The seed is drilled at 10 kg per hectare. Thinning is done to ensure that the plants are 25 cm apart. During the first 40 days, the fields are not watered, but hoeing is necessary for purposes of aeration and weeding. Ridging is done before the first watering. We use an earthing ridger set to form a 91 cm space and a 51cm ridge, at a separation of about 20 cm on either side of the plant rows. This plant configuration and ridging can reduce water consumption by up to 66%. The ensuing seepage gives the plant a boost. With this method only 5 irrigations are applied and with every irrigation there is a water economy of 66% or more.

The tractor-mounted sprayer covers the field with a spray swath 140 cm wide. The water pressure is raised using a diaphragm pump set at 4 kg/cm2 to produce a droplet size of 600 microns, which is ideal for a uniform spray pattern. The nozzles are fitted at a 45ß angle thus producing a uniform mist for longer distances.

The fertilizer applied is single super phosphate (SSP) powder spread by a fertilizer broadcaster, along with an ammonium sulphate application using a locally made drill. It is difficult to spread the fertilizer because it draws in moisture very quickly, but it has to be done.

Picking on my farm is manual. The cost of production is around US$635 per hectare. The average production on my farm has never been less than four tons of seed cotton/ha or about 1,320 kg of lint/ha. Cotton sticks are buried with a rotavator to return nutrients to the soil. Only the fruit or produce of farms belongs to us; the crop residue and stalks should be returned to the earth for further production.

I apply seed treatment, as well as pink bollworm ropes and try to purchase innovative chemical products, if available, to use against target insects/pests. Use of sex pheromones for monitoring is a common practice. Insecticides are sprayed at night, i.e. from dusk till midnight. The Provincial Agriculture Department helps growers in pest scouting and I seek out their recommendations, which help me to control pests.

With the above mentioned cotton cultivation requirements, farmers are unable to go very far from their fields and spend most of their time tending their crop production. Farming is a no-holiday business and when professionals in other occupations are out demanding shorter working hours and increased salaries, farmers are praying for God to increase the work day from 24 hours to 48 hours, i.e. double the working hours, in order to have time enough to fulfill their productive chores, and set aside some bonus moments for rest so that they can go on producing to sustain every living thing on earth.

There is a lot of talk about organic/biological cotton production through a range of techniques such as: IPM practices, introduction of *Chrysopa*, releasing *Trichograma*, crop rotation, planting cover crops, yellow traps, planting Bt cotton, using GMOs or applying organic pesticides. However, there is also a great deal of concern about the implementation of such techniques. If Bt varieties or organic production can save the poor farmer from hazardous applications of toxic chemicals, then such techniques should be awarded a Nobel Prize. If any such exercise could be made foolproof and readily available in any part of the world for large-scale agriculture, every farmer would ask researchers to transfer this life-saving technology by electronic media to this most threatened of all species: "the farmer". May I take the liberty of quoting an Egyptian saying: "the farmer does not have ears - he simply has the eyes." Until and unless they can see for themselves, they don't believe.

Bt Cotton in India: The Technology Wins as the Controversy Wanes

T. M. Manjunath, AgriBiotech, India

Abstract

Bt cotton varieties developed by Mahyco (Maharashtra Hybrid Seed Company) containing the Bollgard® Bt gene, Cry 1Ac, licensed from Monsanto, was approved by the Government of India for commercial cultivation in March 2002. This approval was preceded by a large number of laboratory studies and about 500 field trials during 1996 - 2001 to demonstrate the safety and benefits of Bt cotton as per regulatory requirements. The area planted with Bt cotton in 2002, was 29,415 ha. Area increased to 86,240 ha in 2003 and to 530,800 ha in 2004. A nationwide survey carried out in 2003 indicated that the Bt cotton growers in India were able to obtain, on an average, a yield increase of about 29% due to effective control of bollworms, a reduction in chemical sprays by 60% and an increase in net profit by 78% as compared to their non-Bt counterparts. The indications are that the demand for Bt cotton will grow significantly in the coming years. Realizing its potential, 19 other seed companies have already joined Mahyco-Monsanto as their sub-licensees for Bt cotton. Details of the development of Bt cotton, safety studies, field performance, opposition it faced, the problem of illegal Bt cotton, and the prospects for this technology in India are outlined in this article.

Introduction

Cotton is an important cash crop in India and plays a significant role in the national economy. It supports millions of people through cultivation, processing and trade and contributes

$8 billion to the export income. The area occupied by cotton in recent years fluctuated between 8 and 9 million hectares in India. While India has the largest area under cotton in the world (representing 20 to 25% of the global area), it ranks only third in terms of production after China and the USA. Several factors are responsible for low yields, but losses due to insects are the most important. More than 160 species of insects attack cotton at various stages of its growth. Defoliators, tissue borers and sap-suckers cause yield losses up to 60%. Among the insects, bollworms (tissue borers) are the most destructive. The contribution of Bt cotton in bollworm control is described below.

Cotton Bollworms

The cotton bollworm complex in India includes the 'old world bollworm' or 'false American bollworm' - *Helicoverpa armigera;* pink bollworm - *Pectinophora gossypiella*; spotted bollworm - *Earias vittella* and spiny bollworm - *Earias insulana*. The tobacco caterpillar - *Spodoptera litura*, also a lepidopteron, is a sporadic pest on cotton. Although predominantly a defoliator, it can also damage cotton bolls and squares when there is a severe outbreak.

Among the bollworms, *H. armigera* is dominant and the most difficult to control, chiefly due to its widespread insecticide resistance, multivoltine and prolific pattern of breeding and high polyphagy. It is a highly destructive and wasteful feeder in the sense that a single larva can damage many squares and bolls. *H. armigera* has a wide distribution, but is limited to the old world i.e., Europe, Asia, Russia, Africa, Australasia and the Pacific Islands. The species commonly found in the Americas are *Helicoverpa zea* and *Heliothis virescens*, popularly called 'bollworm' and 'tobacco budworm,' respectively. Hence, reference to *H. armigera* as 'American bollworm' is misleading. To avoid any confusion, it is better to call *H. armigera as* 'old world bollworm' or 'false American bollworm.'

Chemical insecticides are used extensively on cotton to control insect pests, especially bollworms. The number of sprays per crop season varies from 5 to 20 or more. Insecticides worth about $660 million are used annually in Indian agriculture, of which $352 million are spent for the control of cotton pests, and of this $264 million against bollworms alone. In terms of volume, about 54% of the total insecticides used in Indian agriculture are sprayed on cotton. This indicates the economic importance of bollworms in general and *H. armigera* in particular. Despite huge efforts, bollworm control has not been satisfactory because the pest developed resistance to most of the currently recommended insecticides. Nevertheless, farmers continue to use insecticides repeatedly as they have no option except to "spray" or "pray." This has frustrated farmers, scientists and policy makers alike. Bt cotton came at a time when they were desperately looking for an alternative, dependable control measure.

Development of Bt Cotton (Bollgard®) in India

Realizing the economic importance of cotton bollworms and the benefits Bt cotton can offer to growers, Mahyco (Maharashtra Hybrid Seed Company), a leading Indian seed company, in collaboration with Monsanto, took the initiative to introduce this technology into India.

As per regulatory procedure, Mahyco sent its application to the Department of Biotechnology (DBT), Government of India, in March 1995 seeking permission to introduce this technology. On obtaining approval, Mahyco received about 100 gms of Bt cotton seeds containing the Bollgard® Bt gene, Cry 1Ac, from Monsanto, USA, in March 1996. These seeds were first tested in India under greenhouses for germination, plant vigor and efficacy against the Indian cotton bollworms. These were also used in greenhouse breeding programmes. Thus, 40 elite Indian parental lines were introgressed with the Cry 1Ac gene by crossing with the Bt gene donor parent obtained from Monsanto. Mahyco developed several Bt cotton hybrids suitable for different agro-climatic regions, and these were already popular with farmers. Some of these conventional hybrids were converted into Bollgard® using the converted parental lines and tested for their performance and safety as described below.

Regulatory Studies on Safety

In India, two federal ministries are involved in the regulation of GMOs – Ministry of Science & Technology (MoST) and Ministry of Environment & Forests (MoEF). The Department of Biotechnology (DBT) functions under MoST. Two important committees, the Institutional Bio-Safety Committee (IBSC) and the Review Committee on Genetic Modification (RCGM), work under the guidance of DBT. Another major committee, the Genetic Engineering Approval Committee (GEAC), was constituted under MoEF. These committees are represented by experts drawn from various fields and organizations across the country and are responsible to ensure that proactive safety studies are carried out on GM products before they are approved for commercialization.

As per the direction and guidelines of the regulatory authorities, a number of studies were carried out to assess the safety of the protein expressed in Bt cotton plants with regard to its potential for allergenicity, toxicity, gene flow, cross pollination, effects on non-target beneficial organisms and, impacts on soil microorganisms. These data were examined by expert committees.

Feed-safety studies with Bt cottonseed meal were carried out with goats, buffalos, cows, rabbits, birds and fish. The results revealed that the animals fed with Bt *cotton* seed meal were comparable to the control animals in various tests and showed no ill-effects. These studies were carried out by the Industrial

Table 1. Chronology of Development and Approval of Bt Cotton in India

1995 (March)	Mahyco applied to DBT (Department of Biotechnology, Govt. of India) for permission to import a small stock of Bollgard® (Bt cotton) seeds from Monsanto Company, USA.
1996	With the approval of DBT, a nucleus stock of about 100 gms of cotton seeds containing the Bollgard® Bt gene, Cry 1Ac, was received by Mahyco from Monsanto, USA. Initiated crossing with the Indian cotton breeding lines to introgress Cry 1Ac gene. 40 elite Indian parental lines were converted into transgenic Bt lines.
1996-1998	Risk-Assessment Studies conducted using Bt cotton seeds from converted Indian lines. - Pollen escape studies - Aggressiveness and persistence studies - Biochemical analysis - Toxicological studies on ruminants (goats) - Allergenicity study on rabbits
1998 – 1999	Field trials at 40 locations in 9 states to assess agronomic benefits and safety. Data submitted to RCGM (Review Committee for Genetic Modification), Ministry of Science & Technology, Govt. of India.
1999 – 2000	Field trials repeated at 10 locations in 6 states. Data submitted to RCGM.
2000 (July)	Based on the recommendation of RCGM, the GEAC (Genetic Engineering Approval Committee), Ministry of Environment & Forests, Govt. of India, gave approval for Mahyco to conduct large scale field trials on 85 ha and also undertake seed production on 150 ha.
2001	Kharif 2001 – Large scale field trials covering 100 ha. Field trials were also conducted by the All India Coordinated Cotton Improvement Project of the Indian Council of Agricultural Research (ICAR).
2002	On 26 March 2002, GEAC approved Mahyco's three Bt cotton hybrids, Mech 12, Mech 162 and Mech 184, for commercial cultivation in India. This approval was initially valid for three years and also stipulated other conditions.

This is a landmark decision as Bt cotton is the first-ever transgenic crop to receive regulatory approval in India.

Toxicological Research Centre, Lucknow; National Dairy Research Institute, Karnal; Central Institute of Fisheries Education, Mumbai; Central Avian Research Institute, Bareily; National Institute of Nutrition, Hyderabad; and Govind Vallabh Pant University for Agriculture and Technology, Pantnagar.

Studies were also conducted on the effects of leachate from Bt cotton plants on soil rhizosphere and non-rhizosphere microflora, soil collembola and earthworms. The results showed no differences between the soils where Bt and non-Bt plants had been grown. The information generated on pollen dispersal has established that airborne pollen transmission in cotton is limited to only a couple of meters, and the risk of undesirable introgressive hybridization with related species is minimal. Further, Bt cotton hybrids are tetraploid in genetic composition whereas their nearest relatives, the local "Desi" cotton varieties, are diploid and hence are genetically incompatible for hybridization. Studies also revealed that Bt cotton had no adverse impact on biological control agents like ladybird beetles, green lacewings and parasitic hymenoptera.

Studies were also carried out to determine the levels of Bt protein expressed in different tissues (terminal leaves, squares and bolls) at different ages of the crop and at different locations. The results revealed that although the expression varied among tissues and with the age of the plant, the amount of protein present in various tissues at any time was adequate to bring about mortality of the early instar bollworms.

Baseline susceptibility data were also generated for a number of geographic populations of *Helicoverpa armigera* so that it can serve as a benchmark for monitoring resistance, if any, in the future. These studies were carried out prior to commercial cultivation of Bt cotton by the Project Directorate of Biological Control, ICAR, Bangalore.

Field trials conducted from 1998 to 2001 clearly indicate that Bt cotton hybrids provided effective control of the bollworm complex in all locations and seasons. Data generated on all these aspects were submitted to DBT/RCGM for review.

India Approves Bt Cotton – The First Agribiotech Product

Based on the recommendation of RCGM, the Genetic Engineering Approval Committee (GEAC), in its 32nd meeting held in New Delhi on 26th March 2002, approved Mahyco's Bt cotton for commercial cultivation, pronouncing it to be beneficial and safe. This was a landmark decision as Bt cotton is the first-ever agribiotech product to receive such approval. With the decision, India made its entry into commercial agricultural biotechnology. This approval specified three Bt hybrids, Mech 12, Mech 162 and Mech 184, which had undergone all the trials, and approval was initially granted for three years. The approval also stipulated other conditions. Every Bt cotton field must be fully surrounded by a 'refuge' crop comprising the same non-Bt cotton hybrids, and the size of the refuge shall be at least five rows of non-Bt, or 20% of the total sown area, whichever is greater. The "refuge" is to ensure the survival of Bt-sensitive insects, thereby helping to prevent or delay the development of resistance by bollworms to the Bt protein produced in each plant. "Refuges" also act as a "pollen sink" area.

The chronology of events that led to the development and approval of Bt cotton in India are summarized in Table 1.

Field Performance

Three Bt cotton hybrids, Mech 12, Mech 162 and Mech 184 were commercially planted in 2002 on 29,415 ha in six states - Maharashtra, Madhya Pradesh, Karnataka, Andhra Pradesh, Gujarat and Tamil Nadu. Area increased to 86,240 ha in 2003 and to 530,800 ha in 2004. The results demonstrated the following benefits from Bt cotton:

- Good control of bollworm species (false American bollworm, pink bollworm, spotted bollworm, spiny bollworm) in all locations and seasons
- Significantly higher boll retention and higher yields than the control or non-Bt cotton crop
- Reduction in chemical sprays for bollworm control
- Substantial increase in net income to farmers
- No adverse impact on non-target organisms and the adjacent non-Bt cotton or other crops

During the growing season of Kharif 2003, commercial performance trends were tracked by Mahyco for approximately 3,000 farmers covering most cotton growing states in central and south India. Data were taken for all three Bollgard® hybrids. The largest sample was taken in the state of Maharashtra due to greater availability of resources. From a total sample size of 1,700 Maharashtra farmers, trends for relative economic gain in favour of Bollgard® hybrids ranged from $330 to $420 per hectare among the three hybrids. For all Bollgard® hybrids, the average number of insecticide applications for the bollworm complex was about 50% less than that required for conventional commercial hybrids. Seed cotton yields, with Bollgard® hybrids ranged from 1,900 to 2,170 kg per hectare, compared to conventional hybrids where yields varied from 1,100 to 1,309 kg per hectare. Similar trends were documented in other surveyed states. The average net economic benefit from Bollgard® hybrids over non-Bt hybrids among all states in the survey ranged from $208 to 685 per hectare.

A nationwide survey carried out by ACNeilsen-ORG MARG in 2003 which included 3,063 farmers (1,672 Bt farmers and 1,391 conventional farmers) from Maharashtra, Madhya Pradesh, Andhra Pradesh, Karnataka and Gujarat (Tamil Nadu could not be included as the harvest was yet to be completed) clearly indicated the benefits of Bollgard® cotton. It indicated that the Bt cotton growers in India were able to obtain an average yield increase of 29% (range 18% to 40%) due to effective control of bollworms, a reduction in chemical sprays by 60% (range 51% to 71%) and an increase in net profit by 78% (range 66% to 164%) as compared to non-Bt cotton. The net profit translates to an average of $161 (ranging from $123 to 265) per hectare. According to the survey, over 90% of Bollgard® users and over 40% of non-users expressed the intent to purchase Bollgard® seeds in the coming season.

Opposition to Bt Cotton

Bt cotton faced opposition from organizations and individuals from the beginning of its introduction and even before it had complete regulatory studies. A farmers' organization in Karnataka, Karnataka Rajya Raitha Sangha (KRRS), uprooted and burnt a few approved experimental crops in 1998 and 1999, wrongly accusing that Bt cotton contained the so-called "Terminator Technology" and the gene would escape and cause "Gene pollution" and sterility in other plants. They also alleged that Bt protein is harmful to humans, farm animals, other beneficial organisms and soil. They threatened farmers with serious consequences if they planted Bt cotton. They also held repeated public demonstrations against this technology.

There were also other critics. Whenever a cotton crop failed in a certain area, be it due to drought or other environmental stress, wilt or other diseases, sucking pests or any other reason, critics attributed the failure to the Bt-technology and blamed the company as well as the government. They encouraged farmers to claim compensation from the company, ignoring the fact that Bt cotton was developed specifically to offer protection against bollworms, not against any other adverse factors. Their actions and statements received prominent coverage in the print and electronic media and created doubt and confusion in the minds of farmers and the public. It took enormous efforts on the part of Monsanto and Mahyco to mitigate such negative publicity. The role played by DBT, which stood by this technology and organized several educational seminars on biotechnology in several states, is commendable. Except for a very few scientists, the rest of the scientific community remained silent when this emerging technology was unreasonably attacked and misinformation was spread.

The practical results obtained in India with Bt cotton demonstrated that it is safe and beneficial. The results are comparable with those in other countries where Bt cotton was commercialized, starting from 1996 in Australia and the USA. Critics of Bt varieties have little impacts on farmers who have personally cultivated or observed Bt cotton and realized its benefits. It is apparent that as the technology wins, the controversy wanes.

Illegal Bt Cotton in India

Realizing the potential of Bt cotton in India, certain unscrupulous agencies are exploiting the situation through sales of unapproved Bt cotton or spurious seeds. In fact, illegal seeds were introduced into the market while Mahyco was still carrying out regulatory trials and waiting for government approval. Illegal seeds were first discovered in Gujarat in 2000, and Navbharat was identified as the offending company. Later, illegal seeds were found in several other states also where they occupied, and continue to occupy, considerable area. It has the following implications:

- Unapproved commercialization of biotech products is a blatant violation of bio-safety norms and is a punishable offense.

- Spurious producers are not accountable for purity, performance and safety. They may spoil the credibility of the product and technology.
- Ilegal sellers can afford to sell their products at a much lower price as their investment on research is meager.
- Illegal sales will affect the confidence and enthusiasm of genuine technology developers who invest a lot of time, talent and money in developing new products and getting their approval through due regulatory procedures.
- Farmers will be misled and confused.

Illegal Bt cotton is a blatant contravention of bio-safety norms and business ethics. Although the government has shown some concern and initiated action, this serious issue needs to be curbed more urgently and more strictly with severe penalties.

Prospects for Bt Cotton

Bt cotton was first commercialized in the USA in 1996 and subsequently in Australia (1996), Argentina (1997), China (1997), Mexico (1998), South Africa (1998), Colombia (2002) and India (2002). As of 2003, transgenic cotton varieties were planted on 7.2 million hectares in nine countries. Substantial increases in yields due to effective control of bollworms, considerable reductions in chemical sprays and significant increases in net profit to farmers are reported in all countries.

In India, bollworms are a major threat to the cotton crop. Hybrid cotton is more severely attacked than local varieties. The total area under cotton in India is about 9.0 million ha of which 4.8 million ha are occupied by hybrids and rest by non-hybrid varieties. In 2004, Bt cotton occupied only 530,000 ha which constituted less than 6% of the total cotton area or 11% of the hybrid area. Indications are that the area will continue to increase significantly in the coming years. Realizing this potential, about 19 seed companies in India, who have their own cotton hybrids suited for different regions, have already joined Mahyco and Monsanto as their sub-licensees for Bt cotton. Their hybrids, as well as Mahyco's new hybrids incorporated with Cry 1Ac, are already undergoing regulatory trials. In fact, a Bt hybrid, RCH 2, developed by Rasi Seed Company already received regulatory approval in 2004.

Mahyco is also carrying out regulatory trials with Bollgard® II stacked with two Bt genes, Cry 1Ac along with Cry 2Ab, also licensed from Monsanto. Bollgard® II already received commercial approval in Australia in September 2002 and in the USA in December 2002. It is superior to Bollgard® in performance and host range (in addition to other bollworms, it is also effective against Spodoptera spp.) and also makes a very good product for insect resistance management (IRM).

Planting refuge crop is mandatory in India as in the USA, Australia and other countries as a strategy towards insect resistance management. In India, *Helicoverpa armigera*, by far the predominant bollworm attacking cotton, also infests a large number of other crops like chickpea, pigeonpea, tomato, sunflower, maize and sorghum. These crops occupy substantial areas and are cultivated around the cotton crop at the same time in several parts of south and central India. These crops, especially chickpea and pigeonpea, support larger populations of *H. armigera* than cotton, thereby serving as natural refuge and helping IRM. Further, as the area presently occupied by Bt cotton is very small (i.e., less than 6% of the total cotton area or 11% of hybrid cotton), a huge crop of non-Bt hybrids and varieties are also available as refuge. In view of this, it appears that growing non-Bt cotton as structured refuge may not be required in India. In fact, in China, for the same reasons, structured refuge is not mandatory.

Bt cotton is a well-researched scientific product. The facts reveal that in the last 7-8 years of its commercial cultivation in various countries, it has brought significant economic and environmental benefits and did not cause any untoward incidents related to bio-safety, environment or pest resistance. While it may not be worthwhile trying to convince opponents, efforts should be made to prevent misleading and incorrect information going unchallenged. Public relations will continue to be a tough challenge for biotechnology and calls for greater efforts towards biotech awareness and education. Scientific outreach is a highly skilled job where science should be made understandable to common people. Bt cotton is a remarkable product, and Indian farmers should be encouraged to derive the maximum benefit from it like millions of farmers in other countries.

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Multiple Uses of Biotechnology

Kater Hake, Delta and Pine Land Company, USA

Cotton farmers are benefiting from the significant research investment that has applied modern tools of biotechnology and genetics to the control of both weed and insect pests. This investment has resulted in the following commercialized insect control and herbicide tolerance genes in elite cotton germplasm: the Cry Bt proteins (Cry 1Ac, Cry 1Ab, Cry 1F and Cry 2Ab), Cowpea Trypsin Inhibitor (CpTI) a non-Bt gene, and the herbicide tolerance genes for bromoxinyl, glyphosate and glufosinate.

In addition to these commercialized genes, the following novel technologies are being tested in cotton: non-Cry insecticidal proteins, additional herbicidal genes, fiber quality, seed quality, stress tolerance and disease tolerance.

Looking towards the future, several biotech traits could play a significant role in improving the efficiency with which farmers can produce cotton. Additional insect control genes could be beneficial to further delay insect resistance to Cry 1 and Cry 2 proteins, and could be essential for production efficiency if resistance develops to these two commercialized classes of proteins. A loss of efficacy from the current Cry genes may necessitate a return to previous insecticidal usage unless alternative insect control genes are developed in elite germplasm. Some of the alternative genes currently being considered in cotton include: lectins, additional protease inhibitors, and a vegetative insecticidal protein.

Herbicide tolerance research continues to expand in cotton with additional glyphosate tolerance mechanisms and novel herbicide tolerance categories. Fiber and seed quality improvement is a long term challenge. However cotton research continues in China (Mainland), Europe, Australia and the US.

Increased tolerance to stress by cotton plants could lower risk and enhance productivity. Targets are being investigated in cotton that could confer drought tolerance, salt tolerance and chilling injury tolerance.

Disease tolerance could have a huge impact on tropical cotton due to weather patterns that favor disease progression and the lack of cold temperatures to break disease cycles. Biotechnology is being applied to traits targeted at both fungal and viral diseases.

Current planting seed adoption patterns suggest that farmers will continue to want seed-based technologies that address multiple efficiency robbing problems. Delivering multiple solutions in the seed is a highly efficient mechanism to address the yield and efficiency robbing hazards that cotton farmers face. Although plant breeders and seed companies will be challenged by the incorporation of multiple traits into elite germplasm, benefits to farmers should encourage the necessary investment. Whether this investment is available depends less on scientific limitations and more on regulatory hurdles and delays, business models that provide a return from the long term investment, and product stewardship and utilization skills.

Why Fear Biotechnology?

Lastus K. Serunjogi, National Agricultural Research Organization (NARO), Uganda

Introduction

The scope of biotechnology is large (ICAC, 2002). Biotechnology includes experimental techniques for evaluating and manipulating the genetic materials of organisms. Experiments indicate molecular analysis of genetic material, hybridization (even among least related parents), organ and cell culture, plant regeneration, microbial biochemistry and molecular biology and genetics. However, this article on "Why fear biotechnology?" is, confined to the biotechnology involving genetically engineered (GE) plants. These are plants whose