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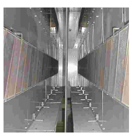
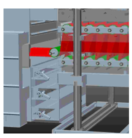
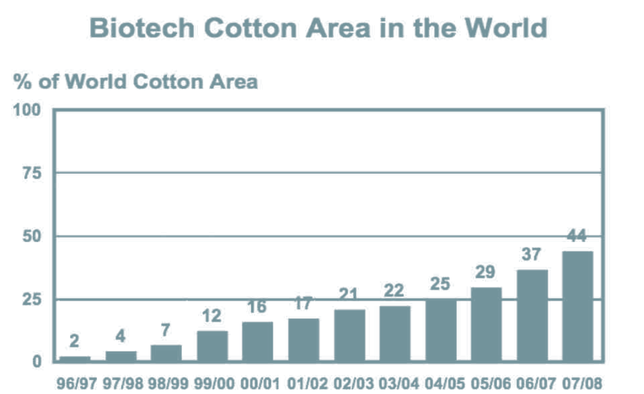
Biotech Cotton: Benefits and Concerns

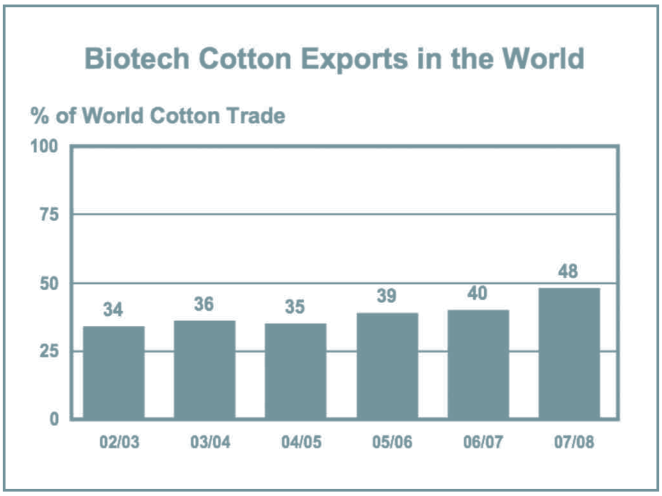




The International Cotton Advisory Committee (ICAC) estimates that biotech cotton was planted on 44% of the world cotton area in 2007/08. Forty-four percent area shared 51% of production and 48% of cotton traded internationally. The countries that have officially approved commercial production of biotech cotton are Argentina, Australia, Brazil, China (Mainland), Colombia, India, Indonesia, Mexico, South Africa and the USA. Indonesia planted biotech cotton for a few years but it is not allowed any more. Many countries are experimenting with biotech cotton particularly resistant to lepidopteron insects but Burkina Faso seems to be ahead of all others so far as commercialization is concerned. Burkina Faso has passed experimental stage and is expected to commercialize biotech cotton for the 2008/09 season.



The herbicide resistant transgenic cotton, alone and in stacked gene form, is allowed for commercial production only in Argentina, Australia, Colombia and the USA. Outside the USA, insect resistant biotech cotton is more popular than herbicide resistant varieties. Biotech varieties were planted on 90% of the cotton area in the



USA in 2007/08. Biotech varieties having the herbicide resistant gene, alone and in conjunction with the insect resistant genes, were planted on over 99% of the total biotech cotton area. It is not expected that herbicide resistant biotech cotton varieties will have the governments' approval any time soon in China (Mainland), India and other developing countries. Availability of cheap labor and extensive use of cultivation practices to eliminate weeds are the factors responsible for lesser popularity of herbicide resistant character.

The Technical Information Section of the International Cotton Advisory Committee has published many reports and papers on biotechnology applications in cotton. All these reports and papers are available at http://www.icac.org/icac/english.html. The application of biotechnology to crop improvement is comparatively new, and it is often misinterpreted. Genetic engineering or development of transgenic crops is a specialized fundamental science and requires basic understanding of how genes operate in the existing genome of species. A gene is a primary unit of inheritance and once a gene is transferred into a species/variety it stays there forever and becomes a part of genomic system. A gene is a chemical, protein in nature, and can interact with genes of the host species/varieties. Though a foreign gene is inserted into cotton with a specific objective or function to perform, a foreign gene could create a chain of reactions overriding the target benefit or benefits. The private sector has taken the lead and surpassed the public sector in developing and testing biotech crops. A number of crops have been transformed and each has its has its own specific objective. According to the International Service for the Acquisition of Agri-biotech Applications (ISAAA) biotech crops were planted on 114.3 million hectares in 2007/08 and cotton was only 13% of the all biotech crops area in the world in 2007.

What is the right term?

A number of terms like genetically modified organisms, transgenic cotton, Bt cotton, genetically engineered cotton, etc., have been used in the popular press and even in the scientific community. Biotechnology is defined as utilization of living organisms for the improvement of living organisms. Biopesticides are biotech products, but they may or may not be, and mostly are not, genetically engineered. The genetic engineering technology is one process used in biotechnology. Using the technique of "gene splicing" or "recombinant DNA technology" (rDNA), scientists can add new genetic material to the existing molecular structure of living organisms for initiating a new character. Transgenic cotton is cotton having a gene from across species. The currently available biotech insect resistant varieties have a gene from soil bacterium *Bacillus thuringiensis,* so they are transgenic and called Bt cotton. But, the original source of a transgene could be different, thus the name Bt is not a universal name that can be applied to all crops and varieties that are transgenic. Transgenic varieties could also be developed using non-recombinant techniques so all varieties may not be genetically engineered. Cotton grown on a commercial scale today has already gone through drastic genetic modifications and is continuously going through additional changes. The cotton varieties, which have been transformed into transgenic varieties, were already genetically modified but now they have been genetically engineered to emerge as transgenic varieties.

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Biotechnology applications in agriculture are new and a much more is yet to come. The nature of products developed through genetic engineering or other forms of biotechnology applications is not even known yet. So, there is a need to identify a term that is even applicable to future products. The International Cotton Advisory Committee (ICAC) decided four years ago to use the term 'biotech', which covers current and possible future outcomes of biotechnology uses in cotton.

Conventional breeding and biotech cotton

The processes used in the past to bring about changes in plants by combining desirable characteristics of one plant with those of another were very slow. As the understanding of cotton plant breeding progressed, scientists found ways of speeding up the breeding process and making it more precise and reliable. It is now possible to identify exactly (for many characters) which genes are responsible for which traits and how they can be quickly and safely transferred to the target genotype. Molecular marker assisted breeding will further ease the breeding process. The back cross process is slow and has number of problems, particularly the linkage between/among various characters and a complex and multiple gene control of a particular character. Biotechnology techniques provide solutions to such problems.

Molecular genetic engineering is just a small component of breeding. Genetic engineering will permit the transfer of characters quickly and efficiently, create non-existing characters and create many more functions not even known yet in breeding. No doubt genetic engineering can perform functions extremely better than conventional breeding, and functions that are impossible with traditional approaches, but the important role of conventional breeding should not be under estimated. Genetic engineering and other biotechnology applications and conventional breeding are complimentary to each other.

Does biotech cotton has higher yield potential?

The insect resistant and herbicide resistant transgenic cottons have specific objectives. The addition of a non-cotton gene from a soil bacterium in no way enhances the genetic ability of the plant to perform better in yield. The inherent ability of the plant to produce buds, flowers and bolls remains the same as in the case of a parental line with or without the Bt or herbicide resistant genes. Thus, the genetic potential does not improve with the insertion of a non-cotton gene in the currently available biotech varieties. It is believed that genetic potential cannot be improved but recoverable potential can be improved. Yield is the most attractive character in crop species and thus so in cotton, but no biotech product at least in cotton has been developed so far that could improve the recoverable potential in cotton. However, the possibility for future improvement does exist.

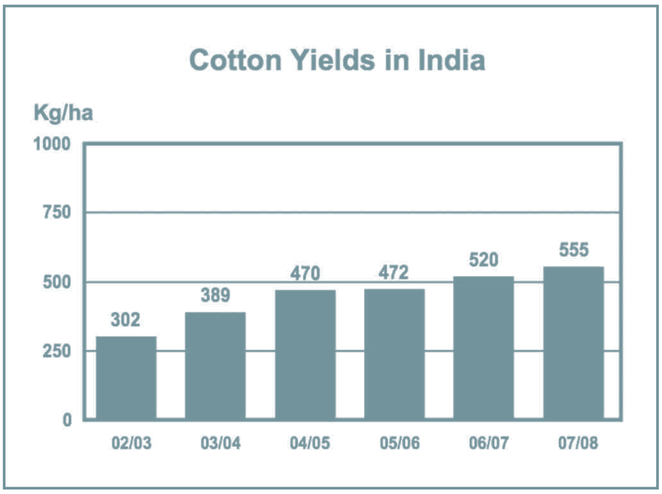
> "Reports from many biotech cotton-producing countries indicate that the cost of production is lower in biotech cotton."

Where does yield improvement come from in biotech cotton?

The genetic ability of the plant to produce higher yield does not improve in transgenic cotton varieties, but some countries particularly India has experienced significant increases in yield since the adoption of biotech cotton. Cotton is vulnerable to a variety of pests, and losses occur if cotton is not properly protected against insect losses. The losses in yield due to pests are directly proportional to the pest pressure. Spraying insecti'adcides minimizes losses due to pests but the loss is not eliminated. It is recommended that insecticides should be sprayed at a particular threshold level, which have been established for various pests. Each threshold is a level or a stage at which benefits of using an insecticide are greater than the cost of the insecticide and its application. But this is a stage when at least some damage to the fruiting forms has already occurred, particularly in the case of a bollworm attack. The use of biotech cotton minimizes/eliminates the pre-threshold losses that had to occur before insecticides were sprayed.

Why there are huge increases in yields in India?

India commercialized insect resistant biotech cotton in 2002/03. Average cotton yield in India in 2001/02 was 308 kg/ha. While some sources place biotech cotton area at 66% in 2007/08, according to Monsanto, biotech cotton was planted on 62% of the total cotton area in India in 2007/08. It is estimated that 72%, 68% and 69% of the cotton area in the Central, South and North region respectively was under insect resistant biotech varieties 2007/08. In six years, average yield in India increased by 80% to 555 kg/ha in 2007/08. It is expected that India will be exporting 1.26 million tons of cotton in 2007/08 for the first time in the history of cotton in the country. Bt gene cannot bring 80% increase in yield but it definitely showed that plant protection was not good in India.



If plant protection (through insecticides) is good in any country, there will not be any significant increase in yield due to insect resistant biotech cotton, as is the case in Australia and USA. And, if plant protection is not good through insecticide applications against target pests, insect resistant biotech can improve yields significantly. However, in India, a new program called 'Technology Mission' has also contributed to improvement of yields.

Effect of currently available non-cotton genes on fiber quality

The currently available non-cotton genes (Bt and others) are not supposed to have an effect on quality. However, a number of reports indicate a decline in average quality in the USA. This is due to that fact that commercialization of biotech cotton slowed down the variety release process for some time. The variety release was slow on account of converting existing varieties into biotech varieties. The rate of introduction of new varieties has a proportional impact on fiber quality improvement. Biotechnology companies decided to introduce the Bt gene and herbicide resistant genes through accepted varieties. It took many years to insert a Bt gene into cotton, confirm its performance, complete the regulatory requirements and introduce Bt varieties on a commercial scale. This process automatically slowed down the rate of adoption of new varieties with improved fiber qualities. The other possible explanation is that the protection of early-formed bolls with biotech cotton may have changed the location of bolls on the plant that were ultimately harvested. Quality depends upon the position of bolls on the plant, which may have affected quality in biotech varieties compared to their parental varieties. One more reason for an effect on quality could be the impact on crop maturity. If a plant retains bolls earlier or keeps setting bolls late in the season, it could also affect quality. The bacterial genes themselves as such are not supposed to have an effect on quality.

> “One of the hardest lessons learnt from the use of pesticides is the development of resistance to insecticides by many species of insects.”

What are other benefits of Bt cotton?

Cost of Production

Reports from many biotech cotton-producing countries indicate that the cost of production is lower in biotech cotton. The cost of production is lower due to lower spending on pest control or increased yields (as in India). Thus, pest pressure/number of sprays per season to control target bollworms and the cost of insecticides vs. the cost of the technology fee will determine the extent of savings in the cost of production.

Environmental Safety

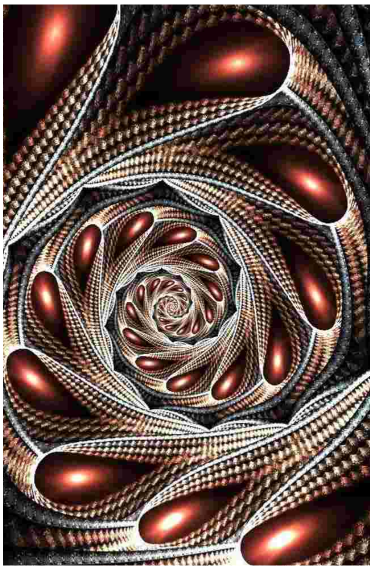
Environmental safety is promoted by reduced pesticide use. Fewer sprays means fewer pesticides delivered to the environment, fewer pesticide containers to be disposed of, less damage to the natural flora and fauna, and reduced human exposure to toxic chemicals. The herbicide resistant biotech cotton will encourage the use of herbicides, which is contrary to the environmental safety factor in insect resistant biotech cotton.

Improved Biological Control

Bt toxin is not harmful to natural predators and parasites, and a reduced use of disruptive pesticides will allow increased emphasis on the management and manipulation of beneficial species. Food sprays and many other means of beneficials' conservation and augmentation could be better utilized in insect resistant biotech cotton compared to fields where insecticide use is frequent.

Guaranteed Control

The cost of insecticide control vs. biotech gene control of target insects could be close. Insecticide applications require continuous monitoring of insect damage in the field, procure good quality insecticides and properly spray them on time. While there could be so many problems in sprayers, rains could washout insecticides if received soon after spraying. Insect resistant gene in biotech cotton provides a guaranteed control, and moreover a farmer gets some free time, which he was going to spend on spraying.



Better Grade

Grade in cotton is determined by trash and color. Due to reduced bollworm damage and lesser weeds, biotech cotton is supposed to show fewer yellow spots, thus improving the grade of cotton.

Biotech cotton and integrated pest management

Integrated pest management (IPM) is the utilization of all possible means of pest control that contribute to an economically feasible and environmentally sustainable pest control approach. IPM involves a multidisciplinary approach that minimizes the use of dangerous chemicals and can be utilized for a long period of time. Biotech cotton, particularly Bt cotton, provides a new tool and foundation on which IPM programs can be based. However, utilization of Bt cotton as a foundation of the IPM system has been minimal so far. There is a need to recognize, and accordingly enhance, the role of Bt cotton in IPM. Refuge crops are must if alternate host crops do not exist in the cotton area. Starting 2008/09, the U.S. Government has permitted not to plant refuge crop in areas where Bollgard II is grown and alternate host crops exist. This covers most cotton area in the USA.

What is a refuge crop?

One of the hardest lessons learnt from the use of pesticides is the development of resistance to insecticides by many species of insects. Some of the target species of insect resistant biotech cotton are notorious for the development of resistance, particularly the cotton bollworm *Helicoverpa armigera*. Bt cotton carries an insecticidal protein on which the bollworms feed throughout the growing season, and year after year. Just as with insecticides, insects can develop resistance to the insecticidal protein produced by Cry1Ac and Cry2Ab, Bollgard®'ae and Bollgard®'ae II respectively. Researchers, utilizing experience with insecticides, have devised resistance development delaying tactics in the form of a 'refuge crop.' The strategy has been strictly implemented and no resistance complaints have been reported so far. Therefore, a refuge crop is required to produce a hybrid population from susceptible insects mating with the resistant population to delay development of resistance to the Cry proteins if alternate host crops do not exist in the area. Refuge crop can be a 5% area grown under unsprayed conditions or 20% area grown under conventional sprayed conditions.

Are biotech cottons safe in the long term?

The answer to this question is "we do not know." It is claimed by companies in the biotechnology business that the proteins in the currently available biotech cotton products have a history of safe use. But the fact is that the non-species genes are being utilized in the cotton genome for the first time and, so far, only 11 years of experience is available with biotech cotton products. There is no assurance that a negative interaction between the foreign gene(s) and the cotton genome will never occur. Moreover, assuming that the currently available transgenic cotton products are safe does not mean that all biotech cotton products will always be safe. The 11-year experience showed that the Bt gene and herbicide resistant genes interact with different varieties differently and their effectiveness is dependent on growing conditions. This is another indication that the long-term impact of these genes is not sure.

Biotech cotton and biosafety regulations

Application of modern biotechnology to cotton in 10 countries by 2007/08 has already proved the success of the technology and the two events commercialized so far. There are many countries where Bt cotton could be as successful as in the countries using it so far. But, national and international patent laws prohibit the use of transgenic cotton in many other countries. Some countries have accepted the technology based on the experience in other countries and do not want to be left behind in acquiring the uses and benefits of this new agricultural revolution. But systems are not in place to utilize the technology in other countries. All countries that intend to use this technology on a commercial scale must have in-house systems to introduce or develop, test and commercialize the technology. Governments and the private sector must work together in the debate on the use of agricultural biotechnology.

> **"Dominance by the private sector – The cost of technology is high and the private sector is providing technology on its own conditions."**

As a matter of priority, governments must establish adequate regulatory oversight and appropriate scientific protocols for agricultural biotechnology. Regulatory protocols are essential for the introduction of agricultural biotechnology in a manner that does not pose unacceptable health and other environmental risks and which has the publics' confidence.

Agronomic requirements of biotech varieties

The agronomic requirements of current biotech varieties are not different from normal varieties. Transgenic varieties require the same amount of water and fertilizer as normal varieties. However, pesticides requirements, and accordingly pest control care, is quite different. Herbicide resistant transgenic cotton will not require intercultural operations carried out in many countries for the sake of removing weeds. The Bt cotton may or may not require insecticide applications against bollworms, but certainly sucking insects have to be controlled as in normal varieties.

How to acquire biotech cotton?

There are only two ways to acquire biotech cotton and legally commercialize it, 1) a joint venture with a company or companies that own genes and the technology to develop transgenic varieties, 2) local researchers identify new genes and insert them into cotton. The experience in China (Mainland), India, US and elsewhere showed that it is not easy to identify effective genes that would produce the desired effect in the plant. This is one of the reasons that most countries are using insect resistant Monsanto genes, Bollgard and

Bollgard II. India has tried and China (Mainland) developed its own biotech cotton but it is not as effective as Monsanto's biotech cotton or WideStrike from Dow AgroSciences.

Foreign gene location and its interaction

Generally it is believed that effect of a gene is limited to a single property but it is not the case always. The effect of a gene is dependent on its location and its interaction with other genes. Therefore, insertion of foreign genes in cotton is bound to cause unpredictable surprises including, in the worst case, the appearance of harmful substances in plant parts. Moreover, the method of genetic engineering is so crude that it is impossible to decide before hand where the inserted gene (s) will stick in the cotton genome. This adds further to the unpredictability of the outcome of artificial gene insertion (genetic engineering).

What are other concerns about biotech cotton?

Organic cotton – Biotech cotton is not eligible for certification as organic production. Biotech cotton has affected organic cotton area particularly in the USA.

Weed control - Herbicide resistant biotech cotton has changed the weed control systems in Australia and the USA. Weed control prior to Roundup Ready cotton involved multi-dimensional approaches from several angles to achieve the best control. These approaches involved preplant incorporation, herbicide applications at planting, post-emergence-directed herbicide applications, mechanical cultivations, non-selective herbicides, layby chemical applications, spot spraying with herbicides, and hand weeding. Roundup Ready Flex cotton was approved in the USA in March 2006. Herbicides can be sprayed on Roundup Ready Flex until seven days before harvest, which is only going to aggravate the potential of resistance development.

Illegal biotech cotton with all of its consequences - Biotech cotton has illegally traveled to many countries. Illegal use of biotech varieties is a blatant violation of biosafety regulations, and could spoil seed purity, performance, and safety as well as the credibility of legitimate biotech products and technology. Biotech pirating could affect the confidence and enthusiasm of genuine technology developers. At the same time, pirating is misleading and confusing users (farmers).

Dominance by the private sector – The cost of technology is high and the private sector is providing technology on its own conditions. This is contrary to what was in the case of 'Green Revolution.'

Technology limitations – Biotech cotton is not for every body. If target pest pests are not a problem in any country, insect resistant biotech cotton is not needed. Search for new genes is expensive and limited.