Bt Cotton or Better Cotton?

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Bt Cotton is a genetically engineered form of natural cotton. The main advantage of utilizing biotechnology in agriculture are the possibilities of increase in productivity through the use of newer varieties that possess properties such as resistance to pests, diseases, and other stressful conditions like drought, salinity, or water logging. Of these measures, imparting the property of insect (specific) resistance through the transfer of a gene from *Bacillus Thuringiensis* (Bt) into target plants by modern biotech methods is presently considered to be one of the most advanced applications of biotechnology.

In a survey conducted on Gujarat farmers, 11% said that Bt was irrigation, 7% said that it was a tractor![1] So what exactly is Bt? It is genetically modified cotton that produces a protein, which when ingested in adequate quantities is toxic to lepidopteron insects. It has been observed that it provides excellent resistance from caterpillar pests in India such as American Bollworms, the spotted Bollworms, the spiny bollworm, and the pink bollworm.

The toxin in Bt Cotton exists in nature within the microorganism *Bacillus Thuringiensis.* The Japanese Bacteriologist Ishiwata Shigetane first discovered it in 1901. Subsequently in 1915 a German scientist, named Ernst Berliner, isolated this toxin from a dead Moth in Thuringen region of Germany. And thus the name *Bacillus Thuringiensis.*[2]

"Genetic Engineering" is the technique by which heritable material, which does not usually occur nor will occur naturally in the organism or cell concerned, generated outside the organism or the cell, is inserted into the said cell or organism. It refers to the formation of new combinations of genetic material by incorporation of a cell into a host cell, where they occur naturally (self-cloning) as well as modification of an organism or in a cell by deletion and removal of parts of the heritable material[3]

The Ministry of Environment and Forests defines Biotechnology as, “the application of scientific and engineering principles to processing of materials by biological agents to produce goods and services.”

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[1] Aibaonline.com

[2] Genetically Modified crops in India with special reference to cotton by Dr. P K Ghosh (DBT);

[3] As defined by the Ministry of Environment and Forests (Rules for the manufacture, use, import, export, and storage of hazardous micro organisms genetically engineered organisms or cells)

Genetically engineered products

The concept of genetically engineered products has been in existence for quite long before we knew them to exist. For instance insulin gene derived from the intestines of pigs is inserted into bacteria. This bacterium grows and makes insulin, which is purified from the bacterial culture and used medically. The same is true of the thyroid hormone, which, until recently, was derived only from animals. Once again, genetic engineering enabled this hormone to be cultured in the bacteria. A real possibility, which is yet to happen, is the genetic engineering of Premarin, a hormone replacement drug made from pregnant mares' urine. The naturally created Premarin leads to around 75,000 unwanted foals each year, many of which are slaughtered. It would be relatively straightforward to clone the relevant gene or genes responsible for the synthesis of Premarin in horses, so it could be produced in bacteria or yeast or tissue culture. While there is a synthetic form of Premarin available, it is not profitable to produce, so drug companies continue to promote the "natural" form, generating those unwanted foals. However, if drug companies were to produce Premarin in bacterial culture by genetic engineering, the profitability and the foal issue would be likely to be resolved.

Other genetically engineered products have been the chemical Aspartame used in diet coke, sugar free etc. and the drug Hepatitis B Vaccine. Earlier it was imported into the country but now it has also been developed in India.[4]

Bt Maize is another Bt crop on which research is being conducted: it was grown on 7.3 million hectares world wide in 2000; it makes up 20% of the total transgenic crop grown in the world. The net gain in producing this crop from 1997 to 1999 was $20 million.

Transgenic crops are grown in many countries like Australia, South Africa, Mexico, Spain, Portugal, Romania, Ukraine, USA, China, etc.

Biotechnology is not new. It is a concept as old as time itself. [5]

1St generation Biotechnology	**2nd Generation Biotechnology**	**3rd Generation Biotechnology**
Leaven Bread	Penicillin	Protein Drugs
Fermented Alcohol	Enzymes	Transgenic Crops

[4] *The Patients' Voice*, summer 2000
http://www.pfam.net/geneticE/43V%20GE%20Foods%20Summer2000.rtf; Cedilla Pharmaceuticals www.cadilapharma.com/newsflash.html+insulin+india&hl=enMontelis
http://www.montelis.com/satya/backissues/jan98/engineered.html

[5] *RIS Biotechnology and Development Review* April 1998, October 1998, April 1999, October 1999, December 2000

	Biotech Pesticides	Genomics

Background in India

Although India has the world's largest acreage of 8.9 million hectares under cotton cultivation, it is only the third largest producer of cotton, with about 2.86 million tones of cotton lint produced each year. In terms of average productivity, India is among the lowest with 320 Kg per hectare[6]. The productivity ranges from 200 Kg per hectare to 600 Kg for hybrid varieties. Cotton is predominantly cultivated in the northern region of the country, mainly in the states of Punjab, Haryana, and Rajasthan. Here the plantations are homogenous and the emphasis is on planting high yield varieties.[7]

About 162 species of insects are known to devour cotton at various stages of growth, of which 15 are considered to be key pests. Among these are jassids, aphids, white fly, spotted bollworm, pink bollworm, and American bollworm; consequentially important diseases are bacterial blight, fusarium wilt, alternaria leaf spot and Grey mildew. Together these pests and diseases result in an estimated loss of 50% to 60%of potential yield. This is similar to losses in other countries.

Pests appear in quick succession in the various stages of growth of the cotton plant. First to infest are sucking pests like aphids and jassids, followed by white flies. It is then the turn of bollworms and by the time the crop enters the flowering stage, bugs take over. Farmers therefore use a cocktail of expensive chemical pesticides to control pest infestation. Currently pesticides account for one-third of total cultivation costs. Increasing reliance on pesticides over the years have replaced traditional methods that include a variety of labor intensive practices like hand picking to remove pests and cultural practices like intercropping, crop rotation, and the burning or removal of cotton residue from the soil.

Intensive cultivation practices and indiscriminate use of conventional as well as fourth generation pesticides like synthetic pyrethroids have created resistance among some of the key pests, including the American bollworm. Monocropping and favorable climatic conditions in certain years have further accentuated the problem. In the early 1990s, the outbreak of leaf virus reached epidemic proportions in the northern plains The reasons for this outbreak are not fully known, however based on the experience of other countries, it is reasonable to assume that excessive use and abuse of pesticides is a major contributing factor. Dependence on chemicals has, in some cases, been so heavy that farmers have had to resort to a mix of several pesticides, the so-called pesticide cocktails. And it is not uncommon to spray more than 30 times per season.

In India, an estimated US$ 620 million (Rs 28 billion) worth of pesticides is used in agriculture, of which US$ 344 million (Rs 16 billion) is used on cotton. Bollworm alone

[6] *Hindu* (May 07,2001)
[7]The Cotton Controversy (Jennifer Ifft)

takes a heavy toll, costing the farmers an annual US$ 235 million (Rs 11 billion). This accounts for more than a third of current pesticides sales in India.[8]

If the crop fails because of weather conditions and / or pest resistance, a rising number of farmers have been known to consume pesticides to end their lives and escape the helplessness and inability that comes with mounting debts. According to official records, more than 500 cotton farmers in Andhra Pradesh, Karnataka, Maharashtra, and Punjab committed suicide in 1998.

Various projects to develop Bt Cotton in India

The Maharashtra hybrid seed company (Mahyco) imported Bt Cotton seeds into India in 1996 from Monsanto Enterprise, which owns a 26% share in Mahyco. After crossing with Indian Cotton varieties, Mahyco conducted greenhouse and small-scale field trials on the newly developed varieties through 1999. In 2000, the first large-scale field trials were approved two months after sowing time. In 2001, Mahyco had been instructed to undertake one more year of large-scale field trials before considering commercialization of Bt Cotton.

In 1994, a research project based in National Botanical Research Institute and funded by the Department of Biotechnology (Ministry of Science and Technology) was conducted. It ended in 1998 without any results. No new varieties of Bt Cotton had been developed. An estimated Rs. 5 crore was spent on this project; in 1990 Monsanto Corp. had offered the same technology for Rs. 2 crore.

2 new varieties of Bt Cotton were developed at the Central Institute of Cotton Research, Nagpur, without the knowledge of Department of Biotechnology (which has legal powers to cover such developments); these were not further developed due to agronomic problems.

Currently a research project is being conducted by ICAR (Indian Council of Agricultural Research), funded by National Agriculture Technology Fund (World Bank) and another project using "slightly different" Bt technology is being conducted at Delhi University, South Campus.

The results of the Bt Cotton field trials have not been made fully public despite protests by environmental NGOs. Mahyco could make this data public, but has strangely remained aloof from this debate. However the results of these trials have been reported to be positive. Reports suggest that like the non-Bt Cotton, this causes no significant risk to the environment.

[8] Genetically Modified crops in India with special reference to Bt Cotton (Dr. P K Ghosh)

Regulatory barriers In India

Any organization / company that wishes to develop a transgenic crop must first form an Institutional Biosafety committee, which necessarily must have a representative of the Department of Biotechnology. This representative can approve low risk, contained research and must report to the Review Committee on Genetic Manipulation (RCGM). Recently, a monitoring-cum-evaluating committee has been appointed by the RCGM to visit and evaluate standards at these trial sites.[9] The state Biotechnology coordination committee and the District Level Committee also monitor transgenic crops at the corresponding levels. The GEAC (genetic engineering approval committee) is the ultimate authority in decisions regarding the commercialization or large-scale testing of transgenic crops.

The All India Biotechnology Association (AIBA) released a damning report in November 2000 blaming the complicated bureaucratic process for the failure of India to adopt GMOs (Genetically Modified Organisms).[10]

The report covered all the inadequacies of GMO regulations:

- Testing and approval has a poor track record
- Private and public sectors conflicts block the former at the entry point
- Mission overlap: Regulators are competitors
- Large scale public funding disfavors private investment
- Prioritization by R&D in public sector is unresponsive to market needs
- Sub-Critical resource allocation from lack of focus

Two committees have made the majority of decisions regarding Bt Cotton approval--the Review Committee of Genetic Manipulation (RCGM) and the Genetic Engineering Approval Committee (GEAC).

GEAC came into the picture in 2000, when it approved large-scale testing of Bt Cotton, 2 months after usual sowing time. The GEAC decided this year that Bt Cotton would not be commercialized and one more year of field trials were needed. Although RCGM gave the go-ahead for four years, the final decision still lies in the hands of GEAC. The waste of public resources is evident, as the GEAC would have to get themselves well acquainted with the trial results and other information, which has already been reviewed by the RCGM.

The Research foundation of Science, Technology, and Ecology (RFSTE) has a case pending in the court against the Department of Biotechnology (Ministry of Science and Technology), The Ministry of Environment and Forests, The Ministry of Agriculture, Monsanto-Mahyco Biotech (India) Pvt. Ltd., Maharashtra Hybrid seed company Ltd.

[9] Bt Cotton not panacea for pest control (US Department of Agriculture)
[10] Aibaonline.com

(Mahyco). The court case is basically based upon the technicalities in the laws governing biotechnology regulation in India.

The RFSTE has also documented instances where trial fields were planted before official approval had been given. Could Mahyco have known that the approval would be given?

Current controversy

According to the central government, Navbharat Seeds Pvt. Ltd. sold seeds illegally to farmers in Gujarat. On October 19, 2001, the Environment Ministry decided to torch the fields in Gujarat, at a time when the harvest was almost ready. The state government claimed that it was not aware of this Central Directive.

On November 1, 2001, the central government instructed the Gujarat government to procure the 5000 acres of Bt Cotton crops, and burn it! This decision was taken in a 5-hour meeting of the GEAC, and that too one day before the hearing of the case filed by Navbharat.[11] According to Navbharat Seeds Pvt. Ltd., the seeds sold to the farmers are not Bt Cotton but are hybrid seeds. Representatives of the Gujarat government say that they cannot foot the bill of procuring the crops and that Navbharat will have to pay for it. The GEAC decided to file a case against D B Desai (owner of Navbharat Seeds) hoping to sell his assets and raise the money. Desai in turn has decided to take the government to court.

An article published by the *Times of India* dated November 1, 2001 stated that more than 50% of the Bt Cotton, which had illegally been sold to the farmers, had entered the market for sale. And that Navbharat Seeds had also sold seeds to other farmers in the states of Maharashtra, Punjab, and Andhra Pradesh.

According to the report, over 11,000 acres of Bt Cotton crop still stand in the fields without approval.[12] The GEAC has asked the State Government to issue a public warning and procure all the cotton, separate the seeds from the lint, destroy the seeds, store the lint for testing and completely sanitize all fields by burning them.

The genetically modified seeds for the cotton crops had come from 2 districts of Andhra Pradesh (Kulnoor and Mehboobnagar). Some farmers in these districts had been hired by Navbharat Seeds to grow the cottonseeds. The seeds were being sown in about 300 to 400 acres.

The Gujarat government is right in showing its annoyance at the fact that the GEAC is focusing more on destroying the crop rather than punishing the guilty. The state government has told GEAC to first file a case against the firm and only then would the

[11] *Indian Express* (November 1, 2001)
[12] *Economic Times* (November 6, 2001)

GEAC's latest orders be followed. GEAC has also agreed to recommend the center to bear the cost.

The cotton procurement started on November 7 by the Maharashtra government[13], and the cash-strapped state has still not been able to pay the farmers for the cotton. Sparked by this incident, the Shetkari Sanghatana leader Sharad Joshi launched an agitation that has spread rapidly through the cotton bowl of Vidarbha. Hundreds of farmers have resorted to rail and road traffic blockades, and stone pelting, catching the government off-guard. The state government has decided to release Rs. 500 crore to mollify the agitated farmers. Joshi, on his part, agreed to put off his threatening hunger strike toll December 1, 2001 to allow for further talks.

Last month, Gene Campaign, an NGO filed a Public Interest Litigation in the Delhi High court seeking an inquiry into the entire transaction and process that lead to transgenic Bt Cotton seeds entering the market[14]. The PIL seeks a regulatory mechanism for the sale and distribution of transgenic crops. The high court has now issued notices to the union government.

Experiences of other countries

In China research on Bt Cotton first began in 1991, and subsequently commercial growing of this cotton started in 1998. The Chinese Situation is very similar to that of the Indian situation because both countries have lots of small farmers and scattered land holdings.

Use of this genetically engineered cotton has been very beneficial to China, making it the biggest producer of cotton in the world. Pesticide use has reduced by 15,000 tons[15], the bio diversity of insects has improved and there is little resistance due to scattered plots and small farmers and also due to the extra insecticide gene present in Chinese Bt Cotton. This variety has led to higher yields and lower costs. Average Chinese yields are about 943 kg / ha[16].

In the United States, research on Bt Cotton began in 1989, and commercial growth began in 1995. Bt Cotton has proved to be very beneficial to the US farmers as well. Total acres under cotton production increased from 12% of total land in 1996 to 36% in 2000. An estimated 260 million pounds extra cotton was produced in 1999, and revenue increased by approximately $99 million. The average insecticide application also decreased from 10 units through 2 units to 0 units.

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[13] *Economic and politically weekly*
[14] *Hindustan Times* (November 22, 2001)
[15] Technological Developments and cotton production in India and China (Current Science)
[16] Impact on Bt Cotton in China–Carl E Pray, Danmeng Ma

South African farmers have also had considerable success with Bt Cotton. It was observed that small scale farmers received benefits estimated at $165 per acre, reduced usage of insecticide sprays by 6% and increased yields by 26%, Large scale farmers received benefits estimated at $112 per acre, reduced usage of insecticide sprays by 4% and increased yields by 23%.

The ground reality

As can be seen from the global reports, increasing use of Bt Cotton substantiates that it has more advantages than disadvantages. Farmers would not have chosen to use Bt Cotton than regular Cotton had it been otherwise.
Even though the results of the field trials haven't been made fully public, they have been reported as positive by both agronomic and environmental measures.
Bt Cotton provides control against the American Bollworm, Spotted Bollworm, Spiny Bollworm and Pink Bollworm. Also, the average use of chemical sprays have decreased from 9-12 units to 0-2 units.

Myths and Realities[17]

- Myth: Transgenic cotton will pollinate other species planted nearby or be carried over long distances with unknown consequences.
- Reality: Trials show that in only 2.1% of cases, do the Bt Cotton's pollen travel across non-Bt Cotton and that too not beyond 2 meters. Also, the pollination is incompatible for cross-pollination with near relatives other than cotton in any Indian conditions.

- Myth: Since Bt Cotton has an in built resistance against bollworm, a pest that is the major threat to cotton, it might also kill other insects, which maybe advantageous.
- Reality: Bt Proteins have no detrimental effects on the survival and production of collmbolla, a beneficial species of insects. Bt can be harmful to useful pests but it has proven to be much better than conventional pesticides.

- Myth: Cattle or animals that gaze may be adversely affected.
- Reality: Studies in the Industrial Toxicology Research Center Lucknow, established that Bt Cotton is safe to mammals, birds and fishes. The data on allergy studies on rats show no adverse effect.
- Myth: Bt Cotton ensures that seeds die with each year's crop forcing the farmer to buy afresh every year. (Referred to as Terminator Gene).
- Reality: There is no Terminator gene in Indian Bt Cotton. The seeds have already progressed to six generations.

[17] *Indian Express* (October 20, 2001)

The most significant downside of Bt Cotton is the threat of development of resistance by insects and pests. This threat can be countered by the use of "Refugia" to prevent or delay the development of resistance.

"Refugia" is a method when non-Bt Cotton is allowed to grow along with Bt Cotton so that the pests can thrive on the non-Bt Cotton and breed with the pests that may have developed resistance, hence reducing the risk of resistance.

Bt Cotton is here to stay

In the 1990s, for the first decade since the green revolution, the rate of growth of food production fell behind the rate of population growth. To feed every India in the year 2011-12 food production needs to grow at a rate of 3.4% per year. The current rate is 1.8%. The gap is clear. How can it be bridged? Certainly not by chemical fertilizers, which operate on the law of diminishing returns. Organic fertilizers beneficial for the soil may be useless in terms of sheer scale. The world's entire organic fertilizer resources can meet the food requirement of 4 billion people. Earthlings already number six billion. Finally, there is a limit to the arable land available. Mankind's only option is biotechnology.[18]

Biotechnology doesn't limit itself to quantity. It promises multi-purpose all-in-one crops. E.g. Rice genome has been sequenced and work is on to identify and modify the genes that will make it amenable to deserts, swamps and salty soil conditions.

The application of genetically modified plants in agriculture is anticipated to be a major event in evolving more productivity and sustainable agriculture in the coming years. The concerns are the risks and the magnitude of the consequences to environment. Technology rarely doesn't have some kind of adverse effect, yet people continue innovating and accepting the new challenges that come with new freedoms. The environmental groups fighting Bt Cotton most likely sit in an office in Delhi cooled by an air-conditioner that spews some kind of harmful matter into the atmosphere. If society were to abandon all technologies that involved some kind of risk, everyone would have to move to forests and survive off nuts and berries. Nevertheless, society must be responsible for technologies that it develops.

There is serious concern among scientists, policy makers, regulatory agencies and the public regarding the widespread release of GM food crops. Currently, the relationship between the scientific community and the general public is poor. Such negative public perception might prohibit advancement of this technology and prevent realization of its great potential. Emerging new technology especially environmentally friendly approaches to genetic engineering, hold the key to addressing these public concerns.[19]

[18] India's Biotechnology plans for the next five years (Biswajit Dhar and Sachin Chaturvedi)
[19] Trends in Plant Science (December 1999)

Bt Crops are increasingly becoming a large part of modern agriculture. Bt Cotton holds great promises for Indian farmers but has yet to be commercially used. Members of the GEAC have delayed the introduction of something that could be very beneficial to farmers. The members of GEAC will receive a guaranteed paycheck but Indian farmers do not have this facility. Until the complexities of biotechnology regulations are addressed in India, farmers will go on facing the same hardships as before and continue waiting for committee approval.

Logic has been defied as Bt Cotton has moved through the complicated machinery of approval of transgenic crops in India. Bureaucrats, environmentalists, and industrialists have debated the dangers of Bt Cotton while the cotton farmers who are the ones most affected have been left out. The Indian Bt Cotton story tells the tale of the complicated maze of approval for transgenic crops. The appropriate role of government in biotechnology regulation is highly contested. This experience sheds light on the controversial issue and can give direction for future policy.