaya, potato and soybean, commercial crops like cotton, canola and sugar-beet, and fruit trees like apples. These crops have only added to farm incomes by reducing the input costs, improved quality and did value addition but also reduced food insecurity by sustaining yields. Food insecurity becomes an essential point of discussion when it comes to developing world. Another benefit which is attached with GM crops is environmental protection from hazardous chemicals sprayed for controlling insect pests on non GM crops. At the same time biopharmaceutical production in natural plant systems by gene manipulations is being materialized. Though many gains are affiliated with GM crops but some of the safety issues are also reported including antibiotic and herbicide resistance through selectable marker genes in non-target organisms on consumption, horizontal and vertical gene flow etc. If seen in the context of South Asia it becomes even more crucial. Almost 1/3rd of the world population resides in this region of the world and to feed such a big number of people on sustainable basis is a tough task. There is no second opinion that all the available strategies should be adopted to sustainably feed such big populations, but at the same time a huge number of people could not be put to risk by introducing controversial products in the market. During the last 15 years GM crops are introduced to South Asia legally and/or illegally or developed locally. At the same time awareness is created publically and governments have developed biosafety rules, and guidelines to deal with GM crops for safe use. In this review we will thoroughly review the benefits this region can gain from GM crops and at the same time we will review biosafety assessments and guidelines adopted by various countries for safe use of GM crops.
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1. Introduction:

Genetically modified organisms can be defined as living substances having genetic material form different sources, through this technology plants of desired qualities can be grow to get different benefits. Production of safe and healthy food, less use of toxic chemical and many other positive aspects of GMOs have been seen in different areas of world. Despite of these advantages of transgenic crops there are many potential environmental and health risks of using genetically modified foods for example allergic reactions, gene flow, vulnerability of plants to disease and many others. Scientists did not conclude the final remarks about this type of food (Du and Rachul, 2012).

Three percent increase in global area of GM crops have been conclude in 2016 with respect of 2015, total cultivated portion of transgenic crops is 185.1 million hectare that were 179.1mh in 2015. From 2012 to 2016, developing countries producing 54% biotech crops are more sincere than industrial countries cultivating 46% GMOs in adopting this technique. Total 26 states are using this practice which included 19 developed and 7 unindustrialized. Out of these 26 republics, 12 were in Americas, 8 in Asia, 4 in Europe and 2 in Africa. With respect to cultivated area, 88% hectares are grown in Americas, 10% in Asia, 2% in Africa and less than 1% in Europe (ISAAA, 2016).

Transgenic crops are used to provide the benefits to farmer like insect and herbicide tolerant crops, GM herbicide tolerant crops accounted for 63% of global GM plantings, while GM insect resistant crops accounted for 15% and stacked herbicide tolerant and insect resistant crops represented 22% of global GM plantings. In 1994, 1st transgenic crop were planted and in 2008 area of transgenic crop increased to 125 million hectare in different 25 countries and the US is the primary producer with 50% of total area and others are Argentina 16.8%, Brazil 12.6% India 6.1%, China 3.0% and Paraguay 2.2%. Almost 44% transgenic crops are produced in developing countries. Soybeans, maize, cotton and oilseed rape are main GM products (Disdier and Fontagné, 2010).

But production of transgenic crops created big disagreement in Europe. On one hand, GMOs are enhancing economic development according to many observers. On the other side, some challenge the possible advantages and made questions about GMOs risks regarding human health and environmental and their social distribution. Although this controversy, GM maize is highly cultivated in Spain since 1998but its only crop with commercial license in EU. It is cultivated in Spain 75.000 ha and also in Aragon and Catalan and in little amount in other EU countries. In the Catalan province of Lleida, GM maize represents more than 60% of the total maize surface. At the same time, the organic agriculture sector is also growing in importance, except for maize (Binimelis *et al.*, 2009).

There is need to understand about first generation and second generation GMOs. 1st generation include herbicide and insecticide tolerant crops while 2nd generation consists of Artic apple to avoid brown color, Omega-3-enhanced soy and the reduced-bruising potato. In short, GMOs is cultivated to provide better human/animal health, food betterment and the protection of environment. Yet, the issues regarding some properties of GMOs, cultivation of transgenic crops have increased worldwide since 1980, concentrating on the total effect on the environment, health and rural livings that enhance the growing, commercialization and consumption of transgenic crops as food and feed. Producers of GM crops claims that many problems like future poverty, food shortage, hunger, change in ecosystem can be solved by using transgenic crops, further production and safety of food will be increased. On the other side, private organizations sense the high risk issues regarding GMOs. There are many serious questions by public about the socio-economic and biodiversity effects of transgenic crops. Many debates related to risk issues has been conduct, and there is different point of view from different scientist as these risks are of real higher effects on health and environment or not (Myhr, 2010).

No doubt there is much potential assistance from the use of GM crops; the possible hazards to human health and the environment are the issues of concern. Many countries have developed regulatory orders to release and assess the risks of GM crops. This regulatory framework of different countries varies to each other depending upon the issues of releasing, goals and financial resources (Li *et al.*, 2014).

The aim of this article is to provide the information about different aspects like diverse types of benefits and risks of GMOs in environment, on human and animal health. This will also provide the knowledge about the different yield, ecological, social and economic effects of transgenic crops.

2. Negative impacts of transgenic crops:

Before adopting any GMOs, there is always two types of communities arises having different comments, one community considered the economic, environmental and yield benefits of genetically modified crops while other have different think so it's right thing to analyzed the different aspects of any newly commercialized GNMOs to safe the better future of that crop. Averages, almost 68% profit of farmers have been increased, 37% use of pesticides has been reduced and 22% crop yield has been improved by picking up this technique. Besides this huge improvements there are many risks associated with this technique can be seen in different area of the world (Klümper and Qaim, 2014).

Before commercialization of any GM crops, it have passed through different stages of checking including laboratory test, biosafety test, environmental release field testing, preproduction testing and application for biosafety certificates. After these tests, it proved that is that transgenic crop is beneficial or harmful (Li *et al.*, 2014).

Health related issue:

Three deaths have been occurred in Perambalur district during last month due to unsafe practice of insecticides in the field of (BT) cotton. Reasons of these human losses were use of dangerous chemical without acquiring any precautionary measurements to remove pink bollworm from the field of BT cotton (Tyagi and Dhanasekaran, 2018)

As well as use of pesticides increased, number of patients also enhanced due to much exposure of these substances. Introduction of these toxic compounds to human bodies change the behavior of disease. During last 25 years, 938% practices of pesticides have been increased from 38 to 370 million kilo. In Argentina, main cause of cancer is considered the too much use of these toxics (Gorban, 2015).

Five different strategies of Samsel and Seneff about the toxic behavior of glyphosate proved wrong experimentally. They conclude that environmental level of glyphosate is main reason of different diseases such as obesity, cancer, infertility, neuropathies, asthma, diabetics, diabetes and osteoporosis and their conclusions was based on misconception and in lab these arguments was not supported by experiments. They postulates that cytochrome P450 enzyme inhibition, amino acid biosynthesis, removal of essential manganese from body, increase in non-celiac gluten synthesis and addition of glyphosate in protein as a substitute of glycine cause many diseases and only glyphosate is responsible of all these factors. In vitro, observations proved wrong this hypothesis that glyphosate is only reason of theses illness and show that there are many other aspects that are toxic and cause of many illness (Mesnage and Antoniou, 2017).

Herbicide resistant crops when expose to the environment, many health risks arise due to glyphosate and its adjuvants such as ammonium sulfate, benzisothiazolone, glycerine, isobutane, isopropyl-amine, polyethoxylated-alkyl-amines and sorbic acid. It can affect the endocrine system and may promote the tumor in non-target species. Many researches proved the negative effect of GMOs on the health of rats which fed on transgenic food suffered from different types of illness like tumor induction, abnormal sperm, DNA damage, blood changes, liver damages and ultimate death (Mesnage *et al.*, 2013).

There are some indirect effect of GM crops on different beneficial animals like control of beneficial pest through pesticides, loss of milkweed habitat for Monarch butterflies through extensive spray of Roundup and neonicotinoid coating of maize affect bees decline (Vives-Vallés *et al.*, 2015).

2.1 Yield related issues:

Since the introduction of (BT) cotton in Pakistan, yield of cotton has been decreased to only four million bale this year while the target were 20 million bales. Main cause of this loss is not only the seed quality but also the lack of knowledge to our famers about the different tools and use of proper chemical substances to improve the growth. To improve the production of cotton in Pakistan there is basic need to control the cotton leaf curl virus and there is no need of GM cotton as it only kills pests (Shahid, 2015).

Genetically modified crops can negatively affect the helpful soil fungi and bacteria by minimizing their number and activities as these useful microorganisms break down the organic compound of soil to release the valuable nutrient to environment and in that response yield can be reduce (Hannula *et al.*, 2014).

Gene from transgenic crop may shift to other plant which compete the original transgenic crop and the loss of genetic information regarding high yield, so these loss cause the reduction in the production of crop (Mintz, 2017).

Production of resistance in pest or herbs against the genetically modified crops is much importance than the increase in production of crops by using this method for example in US, rootworm has been made resistance due to Bt and lowering the yield of cotton so we cannot say the future of high yield production is secured by GMOs (Jacobsen *et al.*, 2013).

Total nine pests have been evaluated that have resistance again BT crops due to large scale adoption of BT crops and proving the upcoming threat of GM technique. In US, resistant weeds to glyphosate have been originated in the area of GM crops. These evolutions of pests and herbs are causing the decline in high yield production. 99% grown area is under HT and IR crops due to high yield but crops of complex traits like abiotic stress tolerance, nutrition use efficiency or yield potential still does not commercialized. To get high yield of that crops, C4 photosynthesis pathway is replacing with C3 crops to increase the yield of crops with C4, it's the present need of world and 1st try to do that was done in 1994 in which phosphoenolpyruvate carboxylase (PEPC) from the C4 crop maize that catalyzes the initial fixation of CO2 was introduced into rice but it's showed that only one C4 gene introduction into rice have null or negligible effect so researcher should try to made enough change that will be proved advantageous to enhance the yield of crops having properties like abiotic stress tolerance, nutrition use efficiency or yield potential (Chen and Lin, 2013).

2.2 Gene flow related issues:

Gene flow means movement of gene from one organism to other. If it occurs between unrelated species then it called horizontal and if it spread through sexual, it called vertical gene flow. Gene may flow from any plant to its wild species, to non-transgenic crop, to other species and induce the transgenic properties which may prove harmful and undesired results origination. Gene flows through pollen movement from one transgenic crop to any other non-transgenic crop. Several factors affect the proper pollination like isolation distance of plantation, wind direction, crop rotation, geographical conditions, and genetic nature of the plant (Talas-Oğraş, 2011).

Movement of gene from a HT plant to wild specie produce resistance into wild so it become too much difficult to control that type of herbs also can say it transgenic herbs. The main cause of this problem is much use of herbicide without adopting the precautions such as "refuge" area without GM crops (Hicks and Millstein, 2016).

Introgression is a phenomenon in which alleles of a crop move to wild species through hybridization and this is the 1st step of introgression. For complete transformation there is a need of back cross of hybrid with wild plants. In Spain, gene flow from GM maize to non GM maize occurs through sea breeze. GM seed from maize translocate to non-transgenic maize so there is need to give some attention to this issue. Gene mobility also have been seen between *Pleurotus ostreatus* and transgenic cotton, slow growth for early 5 days observed in P. ostreatus and gene of genetically modified cotton has been detected at DNA level but not identified at RNA level and growth after 240 days also same like non transgenic *P. ostreatus* (de Jong and Rong, 2013).

3. Positive impacts of transgenic crops:

Beneficial purpose of GM crops means insertion of such trait into the genome of plants that have positive nature as increase resistance against the different diseases, insects, herbs and some unfavorable environmental conditions and increase the nutritional and production quality of food. So there are many benefits have been gained by using transgenic modified crops. Some of advantages include improved feed production for livestock, production of insect and herb resistant crops Increase the income and production of farmers and many others that we are going to discuss here (Deb *et al.*, 2016).

3.1 Benefits of GM herbicide and insecticide tolerant crops:

Profits obtain by adopting genetically modified herbicide and insecticide tolerant crops depend upon the total costs of acquiring this technique and this varies from country vise. By implementing these methods farmer controls the weeds and pests easily and less expensively. Many HT and IR crops like cotton, soybean, canola, sugar beet and corn are cultivating in different areas to make better the growth and income of farmer. Somewhere herbicides and pesticides are used alone and in some places mixture of herbicides and pesticides is needed to use (Brookes and Barfoot, 2016).

By using BT cotton, implementation of chemical reduced and yield of farmer is improved so now a number of farmers are using this technology to make better their living standards. China, India, Brazil, Argentina and South Africa is main five countries which has been adopting this technique on very large scale and produce many different crops having genetically modified traits (Azadi *et al.*, 2016).

As rice is the staple food in many countries especially in developing countries and populations of these countries increased day by day. GM herbicide tolerate rice "Golden Rice" is playing a significant role in increasing yield to meet this issue. Golden rice is vitamin A enriched (Litton *et al.*, 2017).

Improved form of glyphosate resistance gene that can resist to more than one herbicides and the same property of IR crops have been developed and proving beneficial to yield and income of farmers. Besides the herbs and insect, other microbes like fungi, bacteria and viruses also affect the crops and cereal crops having resistance against these microorganisms are in the process of developing in the same way of IR and HR tolerate (Dunwell, 2014).

3.2 Economic advantages of GMOs:

Farmers have been gained several economic benefits by adopting the cultivation of herbicides and insecticides tolerate crops. Basically five different things are measured while checking the economic benefits of GMOs, these included yield, pesticide quantity, pesticide costs, total production costs and farmer income per unit area (Klümper and Qaim, 2014).

Large numbers of economic benefits of this scientific application have been observed. After adopting this method, huge number of inputs decreased like herbicide and pesticides related expenditure and improved the yield revenue, nutritional qualities of food, safety of foods and many others. So GM plants are more advantageous than conventional plants (Jones *et al.*, 2017).

Long shelf life, high yield and affordable prices of GM foods is fulfilling the feed of world and providing advantageous economic factors to producers and consumers (Chow *et al.*, 2016).

In developed countries, GM herbicides tolerate crops serve as saving of budget regarding labor that were needed to control the herbs. Economic benefits basically depends upon the market policies, seed costs, access to labor, and water in different regions as well as farm structure. For example in some locations of South Africa Bt maize is advantageous where issue of stalk borers can occur and the places where no stalk borers problem Bt variety is costly due to high seed rate. Rice is considering major crop in Asia, in India, production of rice have been increased from 2 t/ha to 6 t/ha meeting the demand of rice in people and providing the healthy economic benefit to farmers.16 million farmers have been adopted this technique due to its fruitful economic advantages (Jacobsen *et al.*, 2013).

3.3 Use of GM technique in the field of pharmaceutical:

GM crops can be divided into three altered phases. 1st generation related to solve the agronomic practices like insecticide and herbicide crops. 2nd phase deals with improving nutritional qualities of food and feed. 3rd generation relates to prepare the bio manufacturing like pharmaceuticals, vaccines and industrial substances (Graff and Moschini, 2015).

Production of human pharmaceutical through transgenic rice is growing quickly because of its some handsome characteristics like high grain yield, more recombinant protein preparation and stability of transgenic rice based protein and peptides at room temperature. They can also bear the harsh, acidic and digestive enzymes of stomach (Wakasa and Takaiwa, 2013).

Protein which play role in the production of vaccine and other medicated products can be obtains by GM plants. Still only recombinant human intrinsic factor is commercialized to use in B12 deficiency but some other vaccines are in process of trail like hepatitis B vaccine, heat liable vaccine, human pro insulin and some monoclonal antibodies. These products will be very soon available to markets. By using GM crops such pharmaceuticals can be made which help in the manufacturing of complex multimeric protein like antibodies (Chow *et al.*, 2016).

Earlier GM crops proved its benefits to grower, now next generation GM food having such healthy components that are the need of proper health of public and were obtained by using the drugs. These components incudes: micronutrients (vitamin A, iron, folate, and ascorbate), fatty acid composition (oleic acid, omega-3 fatty acid), resistant starch, and antioxidants (anthocyanin). These healthy metabolites is promoting in the food by adding one or several genes into the metabolic pathways. For example golden rice developed to overcome the vitamin A reduction and some other next generation GM crops is reducing the risk of different chronic diseases such as obesity, heart disease, type 2 diabetes and many types of cancers (Chen and Lin, 2013).

Recent researches proved that GM crops can be used to improve the availability of such micro and macro nutrients in food that is previously ingested through medicine. Food with multi-nutrient qualities can also be obtained and commercialized but with the support of public, media and politician by educating these communities (Farré Martinez et al., 2011).

3.4 Environmental benefits:

No doubt main and unique source of feeding the world is agriculture but due to traditional methods of cultivation and harvesting many environmental issues like contamination of drinking water, soil degradation, erosion and reducing biodiversity so all these problems almost have been solved by using this new technique called Genetically modified (Jacobsen *et al.*, 2013).

This method also showing many benefits regarding environments by adopting insect resistant crops, reduction of many chemically toxic pesticides have been seen in atmosphere. Chemicals like organophosphates and synthetic pyrethroids proved very dangerous to the living organisms and due to this technique exposure of these toxic substances has been eliminated. This is not only a single advantage of GMOs, tillage practices of field also condensed in result of which soil related issue such as soil erosion also solved and organic matter of soil is improved (Azadi *et al.*, 2016).

In non-GM crops, pesticide application expose the dangerous greenhouse gases which pollute the soil and air and these toxicity to our environment can be controlled by using genetically modified crops. These less use of chemical on GM crops is not only favorable to environment but also help to lower the investment of farmer to cultivate crops (Chow *et al.*, 2016).

GM foods can be grown in that places which are unfavorable for traditional crops and reduces the need of toxic substances therefor we can say it environmentally friendly (Bawa and Anilakumar, 2013). Some potential environmental welfare of GMOs are very advantageous to the farmer as transgenic crops can bear the different stresses like floods, doughtiness, salt and some others (Mintz, 2017).

3.5 Improve feed for livestock:

With the increase in the population of world demand of basic needs of humanity like food consumption including milk, meat and vegetables also has been enhanced. Main source of these food stuff are crops as well as beneficial animals. GM crops cultivated for feed consumption of livestock comprise of soya, maize, oilseed rape, cotton seed, canola, as well as other grains. Due to intensification of world's demand for the food ingesting there is need of booster the production of such raw material which acts as feed for livestock. GM technology is playing sufficient role in enlightening the creation of feed material like maize, cotton seed, soya and other material for livestock (Deb *et al.*, 2016).

There is no harmful effect of the milk, egg and meat of those mammals which feed on GMOs. No doubt glyphosate is present in minute quantity in the products of that livestock but there is no harmful difference found between products of the mammals which feed on conventional crops and the animals which feed on GMOs (Van Eenennaam and Young, 2017).

1st trial of feed from GMP was observed in poultry when soybean meal from transgenic hybrids was applied, no significant difference was seen on the health measured. After that transgenic maize and feeding also did not show any significant difference of energy level. These types of feed also applied on pigs but the result was similar. In ruminants, when GM maize given, same results obtained and nothing better seen (Flachowsky *et al.*, 2005).

Glyphosate can affect biodiversity as reports have been published about its negative effect on human and animal health. In vivo, the adverse effects of glyphosate on male reproductive system of ducks and rabbits have been reported. However different opinions occur about its presence in drinking water for animals and humans, some says it shows negligible effect and some consider it much harmful so there is need of deep research about this aspect of glyphosate (Shehata *et al.*, 2013).

4. Biosafety rules of Bangladesh: Ministry of environment and forest has main power about biosafety rules and regulations of the country.

Bangladesh has been become the part of Cartagena Protocol on Biosafety on 24 may 2000. Ministry of Science and Technology of country was first organization which developed Biosafety Guidelines of Bangladesh in 2000. After this some changings and updates in these rules was done by different authorities in 2004 and 2006 in the light of Cartagena Protocol. These biosafety guidelines are applicable for all institutes that are doing research related to GMOs. Scopes and Objectives of Biosafety Guidelines, Institutional Arrangements, General Provisions on Biosafety, Physico-chemical and Biological Containments are the main constituents of this guideline. National committee on Biosafety (NCB), Biosafety Core Committee (BCC), Institutional Biosafety Committee (IBC) and Field level Biosafety Committee (FBC) are regulatory committees under the Biosafety Guideline of Bangladesh. Any application about GMOs moves through these committees. 13 biosafety rules have been passed which includes restriction on import, export and any kind of use of GMOs and many others (Sultana, 2017). GMOs of potato, cotton, rice, brinjal and eggplant have been approved and utilized in Bangladesh (Reaz, 2016).

4.1 Biosafety rules of Sri Lanka:

National biosafety framework was arranged in 2005 in Sri Lanka to access and minimize the risk about any product of biotechnology. Main objective of this framework was to ensure the safety of humans, animals and environment. National policy on biosafety was also prepared in 2005 to make the level of protection and safe use of GMO products. After this National Biotechnology Policy was settled in 2009 to support and promote the research in the field of biotechnology. In GM food regulation, this is clear highlighted that no person has authority to import, export and sale the any food having genetically modified portion without the permission of chief food authority (Pathirana, 2017).

4.3 Biosafety rules of Bhutan:

National Seed Centre (NSC), National Livestock Breeding Program, National Centre for Animal Health and Renewable Natural Resources Research Centers are four organizations which are involved in Biotechnology in Bhutan. In 1995, Bhutan became party to the International Convention on Biological Diversity (CBD). In 2002, Bhutan ratified the Cartagena Protocol on Biosafety (CPB). Biosafety act of Bhutan was passed in 2015. This act is about the all genetically modified organisms, their products and import, export and any commercial use of GMOs. Any transgenic product that is going to market should be labeled (BAFRA, 2017).

4.4 Biosafety rules of India:

Different rules and act has been formed and passed by different scientific Indian authorities since 1989. These all rules and regulations are about the research involving the transgenic products. Preparation, field trial, import, exports and release of transgenic food is done according to the laws formed by scientific societies in India. Recombinant DNA Advisory Committee (RDAC), Institutional Biosafety Committee (IBSC), Review Committee on Genetic Manipulation (RCGM), Genetic Engineering Approval Committee (GEAC), State Biotechnology Coordination Committee (SBCC) and District Level Committee (DLC) are the proper and accurate pathway for the approval and commercialization of GMOs. Transgenic rice, wheat, maize, chickpea, sorghum, pigeonpea, sugarcane, potato and some others have been developed and marketed in India till now. Total 36 crops have been approved as GMOs in this country (Manoranjan, 2017).

4.5 Biosafety rules of Pakistan:

Pakistan Biosafety Rule 2005 was about the manufacture, import and storage of micro-organisms, all research involved in the transgenic plants and animals and import, export and sale of living modified organisms. National biosafety committee, technical advisory committee, institutional biosafety committee and biosafety officer are the organizations that will deal the transgenic products in Pakistan (Kumar, 2009).

Soybean, cotton, maize and canola are the main genetically modified crops that have been commercialized in Pakistan according to biosafety rules of 2005 (Gabol *et al.*, 2012).

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