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# STATUS OF GMOS IN PAKISTAN; NEED, ACCEPTABILITY, DEVELOPMENT AND REGULATION STATUS: A COMPREHENSIVE REVIEW

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**Abstract**

*This review is based on the status of need, acceptability, development, and regulation of genetically modified organisms (GMOs) in Pakistan. Pakistan's population is increasing rapidly, yet many farmers in the 21st century are not familiar with modern agricultural techniques. As a result, food prices have risen and become less affordable for over 30 million people living in poverty in Pakistan. GMOs are the need of the time because of the adverse environmental conditions and increased demand for food and food-related items. Salinity, drought, irrigation, and waterlogging, weed epidemics, insect attacks are major environmental factors which support the notion of cultivation of GMOs in a developing country like Pakistan. However, due to a lack of effective policies, most of the GMOs are not cultivated in Pakistan as consumers are not ready to buy because of the lack of awareness and government policies related to GMOs. There is no doubt that GM crops have benefits but still some drawbacks like increased use of glyphosate-based herbicides manifolds, lack of awareness, allergic effects, risks of crossbreeding between agricultural plants and weeds, religious factors and others which keep farmers and other stakeholders away from expanding cultivation of the GM crops in Pakistan. According to published data, only six GMO events have been accepted till today in Pakistan which suggests steady progress as far as acceptance of GMOs is concerned. The higher crop yields of genetically modified crops can help meet the food and non-food needs of a rapidly growing population, particularly in countries like Pakistan where population growth has been significant in recent decades. This review summarized all the information available on the topic and this will help in the understanding of issues related to the cultivation of GMOs in Pakistan and other associated factors.*

**Keywords:** *Biotechnology, GMOs, Pakistan, Policies, Stakeholders*

## INTRODUCTION

Pakistan is an agricultural country and 61% of its population resides in rural areas. On average 2/3 population of rural areas earned their livelihood through agriculture sector. Agriculture sector is one of the main pillars of Pakistani economy and constitute 18% of its gross domestic product (1). Pakistan's population is growing at an exponential rate but still in 21st century farmers are not familiar with the modern agricultural techniques. In recent years food has become more expensive and become less affordable for more than 30 million poor people of Pakistan (2)

Biotechnology is an emerging field of life sciences and it can come to rescue the crisis of food security in Pakistan by developing genetically modified organisms (3) Diet of Pakistani people are highly dependent on wheat, rice, potato and onions, thus development of the suitable genetically modified seeds of these plants has not only the potential to solve the food crisis of Pakistan but can also accelerate the GDP growth of Pakistan (4) Genetically modified organisms (GMOs) are developed through DNA recombination. Using the technique of recombination any suitable plant, animal or microorganisms can be genetically engineered for the benefit of mankind (5). Researchers are keen to develop such plant seeds which are able to tolerate the climate change of 21st century and can bear salt stress and can survive weed and insect infestation on their own (6).

Genetically modified (GM) crops were first commercially planted in 1994 but in 1996 a biotechnological milestone was achieved when their plantation area exceeds the mark of 1.6 million hectares (7). Since 1996 demand and usage of GM crops has increased throughout the whole world, and in 2020 it was reported that GM crops covered an area of more than 180 million hectares across the globe (8).

Although market of GM crops is expanding at an exponential rate, many environmental and health activists have raised their concerns about their usage (9). Certain GM foods like soybean haven been reported to cause allergy and antibiotic resistance (10). Farm workers working in Bt cotton farms have been reported to develop skin problems (11, 12). Environmental activists have also showed their concerns over the potential evolution of superbugs and super weeds as a result of GM crops (13).

In Pakistan field of biotechnology was first introduced in 1985 and since then its major goal is to produce and develop the GM crops which are able to tolerate environmental stresses (14) Pakistan has signed biosafety protocols like Cartagena Protocol and thus all its 56 biotechnological institutes are working under the ethical guidelines of Cartagena Protocol (15). Although Pakistan's biotechnological institutes have been working for 36 years, still only transgenic versions of cotton are under cultivation in Pakistan (16).

## NEED FOR GENETICALLY MODIFIED CROPS IN PAKISTAN

Economy of Pakistan and its food security depends on the better growth and yield of crops. Pakistan is located on the semi-arid region of the globe that is why occurrence of rainfall differs drastically in various regions of Pakistan. The northern region of Pakistan receives an average of 10 inches of rain every year. The southern Sindh region receives 7 inches. The northwestern frontier region of Khyber Pakhtunkhwa (KPK) receives 20 inches and the Punjab which is the agricultural hub of Pakistan receives on average of 50 inches of rain per year (17, 18).

Due to this fluctuated pattern of rainfall, Pakistan depends highly on the province of Punjab for feeding its people mainly. But in recent years the province of Punjab along with its counterparts Sindh and KPK has suffered from various other environmental stresses which has reduced the yield of crop production drastically especially of Wheat and rice (19). Over the years many certified GM seeds have been developed in several countries. Pakistan can develop its own GMOs or can purchase them from different countries to tackle its problem of food security. Problems causing the food security in Pakistan are discussed below:

### *SALINITY*

Total agricultural land is reported to be about 23.8 million hectares in Pakistan (20). Over the years, due to global warming, floods have become a prevalent issue in Pakistan. Floods have not only displaced millions of people out of their homes but have also caused salinity of the soils. Floods and changing rain pattern around 0.04 million hectares of fertile land is becoming saline in Pakistan every year (21). Due to this changing rain pattern, Pakistan is losing billions of dollars from its GDP every year (22). Most concerning matter for Pakistan is of losing around 5.33 million hectares of land due to salinity (23).

### *DROUGHT*

Changing pattern of climate has affected the areas of Sindh and Balochistan very badly (24). Over the years these both provinces have suffered from drastically low rains and reduced water flow in rivers (25). Around 15 million hectares of land is suffering from excessive droughts in these provinces, thus badly affecting the various important growth parameters of plants i.e., area of the leaves, their ability of transpiration and growth of stem and root which in result have negatively impacted on their yield (26). Production of rice has been reduced up to 50% while that of wheat is reduced up to 31% in drought stress areas and thus these provinces have not just suffered from food security but it also has cost them a loss of around 20 million US dollars per annum (27).

### *IRRIGATION AND WATER LOGGING*

Pakistan has suffered from drastic floods over the years, due to poor economy and lack of proper storage and drainage of that water 1.5 million hectares of land have become water logged in Pakistan (28). According to various estimates water seepage through the canal system of Pakistan is also causing around 0.1 million hectares of land to become water logged every year. Yield of various crops like sugar cane, wheat and rice have reduced up to 58%, 52% and 46% respectively due to waterlogging (29, 30). Poor water conservation strategies and lack of cooperation of India on Indus Water Treaty has made many experts to predict that Pakistan will suffer a reduction in its water by 31 million acre feet by 2025, thus causing severe negative impact on its agriculture (31). In August 2022, Pakistan's provinces Balochistan and Sindh received 590% and 726% more rainfall respectively than average (32). Due to these disastrous rains and subsequent floods approximately 2.8 million ha (57%) of total cropland of Sindh and was affected. The production losses of cotton, rice and sugarcane were 88%, 80% & 61% respectively (33).

## *WEED EPIDEMIC*

Pakistan has been suffering from the infestation of weeds from several decades. Weeds compete with crops for various resources like water and minerals and thus drastically reduce their yields up to 40% (34). Pakistan spend around one billion US dollars annually on the purchase of weedicides from other countries (35). This expensive import reduces the income and also making the food products much more expensive for already inflation plagued Pakistan. Weedicides are cancer causing and thus humans are in dire need to develop such seeds that can compete with weeds naturally (36).

## *EFFECT OF INSECTS*

Wheat and corn are most major crops of Pakistan, and attack of insects on these crops reduced their yield around 40% and 50% respectively (37, 38). Rice, cotton and potato also suffer drastically from the insect infestation every year. According to several estimates 37, 28 and 40% of respective yields of rice, cotton and potato are lost due to insects (39). Just like weedicides, insecticides are not only just expensive but also cause various health hazards, thus insect resistant crops are need to be developed. Pakistan suffers a loss of one billion US dollar per annum just from the loss of cotton by insects (40). Researchers of Pakistan have developed a Mon-531 Bt cotton which is expected to tackle the issues of insect infestation related to cotton (41).

## *CLIMATE CHANGE AND POLLUTION*

Global warming and ozone damage is changing the weather pattern of the world. Some countries like Pakistan are on the front line and have suffered drastic climatic effects over the past decades. Mega floods of 2010 and 2022 have drastically affected the food security in Pakistan. Several experts have estimated that Pakistan will lose 50% of its arable land due to changing climatic and weather patterns. Many international organizations have also estimated that change in climate will cause more growth of pathogens in coming years in Pakistan. In India 22-26% yield of wheat and 3-5% yield of rice has been decreased due to smog in recent years. Smog in recent years has also plagued Pakistan and it has been estimated that 10% yield of wheat has been reduced by it, but several researchers think that figures may be high as no appropriate research has been done yet (42).

## *DISEASES IN PLANTS*

In Pakistan various diseases are also very common in crops. Root rot in cotton, powdery mildew in mango, smut of sugarcane, wilt of tomato, canker in citrus etc. cause millions of US dollars of losses every year. Due to heat wave in summer powdery mildew species are expected to flourish and in wet seasons the downy mildews are expected to cause a ton of fungal diseases in crops in future (43, 44).

## *MALNOURISHMENT*

Pakistan is a developing country and since it has made relative improvement over the years in food security. But still the problem of malnourishment is quite prevalent in its people specially children. In Faisalabad, which is 3rd largest city of Pakistan, 41% of children are reported to be severely malnourished and as its consequence they have suffered a stunted growth (45). While overall around 31.5% children are reported to be suffering from malnourishment in Pakistan (46). In Pakistan people are mainly dependent on wheat and rice, which lack nutrients like vitamin A. Pakistani farmers need to plant genetically modified seeds which are fortified genetically to contain several important vitamins to tackle the plague of malnourishment (47).

## ACCEPTABILITY OF GMOs IN PAKISTAN

Like most of the developing nations, the acceptability of the genetically modified organisms is the biggest issue in Pakistan. This is not limited to the consumers, but policy makers are also reluctant to accept various GMOs which are cultivating in different countries (48, 49) (Ali et al., 2016; Amin et al., 2021). Due to lack of awareness, and effective government policies most of the GMOs are not cultivated in Pakistan (49). However, it is also reported that education is not the issue when it comes to the acceptability of the GMOs, because most of the educated people are against the GMOs. Therefore, only few GMOs are accepted by the regulating bodies. Still there is a needed to increase awareness among consumers, policy makers and regulating bodies that GMOs are safe for environment (50).

## *BARRIERS TO ACCEPTABILITY*

Yield is the major concern for the farmers, policy makers as well as other stakeholders. Canada and United Nations opted for GM crops. However, most of the European countries decided to stay away from the cultivation of the GM crops (51). FAOSTAT (United Nations) showed that there is no considerable difference of yield between the countries opted for GM crops and those which do not. For example, the average corn yield in Canada and US is 9.63 and 10.79 tons per hectare respectively, as compared to Germany (not opted for GM crops) where yield was reported as 9.6 tons per hectare (52). This data showed that various other techniques are more vital. Therefore, most of the countries are needed to work on the irrigation system and related factors to increase the production of the conventional crops. There is no doubt that GM crops has benefits, but still some drawback also exist which keep farmers and other stakeholders away from the cultivation of the GM crops (53).

The use of the pesticides which harm the crops often reduce when GM crops are planted; however, the herbicide use to target weeds often increase considerably. This shows that the increased use of herbicide lead to reduce the benefits for the farmers, as they need to purchase more herbicides to manage crops (54, 55). On average, 80% of the world's GM crops are cultivated are genetically engineered for herbicide resistance, leading to the increase use of glyphosate-based herbicides manifolds. As a result, regulating bodies and farmers do not take risks to plant GM crops especially in the developing nations. The reason they are not certain about the benefits of the GM crops, when they look at the published data of the yield different between conventional crops and GM crops and other associated factors (48, 56).

Certain cases reported in the USA and Europe where allergic effect was seen in some consumers of GMOs. On the other side, some people are more prone to allergic reactions which keep them away from the buying and use of the GMOs (57). The testing of the GMOs is expensive, which indicate that this crop would be best for all kind of the consumers and possess no harmful compound. As a result, trails are needed to be conducted, which are much difficult for the researchers working in the remote labs, having limited or no funds available from the government (47). Therefore, GMOs are not commercialized in a country like Pakistan, due to the limited evidence that this GM crops is safe to use for the consumers.

Biotechnology, one of the most rapidly developing emergent technologies, has the potential to radically transform the structure, nature, and ownership relations of the food production system. It can make farmers entirely reliant on market-based approaches (58). Additionally, certain powerful companies can gain control and strengthen their grip on the seed manufacturing market. Also, throughout many developing nations, the danger to food security may rise instead of reducing if GM crops are unable to withstand changing climatic conditions (50). The ethical and religious aspect is also associated with the production of the GMOs. There is the involvement of the procedure to change the genetic makeup of the organism with the help of biotechnology. Particularly among Muslims, this is regarded as immoral and even against moral principles (59).

Not all the researchers are in the favor of the GM crops as reports are present in the literature as evidence, that GMO may cause unintentional damage to the other organisms in the ecosystem (60). High deaths rates in monarch butterfly caterpillar were observed because of the negative impact of the Bt corn (61). Therefore, there are two school of thoughts related to the acceptance of GM cops and both are right in their own way. These harmful impacts of every GM crop are needed to be studied thoroughly before declaring the safety of GM crop for animals and human use (62). A GM crop can be safe for human or animal use, but how this crop or species will impact on the abundance of other species is also important to analyze (63). One problem, among many others, has been the possibility of crossbreeding between agricultural plants and weeds designed to withstand herbicides, which might lead to the spread of genes responsible for herbicide resistant crops from the crops to the weeds. On the other side, these weeds will also develop a tolerance to herbicides (64). Furthermore, GM crops have capacity of faster growth and development compared to natural species. They become alien because of this faster growth and may compete with the natural species for water, and other biotic and abiotic factors. This results in decline and extinction of the species within very brief period (65).

## *SUPPORTING ARGUMENTS FOR THE ACCEPTANCE OF GMOs*

In Pakistan, some of the GMOs are approved and commercially grown because of the advantages and limited or no harm for humans, animals as well as other associated species. Various arguments are discussed in this section related to the acceptance of GMOs.

Farmers face significant financial losses when crops are damaged by the pests. Consumers across the country are becoming increasingly concerned, that crops sprayed with pesticides are not suitable for human consumption. That may even have detrimental impacts on health of humans (66). Moreover, GM crops can definitely reverse this trend, as these crops may leads to significant reductions in the use of chemical pesticides. The example for this benefit is Bt cotton (67). In most of the cases, weeds removal by physical means like tilling is time taking and need much human capital. Therefore, the use of the herbicides is increasing to inhibit the growth or destroy weeds (68). As far as economics is concerned, both these processes are expensive for the farmers. Therefore, this problem can be solved by planting herbicide tolerant GM crops. Maize and soybean are two important crops which are supporting the plantation/cultivation of GM crops (69).

Scientists from various parts of the world are attempting to defend the plant against certain fungus, viruses, and bacteria that cause several diseases in plants. A possibility for creating crops free of disease is to produce some GMOs (70, 71). The developing world presents a dismal image of malnutrition. The majority of the population in third-world nations, particularly in Africa and Asia, depends on a single crop to satisfy their nutritional needs, with rice serving as their primary source of nutrition (72). Unfortunately, rice is deficient in a number of minerals that our bodies need, including vitamin A. With the help of genetic engineering, it is possible to genetically modify rice to contain more vitamins, thereby addressing numerous nutritional deficiencies (73). For instance, vitamin A deficiencies cause blindness in many individuals, but through genetically modified organisms, researchers were able to create golden rice that has a high level of beta-carotene content (vitamin A). In this manner, malnutrition in future can only be managed with the help of GM crops, especially in the developing nations where numbers of issues exist in the agriculture system (50, 74, 75).

## DEVELOPMENT OF GMOs

The organisms which are produced after the adjustment in their hereditary material (DNA) are known as genetically modified organisms (GMOs) (76, 77). The technology by the aid of which the production of these organisms is possible is called as Modern Biotechnology sometimes also named as Genetic engineering. Now a day many countries are producing GM crops by using biotechnology. At global level USA is the biggest producer and consumer of GMOs (78), whereas Bt cotton is only GM crop which is commercialized in Pakistan (47, 79). Biotechnology had a convincing potential in curtailing poverty and food scarcity by improving the production of crops (80).

According to a survey, a collection of data from 950 farmers of Pakistan, it is suggest that Pakistani farmers, are well aware and are willing to grow GM cash crops as compared to GM food crops (81). Since 1985 with the utilization of modern biotechnology, it is observed that in Pakistan, there are 29 biotech research facilities having a leading focus on production of and cotton (82). Genes which can improve the quality and resistant of crops are also being incorporated in crops. However, no GM crop is released in country for growth or import despite of capacity of production (14).

Genetically modified crops characters have been classified into three generations, first, second and third respectively. Traits like resistance to herbicides, insects and environmental stresses are included in first generation. Value-added yield characteristics, for example, supplement improved seeds for feed are incorporated in second generation. The third generation will incorporate attributes to permit creation of drugs and items past customary food and fiber (83).

Regardless of challenging conditions, the area covered by the transgenic crops globally is growing slowly and steadily. According to an estimate in 2017, area cultivated by USA was 75 million hectares; Brazil was on second number with the cultivated land of 50.2 million hectares, followed by Argentina with 22.66 million hectors (84). According to records Pakistan has 3 million hectares of cultivated GM crops (85). In 2017, out of 189.8 million hectares of global land under GM crops, soybean ranks number one occupying 94.1 million hectares followed by maize (59.7 million hectares), cotton (24.1 million hectares), Canola (10.2 million hectares), Alfalfa (1.2 million hectares), Sugar beet (0.5 million hectares), Papaya (< 1 million hectares) and others (< 1 million hectares) (23).

South Asian markets are slowly adjusting GM crops either by the help of foreign investors or indigenous research institutes. However, the main hurdle is the rules and regulations (86, 87). Bangladesh is first South Asian country who took a pioneer step in the approval of Bt Brinjal cultivation. This GM crop turned out to be resistant to the one of the most common pest in South Asia. A significant amount of bloom in economies of many agricultural countries has been observed after planting pest resistant GM crops (88, 89).

The tilt toward growing GM crops in developing countries is gaining pace then developed countries. According to an estimate the area under GM crops in 1996 was 1.6 million hectares, which increased significantly to 191.7 million hectares in 2018 (90). It was estimated that in 2017, out of total 189.1 million hectares of GM crops, genetically modified soybean comprises of 94.1 million hectares followed by maize, cotton, canola, alfalfa, sugar beet, and papaya (84) (James, 2017). The major reason for the selection and growing the GM crops is that these crops were found to be having herbicidal and pest resistance (91).

The increasing yield of GM crops can solve the problem of food and non-food demands of the increasing population, it is reported that nine thousand farmers in India found that adoption of Bt cotton increases the yield (92) (Bennet et al., 2013). In developing countries, it is observed that growing Bt cotton has significant impact on their economies (67, 93).

GM crops has potential to feed the exploded world population. It is estimated that in 2050, world's population would be around 8.9 to 10.6 billion (94, 95). Hence biotechnology will play a significant role in curtailing food problems by increasing the yield and quality (80, 96). The adoption of Bt technology has a positive effect on yield by 22% and decrease in the use of chemical pesticides by 37% (97). In Pakistan GM crops production is still in its early stages, trials were started in 2010 and during this course of time, Pakistan had made tiresome efforts in modification of these technologies by collaborating with many global agencies (84). The most prominent GM crop of Pakistan is Bt Cotton which is pest, herb, drought and salinity resistant (98). On the other hand, GM food crops like rice, corn, potato, tomatoes, chilies etc. are on experimental stages (60, 84).

In 2018, Imran Khan took the office in Pakistan, Khan's government formed an agricultural research committee with a task to review the agricultural policies of Pakistan. Thus in 2019, under the recommendations put forwarded by the agricultural committee and national biosafety committee. Ministry of National Food Security and Research (MNFSR) released a statement that Pakistan can meet its local demand of maize without planting the genetically modified maize, thus MNFSR suspended the commercialization and field trials of GM maize. Later that year MNFSR also suspended all the field trials of other GM crops like wheat, rice, potato, chickpeas, sugarcane, tobacco, peanut and brassica until further notice without giving any reason. Since 2019 MNFSR has only permitted the commercialization and field trials of GM cotton (99).

**Table I.** Developed GM Crops of Pakistan (Rehman and Anderson, 2021)

| Crop | Trait/ Gene | Approval Stage | Institute | Status |
|---|---|---|---|---|
| | Resistant to Moth | Field Trial | CEMB | In Process |
| | Resistant to Virus (CLCV) (Tr AC gene) | Ready to Release | CEMB | In Process |
| | (CLCV) Virus resistant with RNA interference | Field Trial | CEMB and NIBGE | In Process |
| Cotton | Salt and Drought Resistant (AVP1-H) | Field Trial | NIBGE | In Process |
| | Cry1Ac and Cry2Ab | Field Trial | CEMB, NIBGE and Four Seed Companies | In Process |
| | Cry1Ac, Cry2Ab and Glyphosate | Field Trial | CEMB, NIBGE and Four Seed Companies | In Process |
| | Improved Fiber | Experimental | CEMB | In Process |
| | Rust, drought, & salt tolerant | Field Trial | NIBGE | On hold |
| | Bio-fortified wheat for increased iron (Fe) & zinc (Zn) | Field Trial | FCCU and AARI | On hold |
| Wheat | Efficient Use of Phosphorus | Field Trial | FCCU and A Local Seed Company | On hold |
| | Rust resistant | Experimental | AARI | On hold |
| Rice | Resistant to blight of bacteria with Xa21 gene | Experimental | CEMB | On hold |
| | Resistant to Insects with Cry1Ac and Cry2A gene | Experimental | CEMB, IIUI and IBGE | On hold |
| Brassica | MAX1 gene for enhanced growth of axillary branches. FAEI gene to reduce the | Experimental | AARI and IBGE | On hold |

| | | | | |
|---|---|---|---|---|
| | production of erucic acid | | | |
| | Glucanase gene to resist against fungi | Experimental | CABB | On hold |
| | Resistant to insects | Experimental | CABB | On hold |
| Potato | Resistant to (PLRV, PLXV, PVY) virus, Chitinase gene to resist against fungi | Experimental | NIBGE | On hold |
| Chickpeas | Resistant to Insects | Experimental | CEMB and NIGAB | On hold |
| | mESPSPS | Field Trial | Syngenta | On hold |
| | CEMB GTGene | Field Trial | CEMB | On hold |
| | cry2Ab2 and cry1A.105 and cp4epsps | Field Trial | Pioneer | On hold |
| Maize | cry1Ab x mESPSPS | Field Trial | Syngenta | On hold |
| | cry1F, cry1Ab and cp4epsps | Field Trial | Pioneer | On hold |
| | Resistant to Insects (Cry1Ac and Cry2A) | Field Trial | CEMB and NIGAB | On hold |
| | CEMB AFP | Field Trial | CEMB | On hold |
| | cp4epsps | Field Trial | Monsanto | On hold |
| Peanut | Resistant to Tikka disease, Resistant to herbicides | Experimental | NIGAB | On hold |
| | Resistant to Insects (Cry gene) | Experimental | NIBGE | On hold |
| | Resistant to fungi and virus | Experimental | CEMB and IBGE | On hold |
| | Chloroplast transformation | Experimental | CEMB | On hold |
| | Abiotic stress resistance (scdr1 gene) | Experimental | CABB | On hold |
| | Drought tolerant | Experimental | AARI | On hold |
| Sugarcane | Biotic stress tolerant (SUGARWIN 2 gene) | Experimental | CABB | On hold |
| | SIG, SIG2 and SIG3 | Experimental | CEMB | On hold |
| | Resistant to insects (VIP3+ASAL) | Experimental | CEMB | On hold |
| | Herbicide tolerant | Experimental | CABB | On hold |
| | CHiA, CHiB and CHiC | Experimental | CEMB | On hold |
| | Insect Resistant with synthetic spider venom gene | Experimental | NIBGE | On hold |
| Tobacco | Salt tolerant with $Na^+/H^+$ antiporter genes | Experimental | NIBGE | On hold |
| | Salt tolerant with ArDH | Experimental | CABB | On hold |
| | Resistant to fungi (Glucanase gene) | Experimental | CABB | On hold |

Pakistan positions among the top 10 nations in developing GM crops on the planet. Roughly 725,000 cotton farmers in Pakistan has planted Insect resistant (IR) cotton assortments in 2016, which was the seventh year of business planting starting around 2010 (100). Pakistan has signed the Cartagena Convention of Biosafety, and it came into force on May 31st 2009 (101). Nonetheless, the institutional limit with respect to overseeing GMO is still weak (102). However, the legitimate and administering system is laid out the human limit required for execution of the guideline and rules are as yet inadequate (85).

In Pakistan larger part of the farmers knew and able to develop GM cash crops, while just a little level of the tested ranchers knew and ready to develop GM food crop. Presently, in Pakistan, in excess of 90% region under cotton was covered with Bt cotton. The exact outcomes showed that families with huge land holding and got land freedoms were more ready to develop GM food and cash crops (85). Well off families were more likely able to develop GM food and cash crops. Essentially, the admittance to the market was the significant elements affecting rancher's eagerness to develop GM food and money crops. The ranchers with NGOs participation were hesitant to develop GM food crops yet were more ready to develop GM cash crop.

According to the strategy viewpoint, there should be a reasonable arrangement, rules and guideline on GM food and cash crops, in Pakistan on the advantages and impacts of the GM crops. Likewise, the mindfulness should be made among GM food and money crops among the cultivating local area through compelling augmentation administrations and print and electronic media.

## REGULATORY SYSTEMS FOR GM CROPS AND BIOSAFETY

The term "Biosafety" refers to the safety for human health and environment from probable hazards from genetically modified organisms and pathogenic organisms.

### *HISTORICAL BACKGROUND*

The exact time of origin of biosafety is not known. The field has come into being in recent past after incorporation of knowledge of different fields like microbiology, molecular biology, agriculture, livestock care and development and safety guidelines for anthropogenic environment (103). Very first footsteps for biosafety appeared in late 1890s in Europe as the 1st lab acquired infectious diseases were reported. So after those events, it is mandatory to work with safety measures in laboratories in response to potential risks of pathogenic microbes (104).

In 1970's biosafety guidelines were first implemented in UK and North America (105). These guidelines included operational practices, personal protection and physical restraint methods formulate to limit the dissemination of bio-entities. Later these guidelines applied in laboratories working with genetically modified organisms. In early times, biosafety was contemplated as a sub-discipline of personal safety associated with legislature directed to protect personnel against various risks such as chemical or radioactive. But bio - hazard is distinct from chemical and radioactive hazard as microbes can proliferate in vivo as well as in vitro.

By the passage of time, biosafety became a separate discipline partly due to implementation of biological risk classification system, Gordon conference on nucleic acids (1973) and Asimolar conferences (1973 and 1975) (106). Currently, United Nations member states are following "The Cartagena protocol" on Biosafety to the convention on Biological Diversity (CBD). It is a global pact on biosafety as a supplement to the CBD operational since 2003. The aim of this modus operandi on biosafety is to guard biodiversity from probable threats linked to GMOs.

This Biosafety protocol clearly stated that biotechnological products essentially based upon prophylactic measures and allows developing nations like Pakistan to equilibrate communal wellbeing against commercial gains. A country can ban imports of GMOs if they feel there are not ample scientific evidence for product safety or impose a compulsion to exporters that there should be a tag of genetically modified products such as cotton or corn (107).

### *REGULATION STATUS OF PAKISTAN*

In 2005, Government of Pakistan implemented Biosafety rules, previously there were no rules regarding GMOs and Biosafety. Biosafety rules (2005) are pertinent to:

(a) Manufacture, import and stowage of micro – organisms and biotechnological goods for investigative study purposes whether led in teaching labs, R & D institutes or private firms engaged in the uses and applicability of GMOs and goods thereof.

(b) Every bit of work related to field trials of GM crop plants, livestock, microbes, and cells and

(c) Global trade related activities import and export of alive GMOs, materials or cells and goods.

According to above legislation, Rules 4-9 deal with the establishment and functions of National Biosafety Committee (NBC), a Technical Advisory Committee (TAC) and Institutional Biosafety Committee (IBC). Rule 11 to 16 tells that a license shall be obtained from NBC in order import, export, sell, and purchase etc. of living GMOs. National Biosafety Committee (NBC) may review or validate acquiescence of every state of affairs put down in the license. Cautious or unintended release of GMOs or hazardous microorganisms is not allowed at all. Off-site crisis management strategy for possible major incidents may be prepared by Technical Advisory Committee (TAC) (108). But unfortunately, these rules and regulations are not being implemented in their true letter and spirit as Technical Advisory Committee (TAC) still lacking its complete members and same is the case with National Biosafety Committee (NBC) (109).

Even after so many years of post-18th amendment of 1973 constitution, still no province made their biosafety rules except Punjab (37). So, it required that a capacity should be build up by all concerned Government departments to execute policies as they are understaffed and cannot deliver. In last 2 decades, there is an ample amount of investment is done in Pakistan for the development of agricultural biotechnology. Nevertheless, utilization of biotechnology has been relatively slow due to lack of compliance with already enacted regulatory processes. In addition to this, there also exist a confusion related to adoption of GMOs technology among legislators and regulators. Many nations are adopting GM crops and livestock in their sustenance scheme. But still Pakistan is a GM food free nation according to local regulators.

Therefore, it is need of time to reassess Pakistan's biosafety regulations to ensure better utilization of GMOs and biotechnology products as Government is investing much money since last 2 decades in this field. Therefore, it is suggested that regulations related to biotechnology must be driven by primary evidence with a solid effort on "regulation commensurate with risk'. Further, it is added that domestic and global biosafety regulatory frameworks should be harmonized. This will definitely reduce trade barriers and allow more trade organizations to enter the market. It will be fruitful for our economy and food security.

## CONCLUSION AND FUTURE PERSPECTIVES

In Pakistan, there is the need of expanding cultivation of the GMOs to meet the increased level of food demands. In a developing country like Pakistan, issues such as high salt levels in the soil, drought, poor irrigation practices, waterlogging, widespread weed growth, and insect infestations all contribute to the need for the cultivation of GMOs. However, the barriers to cultivation and acceptance must be handled properly to create a GMOs supporting environment in the country. The government and other associated organization should play their part to improve the policies related to GMOs and support researchers to improve genetic composition of various cash as well as other crops. However, the researchers should also focus on the barriers, and they also need to improve traits of the crops in the same manner which would lead to better impression on the policy makers concerned with the acceptance of GMO crops in Pakistan. Regarding development, Pakistan has a strong agricultural research system, and there are government and private institutions working on developing GMO crops. However, it is important to note that the development of GMOs is a complex and costly process. Finally, regulation of GMOs is also an important issue. Governments have a responsibility to ensure that GMOs are safe for human consumption and the environment before they are allowed to be grown and sold. In Pakistan, the government has the regulatory body "Pakistan Agriculture Research Council (PARC)" which is responsible for providing technical guidance, but their capacity to regulate GMOs may be limited. All in all, a clear direction to the researchers should also be provided by all the relative departments which will only lead to the production of safe and ideal crops for the country's population.

### Authors contribution:

All authors have made equal contributions to this work and have collaborated in the conceptualization, design, data analysis, and writing of the manuscript. Each author has reviewed and approved the final version for publication.

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