Utilization of Genetic Engineering in Commercial Crops: A global Overview

Purvi Mehta-Bhatt [1]

Summary

Over the millennia, farmers and agriculturists have practiced bringing together the best characteristics of individual plants and animals to make more vigorous and productive offspring. The modern tools of crop improvement, including genetic engineering, is an extension of traditional breeding methods and server as an important tool for crop improvement.

While the research activities in genetically modifying crops have been underway for many years, the commercial applications of such crops have been accomplished since last twelve years. The commercial journey of transgenic crops have been astonishingly successful with over 22 countries planting these crops on more than 102 million hectors of land. The successful deployment of transgenic approaches to combat insect pests and herbicide tolerance in important crops like cotton (*Gossypium hirsutum* L.), rice (*Oryza sativa* L.), soybean (*Glycine max*) and maize (*Zea mays* L.) is a remarkable accomplishment. Biofortification by increasing nutrition quality of crops constitutes another exciting and emerging field that will have immense implications on developing countries.

This paper reviews some of the current commercial applications of genetic engineering in crop improvement. It summarizes the global experience of these crops and it's environmental, economical and social benefits. The paper also discusses some of the perceived future direction and prospects of the genetic engineering technology, which has proven to be one of the fastest growing technologies in the history of agriculture sciences.

Keywords: Genetic engineering; Crop; Genetically modifying Crops; Transgenic crops; Food.

Introduction

Food being one of the prime needs of human beings, food production has been recognized as the oldest profession of humanity. Crop cultivation, selection and various breeding methodologies were practiced ever since human being started cultivating crops. Various plant breeding 'techniques' were developed by trial and error methods and over the years human being developed new crops and traits that were the results of human experimentation. A more systematic understanding of these activities were explained in last centaury with the rediscovery and advent of understanding of genetics and cytogenetics. This kind of systematic approach augmented our understanding of crops and crop cultivation.

The modern tools used in plant breeding are the result of our age old experience of early crop cultivation, basic understanding of plant genetic and the various breeding techniques developed in last few decades. Genetic Engineering is one such modern technique that finds it's roots in man's experience and scientific knowledge of several centuries. Genetic engineering is defined as any non-conventional tool aimed at mobilizing specific genetic information from one organism into another. These asexual techniques help to incorporate and engineer new characters in the plants that are otherwise very difficult and time consuming to introduce by conventional breeding.

Genetic engineering has the potential to accelerate crop improvement and has already yielded encouraging results (Jauhar & Chibbar, 1999; Muthukrishnan *et al.*, 2001; Dahleen *et al.*, 2001; Patnaik & Khurana, 2001; Wesseler, 2003 and Sharma *et al.*, 2004). Value added traits engineered into crop plants include resistance to fungal and viral diseases, and biofortification of their nutritional status (Jau-har & Khush, 2002; Schubert *et al.*, 2004 and Bajaj & Mohanty, 2005). The main objective of this article is to review the utilization of genetic engineering technique currently used on some of the important commercial crops around the world, it's future prospects and implications.

Genetic Engineering-One of the Important tools for Crop Improvement

Conventional plant breeding (Duvick, 1984; Jauhar, 1988 and Khush, 1999 & 2001), sometimes assisted by marker-assisted selection (Dubcovsky, 2004 and Lapitan & Jauhar, 2006), and wide hybridization coupled with manipulation of chromosome pairing (Friebe *et al.*, 1996; Fedak, 1999; Jauhar & Chibbar, 1999 and Jauhar, 2003) has been proven very beneficial for improving crops over the years. These tools, however, have been time consuming, less predictable and at times less effective, as compared with the transgenic technology.

Genetic engineering offers an excellent tool for asexually inserting a well-characterized gene (s) of unrelated organisms into plant cells, which on regeneration produce full plants with the inserted gene (s) integrated into their genome. This process may take less than a year to about 18 months in some cases, thus accelerating the process of genetic improvement of crop plants (Jauhar, 2006 a&b). Genetic Engineering has established it self as one of the very important tools for direct DNA transfer into plants by various in vitro methods. These methods include transfer through *Agrobacterium tumefecius,* Particle bombardment, Electrophoresis etc. These tools are now widely used to incorporate a gene of desire into crops and are becoming increasingly important commercial tool of crop improvement and reducing crop losses. According to Oerke *et al.* (1994), up to 42% of pre harvest crop loss in some of the major commercial food crop is due to various biotic stresses (Fig. 1) amounting for huge loss of resources. Genetic Engineer-

1. The Science Ashram, India. www.scienceashram.com,
E-mail: p_mehta_bhatt@rediffmail.com

ing techniques are now used commercially to combat some of these serious challenges of crop production like biotic and

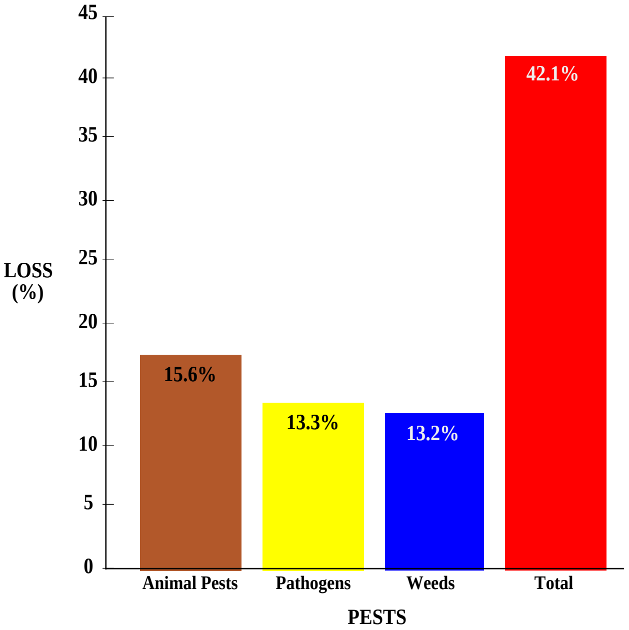

Fig.1. Global losses of eight major food and cash crops of the world (rice, wheat, barely, maize, potatoes, soybean, cotton and coffee) due to animal pests, pathogens and weeds (Oerke *et al.*, 1994).

abiotic stresses, low yield, improved nutrition quality etc.

Some of the important current commercial applications of genetic engineering for crop improvement are summarized in the following section.

Genetic Engineering for Insect resistance

Insect pests have been known to cause large amount of damage across the globe and has been a challenge for agriculture scientists and farmers for many generations. Some of the commercial crops like cotton, maize and rice have been the main victims of insect pests over the years with crop damages reaching to 100% in many regions during some seasons. European corn borer [ECB, Ostrinia nubilalis (Hu" bner)], for example, causes a loss of up to 2000 million dollars annually in the USA alone (Hyde *et al.*, 1999). The lepidopteraa insect causes yield loss of 523 million tons in Asia (High *et al.*, 2004).

A gene from a soil-borne bacterium, *Bacillus thuringiensis* (Bt), when incorporated into the corn genome, confers almost complete resistance to ECB. This is an efficient means of reducing the pest damage and pesticide application. Transgenic plants expressing insecticidal proteins from the bacterium *Bacillus thuringiensis* (Bt) were first commercialized in 1996. Today Bt corn and cotton have been grown on a large area cumulative worldwide (refer to Table- 2 in this paper). Despite some predictions to the contrary, resistance to a *Bt* crop has yet to be documented, suggesting that resistance management strategies have been effective thus far.

As indicated in Table (1) several important crops have been modified for insect resistance across the world with total area under insect resistant GM crops reaching 19.00 million hectors. The insect-resistant trait is reported to benefit small farmers because of higher crop yields and reduced use of pesticides, which is important for health reasons (Huang *et al.*, 2005).

Genetic Engineering for Tolerance of Abiotic Stresses

Abiotic stresses especially, drought and salinity, are estimated to cause yield losses worldwide of more than 50%. While abiotic stresses have been recognized as persistent problem for many commercially important crops, the conventional plant breeding methods have had minimal impact on combating this challenge. Plant adaptation to environmental stresses is dependent upon the activation of cascades of molecular networks involved in stress perception, signal transduction, and the expression of specific stress-related genes and metabolites. Genetic Engineering offers an important tool to protect and maintain the function and structure of cellular components and can enhance tolerance to stress. Several examples of genetic engineering for drought tolerance (Abebe *et al.*, 2003) and salinity tolerance (Apse & Blumwald, 2002 and Flowers, 2004) are available. Abebe *et al.* (2003) demonstrated that wheat engineered with the mtlD gene from *Escherichia coli* had improved tolerance to water stress and salinity. Showed that over expression of E. coli biosynthetic genes (otsA and otsB) as a fusion gene provided increased tolerance to abiotic stress in rice, resulting in elevated capacity for photosynthesis under drought and low-temperature stress conditions. There are several successful experiments of use of transgenic technology for various temperature stresses such as temperatures below freezing, low temperatures above freezing, and high temperatures.

While a large number of scientific groups, around the world are working on various abiotic stresses, genes conferring a degree of drought tolerance is expected to become available around 2010-2011 (Clive James, 2006). This is projected to have substantial impact relative to current input traits and will be particularly important for developing countries which suffer more from drought, an important constraint to increased crop productivity worldwide.

Genetic Engineering for Herbicide Resistance

Transgenic herbicide-tolerant crops have promoted the adoption of farming practices that reduce tillage or eliminate it altogether. Low-tillage practices can decrease soil erosion by up to 90 percent compared to conventional cultivation, saving valuable topsoil, improving soil fertility, and dramatically reducing sedimentation in lakes, ponds, and waterways.

From the genesis of commercialization in 1996, to 2006, herbicide tolerance has consistently been the dominant trait followed by insect resistance and stacked genes for the two traits. In 2006, herbicide tolerance, deployed in soybean, maize, canola, cotton and alfalfa occupied 68% or 69.9 million hectares of the global biotech 102 million hectares. (Table 1 and 2).

Table 1. Global Area of Biotech Crops in 2006: by Country (Million ha)

Rank	Country	Area(million hectares)	Biotech Crops
1*	USA	54.6	Soybean, maize, cotton, canola, squash, papaya, alfalfa
2*	Argentina	18.0	Soybean, maize, cotton
3*	Brazil	11.5	Soybean, cotton
4*	Canada	6.1	Canola, maize, soybean
5*	India	3.8	Cotton
6*	China	3.5	Cotton
7*	Paraguay	2.0	Soybean
8*	South Africa	1.4	Maize, soybean, cotton
9*	Uruguay	0.4	Soybean, maize
10*	Philippines	0.2	Maize
11*	Australia	0.2	Cotton
12*	Romania	0.1	Soybean
13*	Mexico	0.1	Cotton, soybean
14*	Spain	0.1	Maize
15	Colombia	<0.1	Cotton
16	France	<0.1	Maize
17	Iran	<0.1	Rice
18	Honduras	<0.1	Maize
19	Czech Republic	<0.1	Maize
20	Portugal	<0.1	Maize
21	Germany	<0.1	Maize
22	Slovakia	<0.1	Maize

Source: Clive James, 2006.
* 14 biotech mega-countries growing 50,000 hectares, or more, of biotech crops.

Table 2. Global area of genetically engineered crops, 1996 to 2006: By trait (million ha)

Year	Trait				Total
	HT	IR (Bt)	IR/HT	VR/Others	
1996	0.6	1.1	--	<0.1	1.7
1997	6.9	0.4	<0.1	<0.1	11.0
1998	19.8	7.7	0.3	<0.1	27.8
1999	28.1	8.9	2.9	<0.1	39.9
2000	32.7	8.3	3.2	<0.1	44.2
2001	40.6	7.8	4.2	<0.1	52.6
2002	44.2	10.1	4.4	<0.1	58.7
2003	49.7	12.2	5.8	<0.1	67.7
2004	58.6	15.6	6.8	<0.1	81.0
2005	63.7	16.2	10.	<0.1	90.0
2006	69.9	19.0	13.1	<0.1	102.0

Source: ISAAA, Clive James, 2006.
HT= Herbicide tolerance.
IR= Insect resistance (mostly Bt).
VR= Resistance to virus diseases.

A new biotech crop, herbicide tolerant alfalfa, was commercialized for the first time in the US in 2006. RR® alfalfa has the distinction of being the first perennial biotech crop to be commercialized and was seeded on 80'000 ha, or 5% of the 1.3 million ha of alfalfa probably seeded in the US in 2006. RR® Flex herbicide tolerant cotton was launched in 2006 occupying a substantial area of over 800'000 ha in its first year and was planted as a single trait and as a stacked product with *Bt*, with the latter occupying the majority of the hectarage. The plantings were principally in the US with a smaller hectarage in Australia. (Clive James, 2006)

Genetic Engineering for Resistance to Diseases

A large number of fungal, bacterial, and viral diseases pose a major threat to global food security. Conventional plant breeding offers a useful means of breeding disease-resistant cultivars, however, resistance breeding through these techniques can be slow and with limited effectiveness in many crops. Tools of biotechnology offer great promise for accelerating this process.

Transgenic approaches to control fungal pathogens with antifungal genes could help produce crop plants resistant to fungal pathogens (Datta & Muthukrishnan, 1999 and Dahleen *et al.*, 2001). Trans-genic technology also offers an excellent option to protect crop plants against devastating viral pathogens. Transgenic plants with nucleotide sequences derived from viral genomes has been shown to provide protection against the virus from which the sequences were derived. The evidence for such a Pathogen-Derived Resistance (PDR) was provided by Powell, who demonstrated that transgenic tobacco plants expressing Tobacco Mosaic Virus (TMV) coat protein were resistant to the virus. Rice Yellow Mottle Virus (RYMV) is another serious viral disease causing enormous losses in rice yields. A trans-genic approach based on PDR can be employed to produce an RYMV-resistant rice variety (Pinto *et al.*, 1999).

Commercially two transgenic crops, Papaya and squash are available with virus resistance trait. Theses plants have been incorporated coat protein mediated resistance. No commercial cultivars with fungal resistance are available today.

Genetic Engineering for Value-enhancement

More than 842 million people worldwide are malnourished (http://www.fao.org/english/newsroom/news/2003/26659-en.html; verified 10 May 2006). Most of these people live in the countries of Asia and Africa. Value addition in crops, like improving nutritional qualities, reducing post harvest losses is of very high priority. Genetic engineering is being employed to raise the micronutrient content of some stable food like rice. Rice grains, in it's natural form, contains negligible amount of b-carotene, which is the precursor of vitamin A. However, they contain geranylgeranyl

Pyrophosphate that can be sequentially converted to b-carotene by four enzymes. By engineering rice with the four genes for these enzymes, two genes from daffodil and two from the bacterium, genetically engineered rice has been developed to produce vitamin A. Later, by incorporating the iron-synthesizing ability in it, scientists were able to produce rice grains rich in vitamin A as well as iron (Beyer *et al.,* 2002). The resulting rice, called Golden Rice, has the potential of saving millions of lives and averting blind-ness among millions of children, and is therefore referred to as the grains of hope. This strategy is being applied to other cereal crops (Poletti *et al.*, 2004) as well as non cereal crops like potatoes Ducreux *et al.* (2004).

All these examples state a clear potential of genetic engineering as a significant tool to enhance quality and quantity of crop production. Such value enhanced crops have the potential to provide momentum to the agricultural biotechnology industry and to enhance productivity worldwide (US Department of Agriculture Economic Research Service, 1999). Two such crops high oleic soybeans and laurate canola, have been introduced commercially in the USA.

Summary of Commercial Application of Genetic Engineering

As stated earlier in this paper, Genetic engineering finds important applications in crop improvements through interventions in managing abiotic, biotic stresses and also providing value additions to crops. Following is the summary of commercial application of genetic engineering in different parts of the world, on various crops and in different traits.

As indicated in Table (1), Soybean, Maize and Cotton are the most prominent transgenic crops. Table (2) indicate the various traits adopted, with herbicide resistance as the most dominant trait followed by insect resistance.

In 2006 the global area of biotech crops reached 102 million hectares (252 million acres). Biotech crops were grown in 22 countries (listed in Table 1) and grown by 10.3 million farmers. The enormous commercial success of this technology is mainly due to it's well demonstrated economic, ecological and social benefits that are summarized in the following section.

Table (3) indicates various research activities on genetic engineering. The future will depend on our ability of taking these researches into commercial products.

Environmental Benefits

While the first generation of transgenic crops were designed primarily to improve agricultural efficiency, the first decade of commercialization of these crops (1996-2006) have shown significant environmental benefits. The U.S. Department of Agriculture found that U.S. farmers growing transgenic pest-resistant cotton, maize, and soy reduced the total volume of insecticides and herbicides they sprayed by more than 8 million pounds per year (http://www.msstate.edu/Entomology/Cotton.html) Similar reductions have been observed in Canada with transgenic rapeseed, according to the Canola Council of Canada. The accumulative reduction in pesticides for the decade 1996 to 2005 was estimated at 224,300 MT of active ingredient, which is equivalent to a 15% reduction in the associated environmental impact of pesticide use on these crops, as measured by the Environmental Impact Quotient (EIQ) - a composite measure based on the various factors contributing to the net environmental impact of an individual active ingredient (Brookes and Barfoot, 2006).

In less developed nations where pesticides are typically sprayed on crops by hand, transgenic pest-resistant crops have had even greater benefits. In China, for example, some 400 to 500 cotton farmers die every year from acute pesticide poisoning. A study conducted by researchers at Rutgers University in the United States and the Chinese Academy of Sciences found that adoption of transgenic cotton varieties in China has lowered the amount of pesticides used by more than 75% and reduced the number of pesticide poisonings by an equivalent amount.

Genetic engineering can also serve as an important tool to protect biodiversity and the plunging forest resources by providing protection against some fatal diseases. Dutch Elm Disease (DED), for example, has destroyed more than 20 million elm trees (*Ulmus procera salisb.*) in the UK over the last three decades, and more than 70% of the elms (*Ulmus americana* L.) in the USA have perished because of the DED fungal pathogen in the past 70 yr (Gartland, 2002). Genetically modified elms with resistance to the fungal pathogen can serve as an important tool to save these trees and ultimately contribute to the thrust of environmental protection.

As the per hectare productivity of land increase, this offers another environmental benefit by putting less pressure of the natural resources. Transgenic crops with increased water efficiency, salt tolerance consume less water and have the potential to turn waste land green in some regions. Thus, increasing agricultural productivity, reduced use of natural resources is an essential environmental benefit of genetic engineering. Negative environmental consequences have not been documented in any setting where transgenic crops have been deployed to date. Nonetheless, the long term environmental concerns deserve continued monitoring because of the novel nature of genetic engineering.

Implications on Food Security

The UN Food and Agriculture Organization (FAO) estimates that food output must increase by 60% over the next 25 yr to keep up with demand. In a report on the bioengineering of crops written for the World Bank and the Consultative Group on International Agricultural Research (CGIAR) in October last year, a group led by Henry Kendall, chair of the Washington DC-based Union of Concerned Scientists, said that transgenic crops could improve food yields by up to 25% in developing countries and could help to feed an estimated additional three billion people over the next 30 yr.

Apart from producing more food for the world, biotechnology also offers hope of improving the nutritional benefits of many foods. Among the most well known, as de-

Table 3. Global Research Activity on Transgenic Crops (63 countries, 57 crop species)

Type of Crops	Under Commercial Production		Regulatory Approval Received		Under Field or lab/greenhouse studies	Total Crops & Countries	
	Crop	Country	Crop	Country		Crops	Countries
Field Crops	Soybean Cotton Maize Canola	Canada, USA, Argentina, South Africa, Brazil, East Europe, Uruguay, Paraguay and Chile USA, Australia, Argentina, Mexico, China, South Africa, India and Colombia Canada, USA, Western Europe, Argentina, South Africa, Uruguay, Philippines and Chile Canada and USA	Soybean Cotton Maize Canola Sugar beet Flax	Mexico Canada and Egypt East Europe and Honduras Egypt Canada and USA Canada and USA	Alfalfa, Barley, Cassava, Canola, Clove, Cotton, Maize, Rice Safflower Sorghum, Sugarcane, Sunflower Wheat	16	55
Vegtables	Tomato Squash	China USA	Potato Tomato Squash	USA and Canada USA, Canada and Mexico	Black gram, Broccoli, Cabbage, Cauliflower, Carrot, Chickpea, Cucumber, Eggplant, Lettuce, Onion, Pigeon pea, Potato, Spinach Tomato	16	50
Fruits	Pepper Papaya	China Hawaii (USA)	Papaya Melon	Canada USA	Apple, Banana, Cantaloupe, Cherry, Citrus, Coconut, Grape, Kkiwi, Mango, Muskmelon, Pineapple,Plum, Raspberry, Strawberry, Watermelon	17	29
Other Crops	Tobacco	USA	Chicory	USA and Canada	Cocoa, Coffee, Garlic, Lupins, Oil palm, Oilseed, Olive, Peanut (Groundnut), Poppy, Tobacco	11	29

Source: Manjunath T. M, 2005

scribed earlier, is the "Golden Rice," genetically enhanced with added beta carotene, which is converted to vitamin A in the human body. The Golden Rice project is also an important example of the valuable collaboration between public sector, private sector and charitable research activities. The rice's development was funded mainly by the New York-based Rockefeller Foundation, which has promised to make the rice available to poor farmers at little or no cost. It was created by scientists at public universities and private company in Switzerland and Germany with assistance from the Philippines-based International Rice Research Institute (IRRI) and from several multinational corporations.

Admittedly, experts recognize that the problem of hunger and malnutrition is not just due to shortage of food but also due to access to food. Genetic Engineering offers important tool for post harvest preservation, increased shelf life and there by helping preserving the food we produce.

The economic benefits, described in the following paragraph is also linked to the issue of food security. As the income of farmers increase, their ability of purchase food shall also improve and there by ensuring better lives and food security to the rural poor.

Economic Benefits

In a recent survey (Brookes and Barfoot, 2006)*1*of the global impact of biotech crops for the decade 1996 to 2005, estimates that the global net economic benefits to biotech crop farmers in 2005 was $5.6 billion, and $27 billion ($13 billion for developing countries and $14 billion for industrial countries) for the accumulated benefits during the period 1996 to 2005; these estimates include the benefits associated with the double cropping of biotech soybean in Argentina.

Adoption of the first (and the only) transgenic crop in India, the BT cotton, is a good example of economic benefit of genetically modified crops. In India, five years since it's commercialization, approximately 2.3 million small farmers planted on average 1.65 ha of *Bt* cotton in 2006. These farmers are reaping significant benefits from the technology. Coincidental with the steep increased adoption of *Bt* cotton between 2002 and 2005, the average yield of cotton in India, which had one of the lowest yields in the world, increased from 308 kg per hectare in 2001-02 to 450 kg per hectare in 2005-2006, with most of the increase in yield of up to 50% or more attributed to Bt cotton (Clive James, 2006).

The principal gain from *Bt* cotton in India is the significant yield gains estimated at 45% in 2002, and 63% in 2001, for an average of 54% over the two years. Taking into account the decrease in application of insecticides for bollworm control, which translates into a saving, on average, of 2.5 sprays, and the higher cost of *Bt* cotton seed, Brookes and Barfoot estimate that the net economic benefits for *Bt* cotton farmers in India were $139 per ha in 2002, $324 per ha in 2003, $171 per ha in 2004, and $260 per ha in 2005, for a four year average of approximately $225 per ha. The benefits at the farmer level translated to a national gain of $339 million in 2005 and accumulatively $463 million for the period 2002 to 2005.

The example of India and many other countries in the world clearly exhibit the economic benefits of genetic engineering, that offers tool for higher yield, better quality (and thus better market price), reduction in cost of cultivation (e.g. less consumption of pesticides).

Future Prospects

Genetic Engineering in crop improvement is viewed as one of the fastest growing technology in the history of agriculture. With the huge adaptation rates since its first commercialization, the future for biotech crops looks very encouraging. While the area covered under the presently available crops and traits shall increase, the future shall depend upon the new traits and crops that are tailor made to the needs of individual countries and regions. The outlook for the next decade of commercialization, 2006 to 2015, points to continued growth in the global ha of biotech crops, up to 200 million ha, with at least 20 million farmers growing biotech crops in up to 40 countries, or more, by 2015 (Clive James, 2006). The second decade of commercialization, 2006-2015, is likely to feature significantly more growth in Asia compared with the first decade, which was the decade of the Americas, where there will be continued growth in stacked traits in North America and strong growth in Brazil. The mix of crop traits will become richer with quality traits making their long awaited debut with implications for acceptance, particularly in Europe.

Apart from the food and feed crops, that will have very important contribution towards fulfilling the Millennium Development Goals (MDG), the future shall see increased applications of genetic engineering in pharmaceutical products like edible vaccines, nutracuticals etc.

The first decade of transgenic technology has come largely from the private sector; the future shall see more public sector involvement and more commercial products from public sector or from public-private partnerships. It is important to note that in the first decade of genetic engineering, the technology was viewed as new by many countries and hence many parts of the world have taken a ‘sitting on a fence’ approach. Now with more than ten years of experience from 22 countries, the future shall see more countries taking advantage of this promising technology.

Apart from development of GM products in the laboratories, there are greater opportunities for cross sector collaborations for capacity at the grass roots level. In most Asian counties, where 60-70% of the total population is farmers, they simultaneously are also the major consumers or end users. A major thrust is needed to build awareness among farmers of this new technology, its safety precautions, and such consequences to build an informed society and to help growers to take informed decisions on GM crops and biotechnology (Mehta-Bhatt *et al.*, 2005) The need for capacity development added with sensible regulation of transgenic crops cannot be overemphasized (Bradford *et al.*, 2005).

Conclusion

Genetic engineering is playing and will continue to play an important role in crop improvement and there by for human welfare. This technology gives us the ability to change the genotype of a plant in a relatively short period of time, and could serve as a powerful tool to help design crops of desired traits.

Genetic Engineering is one of the important tools that can have very important environmental, economical and social benefits. This tool should not be mistaken as the only solution for the challenges of agriculture but should be viewed as one of the important contributors. As aptly stated by Norman Borloug, Today, with the tools of biotechnology, the ends are reached in a more organized and accelerated way. The result has been the advent of a "Gene" Revolution that stands to equal, if not exceed, the Green Revolution of the 20th century.

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استخدام الهندسة الوراثية في المحاصيل التجارية: نظرة عالمية

بيرڤي ميثار باهات [1]

الخلاصة

على مر السنين كان المزارعون والمتخصصون بالزراعة يقومون بجمع أفضل الصفات النباتية والحيوانية لإنتاج كائنات حية أكثر قوة أو إنتاجية. إن الطرق الحديثة لتحسين المحاصيل والتي من ضمنها الهندسة الوراثية هي امتداد لطرق التحسين الوراثي التقليدي وتستخدم كطرق هامة في تحسين المحاصيل الزراعية.

بالرغم من أن النشاط البحثي في مجال المحاصيل المحورة وراثياً بدأ قبل سنواتٍ طويلة، إلا أن التطبيقات التجارية لتلك المحاصيل تحقق خلال الـ12 سنة الماضية.

تجارة المحاصيل الـمُهندسة وراثياً نجحت في 22 دولة حيث بلغت مساحة الأراضي المزروعة بتلك المحاصيل 102 مليون هكتار. يُعتبر الاستخدام الناجح لوسيلة التحسين الوراثي بالهندسة الوراثية لمقاومة الآفات الحشرية ومبيدات الحشائش في المحاصيل المهمة مثل القطن والأرز وفول الصويا والذرة الصفراء إنجازاً كبيراً.

إن تحسين القيمة الغذائية للمحاصيل بالهندسة الوراثية مجال هام وسوف يكون له تطبيقات واسعة في الدول النامية. تُسلِّط هذه المقالة الضوء على بعض التطبيقات التجارية الحالية للهندسة الوراثية لتحسين المحاصيل الزراعية، كما تلخص التجربة العالمية للمحاصيل المحوَّرة وراثياً وفوائدها الإيجابية على الجانب البيئي والاقتصادي والاجتماعي. وتناقش المقالة أيضاً بعض التوجهات المستقبلية لتقانة الهندسة الوراثية والتي أثبتت بأنها من أسرع التقانات نمواً في تاريخ العلوم الزراعية.

1. الهند. بريد إلكتروني: p_mehta_bhatt@rediffmail.com