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Review Article

The Gene Revolution: Is it a Solution for Solving Food Insecurity Issues?

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Abstract

The world's population is increasing and resources are more limited than before. Genetic engineering is attempting to produce crops resistant to drought, parasites and diseases tried to push the limits aside. Reports have shown that many people in the world are undernourished, in such a situation; it needs to produce more food than ever. In this manner, agriculture, as the main accountable for food and feed, has become more important. Given to the fact that some problems such as loss of arable lands and the prevalence of unfavorable environmental conditions, including drought, salinity, floods, diseases etc. maintaining the amount of food per capita will be a mounting job in the future. Agricultural Biotechnology holds great promise for increasing the world's food supply and improving the food quality and can help to solve the global food crisis and significantly reducing world hunger. In recent years, the term biotechnology, especially genetic engineering has been associated with discussions and debates. In contrast to the benefits of GM crops there are concerns in society, such as potential long-term impacts, health issues, environmental issues, and etc. Therefore, it remains questionable whether GM crops can contribute to combat food insecurity? In this regards, this review paper tried to answer to this critical question.

Keywords: Malnutrition; GM crops; Biotechnology; Agricultural growth

Introduction

Food insecurity is a worldwide problem. Food insecurity is the cause of many deaths in developing countries and is among the most serious concerns for human health. To be healthy, our daily diet must include ample high-quality foods with all the essential nutrients, in addition to foods that provide health benefits beyond basic nutrition. Food security has been defined by FAO in 1996 as a "condition that exists when all people, at all times, have physical, social and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" [1]. When discussing food, one billion is a wonderful number. Around the world, one billion people are living in food insecurity [2]. Food insecurity or inability to access food is the most fundamental form of human deprivation. Food insecurity is a problem that should be combated until 10 years after World Food Conference (1974) but there is a deplorable form around the world yet. In this regards, Millennium Development Goals stated that half of the world's hungry should be reduced by 2015. It was somewhat promising. Nevertheless, despite all efforts taken to reduce global food insecurity, the published statistics of 2012 revealed that there are 852 million people in food insecurity around the world. Having doubled during the last few decades, the global population continues to grow. It is estimated that the world population will reach between 8 and 9 billion people by 2050 [3-5]. Social, economic and environmental issues cause numerous people worldwide to suffer regularly from food insecurity [6], thus subjugating them to limited or uncertain access to nutritionally adequate and safe food, and/or limited or uncertain ability to gain acceptable food in socially acceptable ways [7]. Consuming a variety of nutritious and safe foods is key to reducing malnutrition, including those forms caused by micronutrient deficiency. It is generally accepted that food insecurity has considerable impacts on the physical, social and psychological status of individuals in communities [7]. In this manner, agriculture, as the main accountable for food and feed, has become more important than ever [8].

Unfortunately, for many parts of the developing countries, agricultural growth is low [9] and in this regards, growth in agriculture is an inevitable way to combat food insecurity [10]. With this ever growing rate of population, much pressure has put on natural resources, and agricultural development and environmental protection have become mixed accordingly [11]. Agriculture plays an important role in achieving human food security [12] and it is the main backbone of food production [13]. It should be considered that increasing the agricultural production will be a mounting job in the future due to some problems such as loss of arable lands and the prevalence of unfavorable environmental conditions, including salinity, floods, drought, diseases etc. In order to ensure food security more than double food is needed for future generations than the present, in spite of the predicted adverse environmental conditions [14]. Furthermore, the climate change will lead to the deterioration of the situation to achieve the food security the in future [15-17]. The critical question still remains as to how all these additional people can be fed [3,4]. In this regards the world's agriculture should respond creatively to the demand of increasing population with increased agricultural production [2-5].

Gene Revolution

Two waves of agricultural technology development have been seen in the past 40 years. The Green Revolution was the first wave

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which using technology development, targeted poor people in the poor countries [18]. Green Revolution by using high-yielding crop varieties developed through conventional plant breeding practices and agrochemicals was the cause of the increased crop productivity in some countries. However, for ever-rising global food demand, conventional plant breeding alone, can no longer response [14].

After the Green Revolution, the world has recently experienced the second agricultural revolution; i.e., the "Gene Revolution". Modern biotechnology is the main investment of this recent revolution [29]. In this wave of agricultural development plants, animals and microorganisms modify using scientific techniques to improve their values [21]. This technology has the potential to accelerate a country's transformation into a highly industrialized nation [22-27]. Biotechnology is understood here as any technological application that uses biological systems, living organisms, or derivate thereof, to make or modify products or processes for the specific use [27-30]. Organisms that have been genetically engineered and Modified (GM) are referred to as Genetically Modified Organisms (GMOs) [32]. Biotechnology has caused gene revolution to combat food poverty and hunger [8,32-34] and provides great hope to provide food security and health for the world [35].

Advocates of biotechnology suggest that GM foods may provide solutions to the current problems of conventional agriculture [36-38]. Nowadays, a lot of pesticides not only threaten the farm environment, but it also destroys certain useful organisms in the soil [39]. GM crops reduce the need for herbicides and pesticides; it, moreover, reduced production cost which in turn increases yield and provides the favorable environment for animals and human. Moreover GM crops improve qualification aspects of such crops as higher resistance to dryness and excessive wet weather, shelf-time, flavor, nutritional value, and color [40-43]. They act as a renewable source based on solar system and aid in pharmaceutical products [32,44]. GM crops have been genetically modified to produce plants with the potential to growing in difficult climatic conditions and are resistance to the pests and disease; therefore, they will grow using fewer pesticides and chemical inputs [31].

GM crops cultivation has been increased since 1996. Currently, 16.7 million farmers in an area over 160 million hectares in more than 30 countries produce GM crops. Also, the area under GM crops' cultivation in both developed and developing countries has been uninterrupted upward in 1996 and 2011 (fourteen years. According to the statistics, in 2011, 10 percent of the arable lands around the world were GM crops [45]. Agricultural Biotechnology holds great promise for increasing the world's food supply and improving the food quality and can help to solve the global food crisis and significantly reducing world hunger [46].

GM Crops *versus* Classically-Bred Crops

Historically, genetic experiments have been made by humans for centuries in the form of crossing plants and animals with the purpose of making them better for industrial uses and human consumption. At the moment, the genetic modifications are being done in a scientific way, using advanced techniques, which manipulate and multiply selected genes even when those genes have been derived from a species that is different from the recipient species [38]. Both of Classically-bred and GM crops are created through different means of gene transfer technology [47]. However, in classical breeding thousands of uncharacterized genes of an organism may be involved while the amount of genetic changes by the GM technology is small and well defined. Furthermore, GM crops are the outcome of very specific and targeted modification in the genome. However, in traditional breeding, the genomes of both the parents are mixed together and randomly re-assorted. This is very time-consuming and labor-intensive and this is not always economically practical [14].

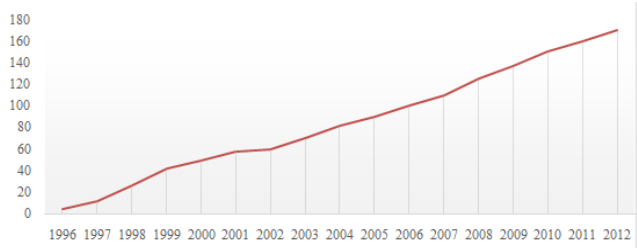

Figure 1: Global area of biotech crops 1996 to 2012 (Million hectares).
Source: Clive James [45].

The Global Statistics of GM Crops

In the past decade, the use of GMOs in food and agricultural applications has increased greatly. Since the first cultivation of GM crops on a commercial scale in 1996, their cultivation area increased rapidly [48], Large-scale planting of GM crops started in 1996, from 1.7 million hectares [49,50] and the global area in which GM crops are grown and tested exceeded 50 million ha in 2001. This growth intermittently increased to 134 million hectares in 2009 [52]. In 2010, 148 million hectares (10% of world's arable land) in 29 countries covered by GM crops, [45,52] among which, 19 were developing and 10 were industrialized nations [45]. As shown in Figure 1 developing countries grew 49.9% of global biotech crops in 2011 and may exceed industrialized countries in total hectares this year [45]. For countries among developing countries, i.e. Brazil, Argentina, India, and China are the largest biotech crop growers [53].

What are the Possible Risks Associated with Using Transgenic Crops in Agriculture?

Although GM crops are known for their benefits, hence there are concerns that GM crops have their shortcomings. These concerns can be divided into three groups: human health risks, environmental hazards and economic concerns [41,43,44,54-61].

Health-Related Issues Such as

Allergens and toxins: People with food allergies have an unusual immune reaction when they are exposed to specific proteins, called allergens, in food [62]. There is concern that intense allergic reactions could happen in consuming GM food products due to splicing of new genes into crops [46].There is a fear that introducing a gene into a plant may cause an allergic reaction in susceptible individuals or create a new allergen [63]. This is the most important concern regarding health issues.

Antibiotic resistance: Antibiotic resistance genes are used to identify and trace a trait of interest that has been introduced into plant cells. Therefore, the researchers will be ensuring that a gene transfer during genetic modification was successful [63]. There

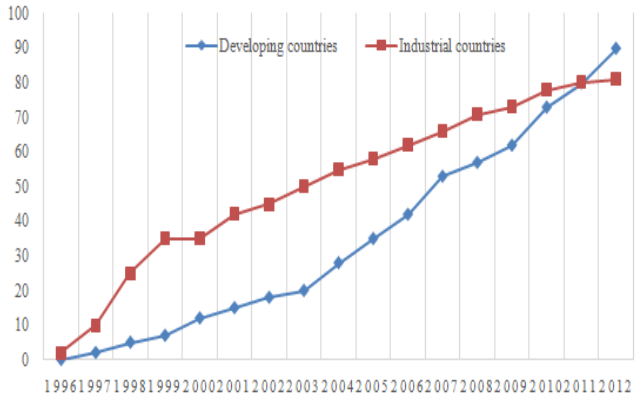

Figure 2: 18 biotech mega-countries growing 50,000 hectares, or more, of biotech crops.
Source: Clive James [45].

are concerns that these genes might unexpectedly recombine with pathogenic bacteria in the environment or with naturally-occurring bacteria in the gastrointestinal tract of mammals who consume GM foods. The presence of antibiotic resistance genes in foods might produce harmful effects.

Toxic to human health: One of the concerns of GMOs is the possibility of the existence of other toxic substances within them (such as increased amounts of heavy metals) [46].

Unknown effects on human health: It may seem that many of the novelty genes are the cause of the health risks of GM food; therefore, the removal of genes from plants can lead to the production of desirable/undesirable traits [31].

Environmental and ecological issues such as

Potential gene escape and super-weeds: Herbicide and insect resistance crops could cross-pollinate with wild species; therefore, unintentionally create super-weeds, particularly in small farm fields surrounded by wild plants.

Impacts on "non-target" species: Some environmentalists are concerned about the unforeseen and undesirable effects of GM crops after they released. Although GM crops are tested but not every potential impact can be foreseen.

Insecticide resistance: There is the fear that large-scale use of BT will result in making resistance in pest population [64].

Loss of biodiversity: Many environmentalists and farmers are worried about the loss of biodiversity in the natural environment.

Creation of super weeds: The critics of genetic engineering argue that GM crops are sensitive to mutagenicity, can lead to the creation of super weeds (that are resistant to herbicide) [46].

Economic concerns: some economists believed that bringing a GM food or crops to market is a costly process. The patents for GM crops present an additional problem to agricultural development in developing countries. Patents increase costs and restrict experimentation by individual farmers. Therefore, there is particular concern regarding present intellectual property rights instruments, which may inhibit sale, exchange, seed-saving, and access to proprietary materials of vital importance [46].

Conclusion and Recommendation

Gene Revolution is a new revolution in agriculture which aimed to combat food insecurity and hunger [46]. This new revolution in agriculture is in accordance with biotechnology completely [13]. In recent years, biotechnology and genetic engineering have created great developments in agriculture, medicine, industry and environment. Using the worlds' genetic resources for crop improvement is provided by genetic engineering and eliminating the barriers of traditional methods of plant breeding. In recent years, the term biotechnology, especially genetic engineering has been associated with discussions and debates. The most of the discussions carried out by the opponents of this technology as it is an abnormal technology. For the concerns of GM crops, there is no positive reliable observation yet. But also there are some negative reports, for example the Food and Drug Administration (FDA) checks to ensure that the levels of naturally-occurring allergens in foods make from transgenic organisms have not significantly increased above the natural range found in conventional foods. One of the most serious causes of food allergy is peanuts and now the genetically modified technology is used to remove the allergens from it [61]. Also the treatments with common antibiotics are a crucial medical concern of some opponents of genetic engineering technology [63]. In addition, recent advances in genetic engineering do not employ the use of such selection markers, and their use is likely to diminish [65]. Moreover, if consumer advocates are concerned that patenting of new plant varieties will be the cause of raising the price of seeds as much as those small farmers will not be able to afford seeds for GM crops. Patent enforcement is also difficult, as the contention of the farmers whom they involuntarily grew GM strains. In this regards introducing a "suicide gene" into GM plants is one way to combat possible patent infringement. These plants would be viable for only one growing season and would produce sterile seeds [61].

From the past to present, food has always been a major concern for humankind to survive. Governments in different ways trying to solve the equation of unequal human food and population. Today, in the official reports of various international organizations repeatedly warned about the food shortages that will arise for the future generations [45]. If present trends of population growth continued, certainly, future generations will face food shortages [66]. In fact, none of the technologies is safe completely. It is rational that if advantages of a technology overcome its disadvantages it can be used. Therefore, it should be considered that cannot be dodged from the gene technology [67-69]. It would suggest that with attention to the carefully risk assessment of GM crops and comprehensive assessment by stakeholders, its use can be suggested. In this regards, the following recommendations could be taken into account.

Increasing knowledge (not only pure theoretical knowledge) of stakeholders about the technology is a good way to make a better understanding about it. In this regards, paying more attention to hold symposia and seminars on this subject can be very effective.

GM crops should buy from the farmers by the agricultural ministry with a guaranteed price to avoid pressure on the poor resources farmers.

The commercial release and extensive cultivation of GM crops in agri-ecological systems may pose potential environmental risks. Therefore, the country should emphasize a science-based and case-by-case environmental biosafety assessment prior to the commercial production of any GM crop. For safety assessment of transgenic crops, the concept of substantial equivalence that has been recommended by OECD (OECD, 1993) and FAO/WHO (FAO/WHO) can be used. The concept mainly focuses on the compositional comparison between transgenic foods and their none-transgenic counterpart. In this regards, a committee which is compromised with representatives of stakeholders groups can monitor this process.

Furthermore, the organizations related to the GM crops should increase public awareness about their activities related to GM crops. Trust in the regulatory institutions and scientists have a strong effect on the benefit perception and it has a positive impact on their behavioral intention. In this regard, mass media debate on positive and negative aspects of GM crops can enhance the public awareness of it. In this regards, primary sources of information i.e. scientists and academics without any financial interests in GM are regarded as a knowledgeable independent third-party source about GM crops. Which when a participant acquired GM information from a third-party source, the probability of the consumer being out of the market for GM foods is decreased. Therefore, it suggests that information from third-party source reduces the effect of negative information supplied by consumers and environmental groups. Thus, in the mass media and producing the programs using these third-party sources of information proposed.

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