Advances in Crop Science and Technology
ISSN: 2329-8863
Tiruneh, Adv Crop Sci Tech 2023, 11:9
Review Article
Open Access

Review on Debates Over Genetically Modified Crops in the Context of Agriculture

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Abstract

Genetic engineering is a technology by which the genetic material of an organism can be modified through the introduction of a gene from the same species or across the boundary. GM crops add benefit for human beings by increasing the importance of desirable traits. However, the technology comes across with challenges for different stakeholders. Undesirable gene flow from GM crops is the most touching risk associated with this technology. The major debate over genetically modified crops in the world exists between proponents and opponents. GM supporters believe that the improvement of crops through conventional breeding is related to species-dependent, time-consuming and inexact processes. The opponent on the other side claims the potential risk of GM crops through the reference of human health and environmental concern. The main arguments over GM crops can be done through the reference of sustainable development, namely environment, which also include human health issues, economics and social development. Both sides use such terms as sustainability, but each of them states them differently. Thus, this paper will contribute to know the debate over genetically modified crops and show possible causes in the context of agriculture.

Keywords: Genetically modified crops; Sustainability; Undesirable gene flow; Genetic material

Introduction

Agriculture is a very old form of human technology. By harnessing sunlight, soil nutrients and water toward satisfying their wants and needs, human beings for much of their history have made more productive use of agriculture than they ever could have derived from hunting and gathering. For millennia, farmers have relied on selective breeding and cross-fertilization to modify plants and animals and encourage desirable traits that improve food production and satisfy other human needs crop improvement programs need to become more efficient to close the yield gap between yields on station and farmer fields [1].

The discovery of the molecular structure of deoxyribonucleic acid by Watson and Crick in the early 1950s and the cracked genetic code for DNA information paved the way to determine each of the 20 amino acids, accounts immeasurable contribution on gene manipulation to advance the performances of an organism for human benefit. The technology often called “genetic engineering” is a technology by which the genetic material (DNA) of an organism can be altered in a way to introduce a gene from another organism or species. It has been widely applied in agriculture to produce crops with desirable economical traits and the transgenic plants called genetically modified crops [2].

The first genetically modified plants were tobacco in the 1883s and so far, a lot of crops were modified for different uses. In 2014, a total of 18 million farmers planted biotech crops in 28 countries, were in greater than 16.9 million farmers were from developing countries. James, showed the global genetically modified crops area by country and USA ranked first followed by Brazil and Argentina respectively, furthermore, the author stated, despite some challenges, the African continent also continued to make general progress towards conducting field trials on priority biotech crops for their region. However, the rise of agro-biotechnology comes across with both opportunities and challenges for farmers, agro-companies, retailers, consumers and policymakers in the world [3].

Mannion and Morse reported that genetic modifications of major economic crops added benefits in the case of enhancing yields per unit areas due to the control of pests and ecologically none target plants are saved due to the reduced use of pesticides. The author further explained the health benefit of golden rice. With the increase of world population and slow rate of conventional breeding on the declining area of land, there is a need for crop improvement through new technology and thereby create GM crops [4].

Gene flow is the most touching risk arising from GM crops and is categorized into three types: Within species, between species and between GM crop and other organisms. Therefore, which causes the transgenic crop to become weedy, the GM crop itself could become an environmental hazard. Due to the positive and negative impact of such a new technology on genetically modified crops, there have been many debates between scientists, governmental authorities, agricultural producers, industries and consumer groups [5].

The supporters of this technology claim that bio-engineered food is safe and equivalent to what has been used for the last thousands of years. However, opponents believe that genetically engineered food is not an alternative to food obtained through conventional breeding.

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Received: 09-June-2021, Manuscript No. ACST-23-33496; **Editor assigned:** 14-June-2021, PreQC No. ACST-23-33496 (PQ); **Reviewed:** 28-June-2021, QC No. ACST-23-33496; **Revised:** 04-August-2023, Manuscript No. ACST-23-33496 (R); **Published:** 01-September-2023, DOI: 10.4172/2329-8863.1000615

Citation: Tiruneh A (2023) Review on Debates Over Genetically Modified Crops in the Context of Agriculture. Adv Crop Sci Tech 11: 615.

Both of them raise the issue of their argument over genetically modified crops by stating different reasons. This paper aims to review the debate over genetically modified crops and show possible causes in the context of agriculture.

Literature Review

Current production status of GM crops

The global hectarage of genetically modified crops in 2015 was 179.7 million hectares which showed 100-fold increments from 1.7 million hectares in 1996 to 2015 by up to 17 to 18 million farmers. The US has continued to be the lead country on planting biotech crops with 70.9% million hectares and having 39% of the global share with over 90% adoption of the principal crops of maize, soybean and cotton with 92%, 94% and 94% respectively. The second-largest grower, Brazil has reached 25% global share for the first time in 2015 with an area coverage of 44.9 million hectares. Argentina, India and Canada ranked third, fourth and fifth with 24.5, 11.6 and 11 million hectares of area coverage respectively. Up to 28 countries per annum grew biotech crops, in the period 1996 to 2015; Vietnam grew a biotech crop for the first time in 2015. Developing countries have grown more genetically modified crops in 2015 with a higher hectarage of 97.1 million hectares compared with 282.6 million hectares in 2014. Although there are some significant challenges in Africa, the continent on several fronts has continued the progress of adopting biotech crops. In addition to the already GM crops adopting country of South Africa, South Sudan and Burkina Faso, eight countries Cameron, Egypt, Ghana, Kenya, Malawi, Nigeria, Swaziland and Uganda conducted field trail in some principal crops of the region [6,7].

General characteristics of debates over the use of GM crops

A technique by which a gene from one organism is isolated and copied to other organisms following several stages like a laboratory, greenhouse, field trial and risk assessment test before release for human use is called a genetic modification. The modified crops under laboratory regulation will further go to discussion and policymaking for use in agriculture. Supporter of this technology have tried to show the safety of such technology; however, it is a serious issue on the opponent side [8].

The major debates over GM crops are appearing between activists, often among themselves and scientists. Farmers and consumers are often referred to as their voters who would benefit from the results of such lobbying. Indeed, some people who represent the scientific community become activists and vice versa. For example, Dr. Fagan, a molecular biologist, in 1994 took a stand against genetic engineering, renounced his grants and decided to dedicate his time to anti-GM activism. In the other direction, Mark Lynas, a former Greenpeace activist, left green activism and has joined Cornell university to work alongside the scientists instead. Also, there is a geographical context Europe and some regions of developing countries are known on opposing the cultivation of GM crops [9].

GM advocates believe in the possibility of achieving crop improvement through conventional breeding, but it can be only within related species and in a lengthy and imprecise process. However, their counterpart argues and explains the impossibility of bearing resemblance result to natural breeding through forcibly combines genes from unrelated species together.

The main arguments over GM crops can be done through the reference of sustainable development, namely environment, which also include human health issues, economics and social development. Both sides use such terms as sustainability, but each of them states them differently. However, much of the debates on agricultural biotechnology have focused on the potential risk of human health [10].

Discussion

Genetically modified crops and Economic concern

GM crops have a significant economic concern of which, yield and level of input cost are the major issues discussed in the economic debates of GM crops. The proponent has been argued the importance of genetically modified crops for herbicide-resistant by simplifying weed control procedures and thereby reduce labor-intensive weed managements. On their counter side, the opponent mentioned the relative advantage of using non-GM crops with low cost in the region where labor is enough. Gruere and Sun showed that Bt cotton contributed significantly to cotton yield growth, with 0.29%-0.39% % annual yield increases per percent adoption or a total 19% increase from 1975 to 2010. However, the opponent has argued on these achievements with the explanation of, high yield is a complex genetic trait resulting from many genes working together so that cannot be genetically engineered into crops with the existing biotechnology so that the yield advantages might be due to the existence of other factors than the Bt trait had a significant effect, especially the use of fertilizers and hybrid seeds. Further, they add another alternative, good farming methods, such as maintaining soil fertility, are equally or more important to maximizing yields. The increased yield of wheat by 3.5 times and doubling of rice yield *via* the green revolution technique were some of the achievements since the 1960s in Asia. Rice yields in India raised from 2 t/ha in 1960 to 6 t/ha in 1990, with a simultaneous reduction in price from 550 USD/t in 1970 to 200 in 2001 [11].

Small holder farmers that adopted Bt varieties of white maize in South Africa did benefit from planting Bt maize in high maize stalk borer infestation years, but when planted in locations or years when stalk borers were not a problem, Bt was not profitable because of higher seed costs. Which showed the dependency of economic gain of farmers from GM crops on certain factors.

A major part of the total public research funds for agriculture in Europe and elsewhere is allotted to projects using technically advanced methods associated with scientific prestige and corporate investments, but sometimes with dubious goals and questionable impacts. The large investment in the private sector indicates that research on genetically modified versions of major crops is expected to continue, while organic and other agro ecological methods are not likely to attract a similar investment. This increased specialization and intensification of production systems have led to a reduction in crop biodiversity and increased genetic vulnerability and erosion. Favoring biodiversity does not exclude any future biotechnological contributions, but favoring biotechnology threatens future biodiversity resources [12].

The costly process of bringing genetically modified seeds and patenting new varieties raise the price of seeds, so that small farmers and third world countries will not be able to afford seeds for GM crops. Patent enforcement may also be difficult, as the contention of the farmers that they involuntarily grew Monsanto-engineered strains. One way to combat possible patent infringement is to introduce a

"suicide gene" into GM plants. These plants would be viable for only one growing season and would produce sterile seeds that do not germinate.

Genetically modified crops and social concern

The most discussed issues about GM crops are social aspects, the impacts of GM on small farmers in a developing country. An intellectual property right is one of the important factors in the current debate over genetically modified crops. Patented GM crops by agribusiness companies leading to a monopolization of the global agricultural food. The social activist believes that the hidden reason biotech companies of producing GM crops are because they can be privatized, unlike ordinary crops which are the natural property of all humanity. The patenting of seeds by the agro-companies has been called biopiracy, which prevented farmers from having their own seeds supply and created a dependency on big business.

Aheto et al., 2013 reported that farming within the African context is operated on small plots of land mostly in a size range of below two hectares. In smallholder agriculture in Kenya, open-pollinated varieties and seed-saving and exchange are common. The use of genetically modified varieties would limit options for these traditional practices and put farmers and their households at risk [13].

The use of biotic crops as a portion of food has illustrated the serious conflict between the agri-biotech investors and their affiliated scientists who consider agricultural biotechnology as a solution to food shortage, the scarcity of environmental resources and weeds and pests infestations and independent scientists, environmentalists, farmers and consumers who warn that genetically modified food introduces new risks to food security, the environment and human health such as loss of biodiversity; the emergence of super weeds and super pests; the increase of antibiotic resistance, food allergies and other unintended effects.

Environmental and health concern of GM crops

Much of the debate on GM crops has focused on the potential risks of GM crops for human health. Agri-biotech companies claim that recombinant DNA techniques can bring advantages for the consumer such as nutritional enhancement as well as improving the quality and yield of food. However, independent scientists warn that the publications on the success of the modified crops in offering more nutritious and safe food are not based on scientific standards. One of the main problems which claim about the health and environmental safety of GM crops is the absence of intellectual freedom for an independent researcher to test the negative impact of modified crops after firms invoked intellectual property.

The techniques have been used to transfer single gene traits such as herbicide tolerance from soil microbes into plant cells. However, genes in higher eukaryotic don't work independently and work in a cell by interconnection so that one gene might not determine one trait, be it herbicide or pest side resistance. The recombinant vector used in the technique might contain several elements like viral promoter, antibiotic resistance and the like. There is concern that the viral promoter used in the vector exposes the consumer for viral infection the Cauliflower Mosaic Virus (CaMV) promoter is exploited to induce the expression of transgenes, Bt-maize of Novaris and GM cotton and canola. Seed companies argue that viruses have been engineered to be dormant in plant cells and therefore they are safe. Contrary to these claims, studies have shown that viruses, lacking the gene needed for movement, can easily gain it from neighboring genes.

Rats exposed to transgenic potatoes have shown abnormal sperm, cows and goat grazing Bt maize, had shown infertility problems and many of them died. However, companies producing such GM crops didn't show any negative effect on mice. Also, studies have revealed Bt corn expresses an allergenic protein that alters overall immunological reactions in the body.

Pollen from Bt corn caused high mortality rates in monarch butterfly caterpillars. Monarch caterpillars consume milkweed plants, not corn, but the fear is that if pollen from Bt corn is blown by the wind onto milkweed plants in neighboring fields, the caterpillars could eat the pollen and perish. Bt toxins kill many species of insect larvae.

Proponents stated that biotech crops have delivered substantial environmental and health benefits to farmers and increasingly, to society at large. Thereby, the important mission of the golden rice project is to contribute to improving the health of millions of people suffering from micronutrient deficiency. On the contrary, opponents reported that in early 2014 field trials in the Philippines found that GM golden rice failed to produce the yields and agronomic performance necessary for farmers to adopt it. IRRI noted, "Average yield of GM golden rice was, unfortunately, lower than that from comparable local varieties already preferred by farmers".

Allergic reactions to traditional foods are well known. The major food allergens are proteins in and derived from soy, tree nuts and wheat. GM crops make food less safe if the newly added protein proves to cause an allergic reaction once in the food supply. A well-known case is the transfer of a gene encoding a known allergen, the 2S-Albumin gene from the Brazil nut, to a previously safe soybean variety. When the allergenic properties of the transgenic soybean were tested, sera from patients allergic to Brazil nuts cross-reacted with the transgenic soybean. For this reason, a commercial product was never pursued. On the other hand, the introduction of an entirely new protein that has not been previously found in the food chain represents a different case.

The genetic material in soybeans that make them herbicide tolerant transferred into the DNA of human gut bacteria and continued to function. That means that long after we stop eating a GM crop, its foreign GM proteins may be produced inside our intestines. The perceived benefits of growing GM crops for poverty alleviation in Africa must be evaluated together with possible conflicts posed to the environment as well as with the bigger picture of food insecurity on the continent.

The agricultural structure in most of sub-Saharan Africa is not only small-scale but typically dense. The dominance of small fields with relatively few larger fields in the neighborhood is common. This type of agricultural setup would facilitate the possibility of transgene flow through higher cross-pollination among small field neighbors. Maize has a high risk of gene flow through cross-pollination, particularly when landholdings are fragmented, varieties are planted contiguously and farmers recycle, exchange or mix maize seeds.

A majority of traditional farmers acquire seeds for planting from a wide variety of sources within the informal sector. Acquisition of seeds as gifts from neighbors or home-saved from previous harvests are relevant sources. Commercial procurement of seeds does not rely upon a need for insect-resistant varieties but rather on more stable high-yielding varieties that may be shared among farmers in

subsequent seasons. Farmers would like to grow different crop varieties, *i.e.* landraces. Also, seed exchange among farmers limits the possibility of co-existence of farming systems involving conventional and GM crop farming, possibly lowering the economic value for conventional and organic food producers and causing a decline in crop genetic purity.

In summary, conventional breeding and genetic engineering are different but complementary ways of improving crops and either can be appropriate or inappropriate in particular cases, depending on the breeding objectives. Although neither improvement strategy is total without risk, the potential for a poor choice of target gene makes regulatory oversight important and obligatory during the development of transgenic crops through genetic engineering.

The latest development of biotechnology, particularly molecular biology, genetic engineering and transgenic technology has a very large number of potential applications in food production. Genetic modification has increased production in some crops. But the technology has challenges in a few crops. The results of such possible benefits and challenges of the technology bring a controversial debate which is usually applied by either extreme proponents or opponents of the technology. Debates on the technique of modifying crops for human benefit through introducing genes to plants within related or unrelated species appear between activists, usually among themselves and scientists. Genetically modified food crops pose both negative and positive effects. As an example of benefit, insect-resistant Bt expressing crops will reduce insect infestation on the modified crops, but if there are few pests, the farmer will not be going to apply pesticide so that the new pest may develop.

Conclusion

The important negative impact of biotech crops might have happened when genes from one modified crop flow to unmodified crops, the process might create crops with a negative side effect for the users. However, much of the debates on genetically modified crops are focused on the touching risk of human health and environmental effects. The main problem and arguments related to genetically modified crops on health and environmental safety were raised from the absence of intellectual freedom for an independent researcher to test the impact of GM crops after owned by a private company.

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