



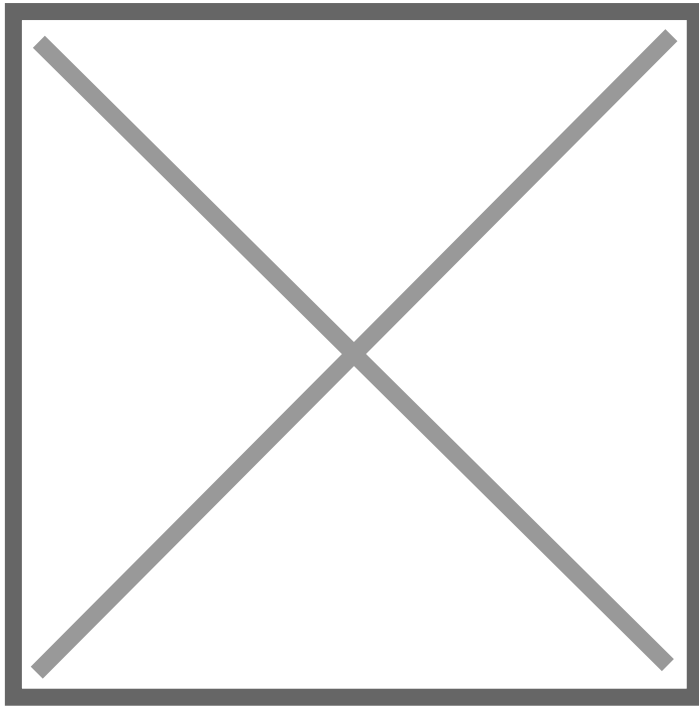
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India beats China in Bt cotton cultivation

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India beats China in Bt cotton cultivation

For the first time, India grew more Bt cotton (3.8 million hectares) than China (3.5 million hectares) and moved up the world ranking by two places to number five in the world of biotech crops, overtaking both China and Paraguay.



Cotton cultivation in India covers an area of approximately 9 million hectares, representing about one quarter of the global area of 35 hectares under cotton. Cotton is cultivated by four million small farmers and involves many more in the processing, textile manufacture and trade. However, the average yield of cotton, 440 kg/ha, is far below the world average of 677 kg/ha and the production is only about 16 percent (4.13 million tons) of the world production of 26.19 million tons.

The main losses in cotton production are due to its susceptibility to about 162 species of insect pests and a number of diseases. Among the insects, cotton bollworms are the most serious pests of cotton in India causing annual losses of at least \$300 million. It is estimated that insecticides worth \$660 million are used annually on all crops in India of which more than half are used on cotton. For example, in 2001, the cost of 21,500 metric tons of insecticides used on cotton was worth \$340 million. Further, among the cotton bollworm complex, the American Bollworm or the *Helicoverpa armigera* is the most destructive pest and has developed resistance against most of the recommended insecticides. This has forced the farmers to apply as many as 10-16 insecticide sprays on the crop.

Organizations working on Bt cotton (under development & field trials)

Organization	Transgene
Ankur Seeds P Ltd, Nagpur	cry1Ac; cry1Ac & cry2Ab
Ajeet Seeds, Aurangabad	cry1Ac; cry1Ac & cry2Ab
Ltd, Hyderabad	cry1Ac; cry1Ac & cry2Ab
Emergent Genetics Ltd, Hyderabad	cry1Ac; cry1Ac & cry2Ab
Ganga Kaveri Pvt. Ltd, Hyderabad	cry1Ac
JK Agri Genetics, Hyderabad	cry1Ac
Krishidhan Seeds, Jalna	cry1Ac; cry1Ac & cry2Ab
Mahyco, Mumbai	cry1Ac; cry1Ac & cry2Ab
Metahelix, Bangalore	cry1Ac
Nandhi Seeds Ltd, Hyderabad	cry1Ac
Nath Seeds, Aurangabad	GFM cry1Aa
Nuziveedu Seeds, Hyderabad	cry1Ac; cry1Ac & cry2Ab
Namdari Seeds Ltd, Bangalore	GFM cry1Aa
Pravardhan Seeds, Hyderabad	cry1Ac
Prabhat Agri Biotech Ltd, Hyd.	cry1Ac; cry1Ac & cry2Ab
Rasi Seeds Ltd, Attur	cry1Ac; cry1Ac & cry2Ab
Safal Seeds Ltd, Jalna	GFM cry1Aa
Syngenta India Ltd, Pune	Vip-3a
Tulsi Seeds, Guntur	cry1Ac; cry1Ac & cry2Ab
Univ. Agri. Sciences, Dharwad	cry1Ab
Vibha Seeds Ltd, Hyderabad	cr1Ac
Vikki's Agrotech, Hyderabad	cry1Ac
Vikram Seeds Ltd, Ahmedabad	cry1Ac
Zuari Agrotech Ltd, Bangalore ,	GFM cry1Aa

The Genesis

In this scenario, incorporating insect resistance has been an important objective in the cotton improvement efforts. In 2002, after extensive testing, Bt cotton was introduced for commercial cultivation in the country for a period of three years, till March 2005. Bt cotton is a variety of cotton genetically modified to contain a gene (cry1Ac) of *Bacillus thuringiensis* (Bt), which is foreign to its genome and is a naturally occurring soil bacterium used to control Lepidopteran insects because of a toxin it produces. Splicing this gene within the genetic structure of cotton makes the cotton plant poisonous to the boll weevil, the notorious cotton pest. The US-registered multinational corporation, Monsanto, first developed Bt cotton and three genetically modified cotton hybrids (Bt Mech 12, Bt Mech 162 and Bt Mech 184) developed by Monsanto in collaboration with its Indian partner Mahyco were released for commercial cultivation in central and southern India in 2002.

India approximately grew 50,000 hectares of officially approved Bt cotton hybrids for the first time in 2002, and doubled its Bt cotton area to approximately 1,00,000 hectares in 2003. During April 2004, the Genetic Engineering Approval Committee (GEAC), the regulatory authority for transgenic crops in India, approved RCH 2 Bt developed by Rasi Seeds for commercial cultivation in central and southern parts of India. With this, RCH 2 Bt became the fourth transgenic cotton crop to be approved for commercial cultivation. This resulted in an increase of the total Bt cotton area in the country by fourfold in 2004 to reach half a million hectares.

In addition, during 2004, GEAC approved 12 Bt cotton varieties in the country for large-scale field trials and seed production: RCH 118 Bt and RCH 559 Bt in central India, RCH 368 Bt in south India and RCH 317 Bt in north India by Rasi seed; Ankur 651 Bt and Ankur 2534 Bt in north India, Ankur 651 Bt and Ankur 09 Bt in central India by Ankur seeds; and MRC 6301 Bt, MRC 6160 Bt in central India and MRC 6301 Bt and MRC 6322 Bt in South India by Mahyco.

The players

Presently the 62 approved hybrids are being marketed by the following seed companies from India:

- Mahyco (MECH and MRC)
- Rasi (RCH)
- Ankur Seeds (Ankur)
- Nuziveedu Seed (NSC)
- JK Seeds (JKCH)
- Nath Seeds (NCEH)
- Ganga Kaveri Seeds (GK)
- Tulasi Seeds (Tulsi)
- Ajeet Seeds (ACH)
- Emergent Genetics (Brahma)
- Vikki Agrotech (VCH)
- Pravardhan Seeds (PRCH)
- Krishidhan (KDCHH)
- Prabhat (PCH and NPH)
- Vikram Seeds (VICH)

All the Bt cotton hybrids developed by these three companies contained Bt cry 1 Ac gene developed by the US seed multinational, Monsanto. While Mahyco has been Monsanto's partner in India, Rasi Seeds and Ankur Seeds are sub-licensees of Monsanto.

Increasing the spread

In April 2005, the GEAC approved six new Bt cotton hybrids for commercial cultivation in northern India. In May 2005, post reviewing the performance of the three Bt cotton hybrids commercialized by Mahyco Monsanto Biotech (MMB) during the period 2002-2005, the GEAC renewed permission for MMB to market MECH-12 Bt, MECH-162 Bt and MECH-184 Bt in the central zone (Madhya Pradesh, Gujarat and Maharashtra) for another two years. It approved cultivation of MECH-162 Bt and MECH-184 Bt in Tamil Nadu and Andhra Pradesh, but not of MECH-12 Bt. In addition, for central India, five new hybrids were approved for commercial cultivation - RCH-144 Bt and RCH-118 (of Rasi Seeds), MRC-6301 Bt (Mahyco) and Ankur-681 and Ankur-09 (Ankur Seeds). For the south, Mahyco's MRC-6322 Bt and MRC-6918 Bt and Raasi's RCH-20 Bt and RCH-368 Bt were approved. In 2005, the area under Bt cotton in India continued to climb reaching 1.3 million hectares, an increase of 160 percent over 2004.

The GEAC also approved 20 large-scale field trials for different types of Bt cotton in south and central India. Significantly these trials included the testing of three different "events" via the JKCH-1947 of JK Agri Seeds (Containing cry1Ac event 1 developed by the Indian Institute of Technology Kharagpur), NECH-6R Bt of Nath Seeds (containing fusion genes cry1Ab/cry1Ac from China) and 02-50 VIP of Syngenta Seeds in north India.

Current scenario

According to latest survey findings of The International Service for the Acquisition of Agri-biotech Applications (ISAAA), in 2006, the record increase in adoption continued with almost a tripling of area of Bt cotton to 3.8 million hectares. In 2006, this tripling in area was the highest year-on-year growth for any country in the world. Notably, India's Bt cotton area in 2006 (3.8 million hectares) exceeded for the first time with that of China (3.5 million hectares), the third largest cotton producer in the world. Of the 6.3 million hectares of hybrid cotton in India in 2006, which represented 70 percent of all the cotton area in India, 60 percent or 3.8 million hectares was Bt cotton—a remarkably high proportion in a fairly short period of five years. Of the 3.8 million hectares of hybrid Bt cotton grown in India in 2006, 34 percent was under irrigation and the 66 percent rainfed.

A total of 62 Bt cotton hybrids were approved for planting in 2006 compared with 20 in 2005 and four in 2004. The major states growing Bt cotton in 2006, listed in order of hectareage, are Maharashtra (1.840 million hectares representing almost half, 48 percent of all Bt cotton in India in 2006) followed by Andhra Pradesh (830,000 hectares or 22 percent), Gujarat (4,70,000 hectares or 12 percent), Madhya Pradesh (3,10,000 hectares or 8 percent), and 2,15,000 hectares (6 percent) in the northern zone and the balance in Karnataka and Tamil Nadu and other states.

Events and Bt cotton hybrids

The number of events as well as the number of Bt cotton hybrids and companies marketing approved hybrids increased from one event and 20 hybrids in 2005 to four events and 62 hybrids in 2006. This has provided a wider choice to the farmers in the different regions of the country.

In 2006, a total of four events, of which three were new in 2006, were approved for incorporation in a total of 62 hybrids offered for sale. The first event known as Bollgard-I (BG-1), featuring the cry1Ac gene was developed by Maharashtra Hybrid Seed Company (Mahyco), sourced from Monsanto, and approved for sale for the sixth consecutive year in a total of 48 hybrids for use in the different regions (north, central and south) in the country.

The second event, Bollgard-II (BG-II with event MON 15985) also developed by Mahyco and sourced by Monsanto, which featured the stacked genes cry1Ac and cry2Ab, was approved for sale for the first time in a total of seven hybrids for use in the central and south regions.

The third event, known as Event 1 was developed by JK Seeds featuring the cry1 Ac gene, sourced from IIT Kharagpur, India and approved for sale for the first time in a total of four hybrids for use in the north, central and south regions.

The fourth and the last event, the GFM event, was developed by Nath Seeds, sourced from China, featured the fused genes cry1Ab and cry1Ac and approved for sale for the first time in a total of three hybrids, one in each of the three regions of the country.

Rolly Dureha with inputs from
Ch. Srinivas Rao and
Narayan Kulkarni

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The technology involved

The core genetic engineering experiments, which culminated in the development of insect-pest resistant cotton (Bt cotton) were conducted by Monsanto, USA and comprised isolation of gene from *Bacillus thuringiensis* and its further development to ensure its expression in the fully-grown plant. The plasmid construct comprised:

The cry1Ac gene, which encodes for an insecticidal protein, cry1 Ac.

The 35 S promoter from cauliflower mosaic virus that drives expression of the cry1Ac gene in all parts of the plant leading to the production of the Bt protein.

The nptII gene, the selectable marker, which encodes the enzyme neomycin phosphotransferase II (NPT II), is used to select transformed cells/plants on media containing the antibiotic kanamycin.

The aad gene which encodes the bacterial selectable marker enzyme 3''(9)-O-aminoglycoside adenylyltransferase (AAD) and allows selection of bacteria containing the cry1Ac plasmid on a medium containing the spectinomycin or streptomycin.

Cotton tissue cultures (variety Cocker-312) were infected with the soil bacterium, *Agrobacterium tumefaciens* containing the plasmid with the above sequences. The transformed cotton lines were screened to identify those with desirable insect control and agronomic performance.



Latest Bt cotton statistics

According to the latest ISAAA findings, it is estimated that approximately 2.3 million small farmers planted on an average 1.65 hectares of Bt cotton in 2006. The number of farmers growing Bt cotton hybrids has increased from 3,00,000 small farmers in 2004 to one million in 2005, with over a two-fold increase in 2006, to 2.3 million farmers. Coincidental with the steep increased adoption of Bt cotton between 2002 and 2005, the average yield of cotton in India, which has one of the lowest yields in the world, increased from 308 kg per hectare in 2001-02 to 450 kg per hectare in 2005-06, with most of the increase in yield of up to 50 percent or more, attributed to Bt cotton.

As per the minutes of the third meeting of the Cotton Advisory Board for the cotton year 2005-06 held in November 2006, at a national level, the introduction of Bt cotton has been a major factor in higher cotton production increasing from 15.8 million bales in 2001-02 to 24.4 million bales in 2005-06, which has been a record cotton crop for India.

According to the paper "Economic impact of genetically modified cotton in India" published by Bennett et al in Agbioforum the principal gain from Bt cotton in India is the significant yield gains estimated at 45 percent in 2002 and 63 percent in 2001 for an average of 54 percent over the two years. Taking into account the decrease in application of insecticides for bollworm control, which translates into a saving of 2.5 sprays and the increased cost of Bt cotton seed, Brookes and Barfoot estimate that the net economic benefits for Bt cotton farmers in India were \$139 per hectare in 2002, \$324 per hectare in 2003, \$171 per hectare in 2004 and \$260 per hectare in 2005, for a four year average of approximately \$225 per hectare. 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. Other studies report results in the same range, acknowledging that benefits will vary from year to year due to varying levels of bollworm infestations. The recent study in 2006 by V Gandhi and NV Namboodiri of IIM Ahmedabad on "The Adoption and economics of Bt cotton in India: Preliminary results from a study", report a yield gain of 31 percent, a significant reduction in the number of pesticide sprays by 39 percent and an 88 percent increase in profit or an increase of \$250 per hectare for the 2004 cotton growing season.

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The Indian biotech cotton initiative

The Nagpur-based Central Institute for Cotton Research (CICR) has been working on the development of Bt cotton varieties since the early 1990s. Now the institute is close to launching the sole Bt cotton variety in the country. The institute has been able to introduce the Cry1 Ac gene in an Indian cotton variety.

The CICR Bt will be an independent variety, which the farmers will not have to buy every year from the market like the Bt hybrids available currently, as the primary transgenic is the original variety of the seed which can be preserved and used by the farmer in successive years. Hybrid seeds have to be bought anew every year.

Elaborating further, Dr BM Khadi, director, CICR, said, "We have been working on this project for the last five to six years. The cotton system is a very tough to transform from a biotechnological point of view. Now we have been able to develop a special protocol for developing a transgenic Bt cotton variety. At present the variety will contain Cry1Ac gene. Cry 1Aa3 gene will also be introduced later. Both these genes are directed towards the bollworms."

Currently the variety is under the RCGM trials. It is expected that it would take another one or two years to commercialize this variety, as the bio-safety and the all India level coordinated trials have to be yet conducted.

CICR along with its test centers at the National Research Centre on Plant Biotechnology (NRCPB), Indian Council of Agricultural Research (ICAR) and the University of Agricultural Sciences (UAS) Dharwad have been working on this project and about Rs 6 crore has been spent on it.

Cotton cultivation

Approximately 65 percent of India's cotton is produced on dry land and 35 percent on irrigated lands. Hybrids occupy 70 percent (6.3 million hectares) of the cotton area and 30 percent (2.7 million hectares) are varieties. The percentage devoted to hybrids has increased significantly over the last few years, a trend that has been accentuated by the introduction of Bt cotton hybrids in 2002. Cotton is the major cash crop of India and accounts for 75 percent of the fiber used in the textile industry, which has 1,063 spinning mills and accounts for four percent of the GDP. Cotton impacts the lives of an estimated 60 million people in India, including farmers who cultivate the crop, and a legion of workers involved in the cotton industry from processing to trading.

IMRB survey reveals high degree of farmer satisfaction with Bt cotton

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The IMRB survey on Bt cotton cultivation in India, one of the first of its kind aimed at understanding the awareness, perception and acceptability of Bt cottonseeds among cotton growing farmers in India, shows that low minimum support price and high input costs were some of the key reasons for the financial distress amongst farmers in the cotton growing regions of India. With respect to farmers' experience with Bt cotton,, the survey revealed that farmers using certified Bt cottonseeds showed significantly higher levels of satisfaction than farmers using non-hybrid as well as hybrid non-Bt seeds and that farmers' productivity expectations with certified Bt cotton were higher productivity expectations with non-Bt hybrid and non-hybrid seeds. The survey also revealed that a large percentage of farmers using certified Bt cottonseeds are likely to recommend Bt cotton as well as Bt fruits and vegetables to other farmers

The study conducted in 23 districts across the five key cotton growing states of Maharashtra, Gujarat, Madhya Pradesh, Andhra Pradesh and the Tamil Nadu and Karnataka, revealed significantly higher levels of satisfaction amongst farmers using certified Bt cottonseeds as opposed to farmers using non-hybrid seeds as well as hybrid non-Bt seeds. Across all the five clusters, mean satisfaction levels of farmers using certified Bt cottonseeds were 4.36 (on a scale of 5) as opposed to scores of 4.14 and 3.96 recorded by farmers using ordinary cotton and hybrid non Bt cotton. Higher yields, good quality cotton production, higher pest resistance and higher return on investment were some of the key reasons for higher satisfaction levels with certified Bt cottonseeds.

