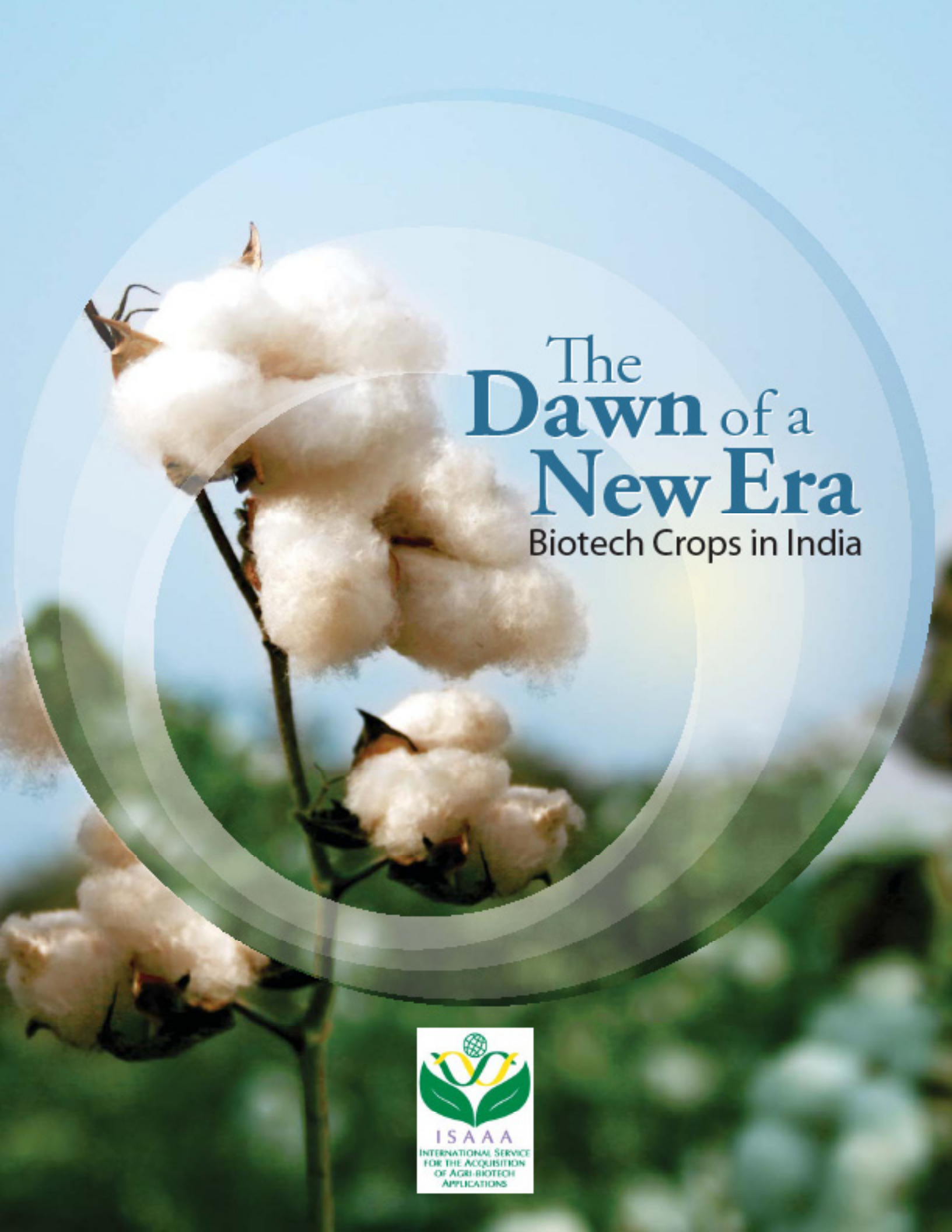

The Dawn of a New Era

Biotech Crops in India

ISAAA
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Executive Summary

In 2008, 5 million small farmers in India planted and benefited from 7.6 million hectares of Bt cotton, equivalent to 82% of the 9.3 million hectare national cotton crop, the largest in the world. This is a significant increase over 2007 when 3.8 million farmers planted 6.2 million hectares equivalent to 66% of the 2007 cotton crop. The Bt cotton story in India is remarkable, with an unprecedented 150-fold increase in adoption between 2002 and 2008. In the short span of six years, 2002 to 2007, Bt cotton has generated economic benefits of US$3.2 billion, halved insecticide requirements, contributed to the doubling of yield and transformed India from a cotton importer to a major exporter. Socio-economic surveys confirm that Bt cotton continues to deliver significant and multiple agronomic, economic, environmental and welfare benefits to farmers and society. A 2007 study reported that 70% of the middle class in India accept biotech foods, and furthermore are prepared to pay a premium of up to 20% for superior biotech foods, such as Golden Rice, with enhanced levels of pro-vitamin A. India has several biotech food crops in field trials, including biotech rice. However, Bt brinjal, an important vegetable that requires heavy applications of insecticides, is the most likely to be the first food crop to be commercialized in India, requiring significantly less insecticides and capable of contributing to the alleviation of poverty of 1.4 million small, resource-poor farmers who grow brinjal in India.

India, the largest democracy in the world, is highly dependent on agriculture, which generates almost one quarter of its GDP and provides two thirds of its people with their means of survival. India is a nation of small resource-poor farmers, most of whom do not make enough income to cover their meager basic needs and expenditures. The National Sample Survey conducted in 2003, reported that 60.4% of rural households were engaged in farming indicating that there were 89.4 million farmer households in India (National Sample Survey, 2003). Sixty percent of the farming households own less than 1 hectare of land, and only 5% own more than 4 hectares. Only 5 million farming households (5% of 90 million) have an income that is greater than their expenditures. The average income of farm households in India (based on 40 Rupees per US Dollar) was US$50 per month and the average consumption expenditures was US$70. Thus, of the 90 million farmer households in India, approximately 85 million, which represent about 95% of all farmers, are small and resource-poor farmers who do not make enough money from the land to make ends meet – in the past, these included the vast majority of over 6 million Indian cotton farmers. India has a larger area of cotton than any country in the world – 9 to 9.6 million hectares (estimated at 9.6 million hectares in 2007 and 9.3 in 2008) and cultivated by approximately 6.4 million farmers in 2007 and 6.2 million farmers in 2008. Based on the latest estimate (Table 1), the Directorate of Cotton Development, Ministry of Agriculture reports that 6.4 million farmers planted cotton on 9.6 million hectares in 2007 with an average cotton holding of 1.5 ha (Cotton Statistics at a Glance, 2007). In 2008, the total hectarage of cotton in India was estimated at 9.3 million hectares farmed by 6.2 million farmers, approximately 3% lower than the 9.6 million hectares farmed by 6.4 million farmers in 2007; this decrease is slightly lower than the 6% decrease in cotton hectarage globally in 2008 versus 2007. Comparing the distribution of cotton hectarage by states in India in 2007 (Table 1), Maharashtra, the

largest cotton-growing State, had 2.2 million farmers growing cotton, which occupied approximately 33% of India's total cotton area; this was mostly cultivated on dry land. Gujarat had 1.4 million farmers, followed

Table 1. Land Holdings Distribution and Production of Cotton in India, 2007 to 2008

No.	State	Average cotton holding per farm (Hectare)	Area of cotton (Million hectare)	Production (Million bale)	Average yield (Kg/ha)	No. of cotton farmers (Million)
1	Punjab	2.64	0.641	2.200	583	0.243
2	Haryana	1.72	0.483	1.600	563	0.280
3	Rajasthan	0.98	0.368	0.900	416	0.375
4	Gujarat	1.80	2.516	11.200	757	1.400
5	Maharashtra	1.46	3.191	6.200	330	2.183
6	Madhya Pradesh	1.38	0.662	2.100	539	0.478
7	Andhra Pradesh	1.45	1.096	4.600	714	0.760
8	Karnataka	1.56	0.388	0.800	351	0.250
9	Tamil Nadu	0.52	0.130	0.500	654	0.250
10	Orissa	0.76	0.050	0.150	510	0.066
11	Others	0.30	0.030	1.250	283	0.103
	(Weighted Average) or Total	**1.500**	**9.555**	**31.500**	**560**	**6.388**

(Source: Cotton Statistics at a Glance, Ministry of Agriculture India, 2007)

Picture 1. Bt cotton farmers with ISAAA team in the field, Haryana

by 0.76 million in Andhra Pradesh, 0.47 million in Madhya Pradesh, 0.37 million in Rajasthan, 0.28 million in Haryana, 0.25 million farmers each in Punjab, Karnataka and Tamil Nadu and the balance in other states of India.

Whereas, India's cotton area represents 25% of the global area of cotton, in the past it produced only 12% of world production because Indian cotton yields were some of the lowest in the world; the advent of Bt cotton over the last 7 years has coincided with more than a doubling of yield, with 50% or more of the increase attributed directly to yield increases from Bt cotton.

The majority of the cotton in India is grown in ten states which are grouped into three different zones namely, Northern zone (Punjab, Haryana and Rajasthan), Central zone (Maharashtra, Madhya Pradesh, Gujarat and Orissa) and Southern zone (Andhra Pradesh, Karnataka and Tamil Nadu) (Table 2). Approximately 65% of India's cotton is produced on dry land and 35% on irrigated lands. Except for the Northern Zone, which is 100% irrigated, both Central and Southern cotton growing zone are predominately rainfed. In 2008, of the total 9.3 million hectares, hybrids occupied 85% (7.9 million hectares) of the cotton area and only 15% (1.4 million hectares) were occupied by varieties. The percentage devoted to hybrids has increased significantly over the last few years, a trend that has been accentuated by the introduction in 2002 of high performance Bt cotton hybrids, which have out-performed conventional hybrids. Cotton is the major cash crop of India and accounts for 75% of the fiber used in the textile industry, which has 1,063 spinning mills, and accounts for 4% of 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. India is

Table 2. Cotton Growing Zones in India

Zones	North Zone	Central Zone	South Zone
States	Punjab, Haryana, Rajasthan	Maharashtra, Madhya Pradesh, Gujarat, Orissa	Andhra Pradesh, Karnataka, Tamil Nadu
Area	1.492 Million hectares	6.369 Million hectares	1.614 Million hectares
Production	4.7 Million bales	19.5 Million bales	5.9 Million bales
Productivity	536 kg/ha	520 kg/ha	620 kg/ha
Conditions	100% irrigated	Irrigated and rainfed	Irrigated and rainfed
Nature of Genotype	Hybrids and varieties	Hybrids and varieties	Hybrids and varieties
Species	*G. hirsutum*, *G. arboreum*	*G. hirsutum*, *G. arboreum*, Intra hirsutum, *G. herbaceum*	*G. hirsutum*, *G. arboreum*, *G. herbaceum*, *G. barbadense* Interspecific tetraploids (HB)
Insect/Pest	Heliothis, Whitefly, Jassids, Pink bollworm, Mealy bug	Heliothis, Whitefly, Jassids, Aphids, Pink bollworm, Mealy bug	Heliothis, Whitefly, Jassids, Aphids, Pink bollworm
Diseases	Leaf curl virus, Wilt	Wilt	Wilt, Foliar disease
Sowing Method	Drill Sown	Hand dibbling	Hand dibbling
Time of Sowing	April-June	June-July	July-August

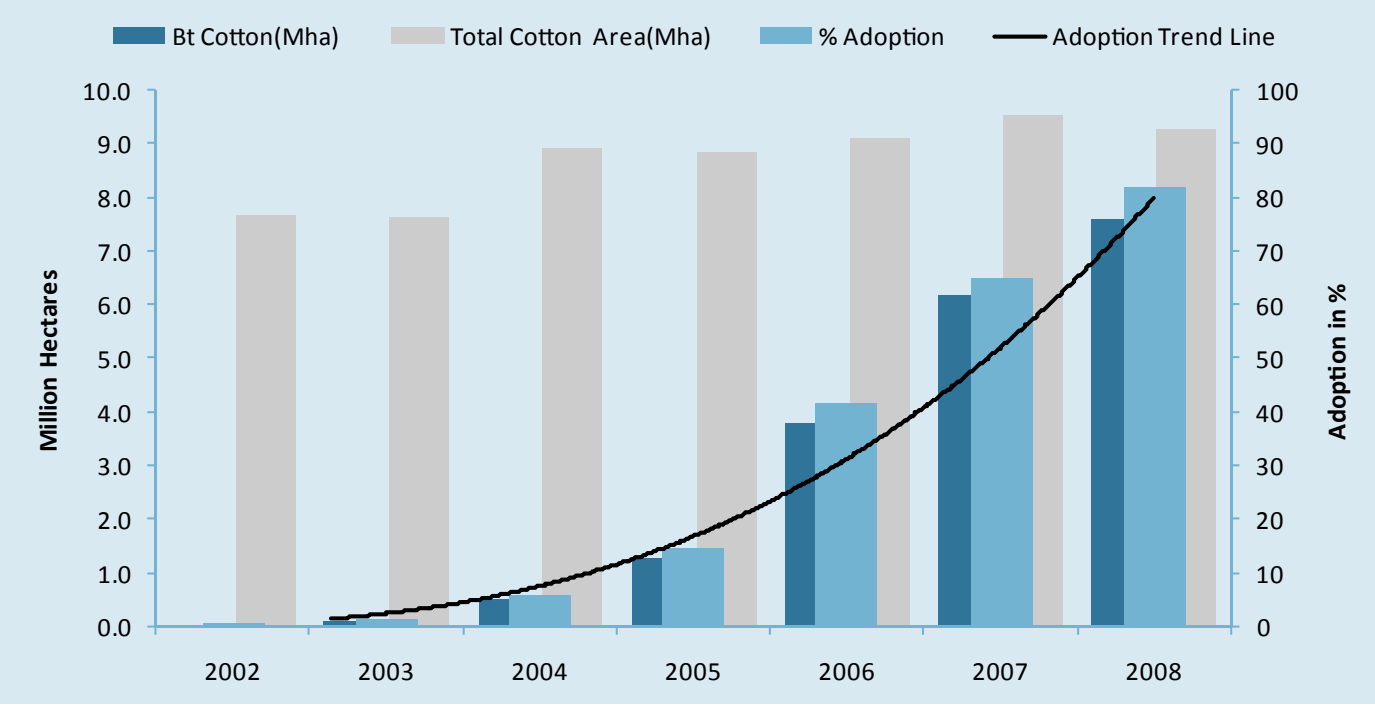
(Source: Cotton Statistics at a Glance, Ministry of Agriculture, India 2007)

the only country to grow all four species of cultivated cotton *Gossypium arboreum* and *G. herbaceum* (Asian cottons), *G. barbadense* (Egyptian cotton) and *G. hirsutum* (American upland cotton). *Gossypium hirsutum* represents 90% of the hybrid cotton production in India and all the current Bt cotton hybrids are *G. hirsutum* (Table 2).

Hectarage of Bt Cotton Hybrids Planted in India, 2002 to 2008

Bt cotton, which confers resistance to important insect pests of cotton, was first adopted in India in hybrids in 2002. In 2002, 54,000 farmers grew approximately 50,000 hectares of officially approved Bt cotton hybrids for the first time and doubled their Bt cotton area to approximately 100,000 hectares in 2003 (Figure 1). The Bt cotton area increased again four-fold in 2004 to reach half a million hectares. In 2005, the area planted to Bt cotton in India continued to climb reaching 1.3 million hectares, an increase of 160% over 2004. In 2006, the record increases in adoption continued with almost a tripling of the area of Bt cotton to 3.8 million hectares. This tripling in area was the highest percentage year-on-year growth for any country planting biotech crops in the world in 2006. Notably in 2006, India's Bt cotton area (3.8 million hectares) exceeded for the first time, that of China's 3.5 million hectares. In 2007, the Indian cotton sector continued to grow with a record increase of 63% in Bt cotton area from 3.8 to 6.2 million hectares, to become the largest hectarage of Bt cotton in any country in the world. In 2008, Bt cotton area increased yet again to a record 7.6 million hectares from 6.2 million hectares in 2007. This is the fourth consecutive year for India to have the largest year-on-year percentage growth of all biotech cotton growing countries in the world; a 160% increase in 2005, followed by a 192% increase in

Figure 1. Adoption of Bt Cotton in India for the Seven Year Period, 2002 to 2008



(Source: Compiled by ISAAA, 2008)

2006 and a 63% increase in 2007 and a 23% increase in 2008 (Figure 1). In addition, in 2006-07 India overtook the USA to become the second largest cotton producing country in the world, after China (USDA/FAS, 2007).

Of the estimated 9.3 million hectares of cotton in India, in 2008, 82% or 7.6 million hectares were Bt cotton hybrids – a remarkably high proportion in a fairly short period of seven years equivalent to an unprecedented 150-fold increase from 2002 to 2008. Of the 7.6 million hectares of hybrid Bt cotton grown in India in 2008, 35% was under irrigation and 65% rainfed. A total of 274 Bt cotton hybrids were approved for planting in 2008 compared with only 131 in 2007, 62 in 2006, 20 in 2005 and only 4 Bt cotton hybrids in 2004. Over the last seven years, India has greatly diversified deployment of Bt genes and genotypes, which are well-adapted to the different agro-ecological zones to ensure equitable distribution to small and resource-poor cotton farmers. The distribution of Bt cotton in the major growing states from 2002 to 2008 is shown in Table 3 and Figure 2. The major states growing Bt cotton in 2008, listed in order of hectarage, were Maharashtra (3.13 million hectares) representing almost half, or 42%, of all Bt cotton in India in 2008, followed by Gujarat (1.36 million hectares or 18%), Andhra Pradesh (1.32 million

Picture 2: Bt cotton in full bloom

Table 3. Adoption of Bt Cotton in India, by Major States, 2002 to 2008 (Thousand Hectares)

State	2002	2003	2004	2005	2006	2007	2008
Maharashtra	25	30	200	607	1,840	2,800	3,130
Andhra Pradesh	8	10	75	280	830	1,090	1,320
Gujarat	10	36	122	150	470	908	1,360
Madhya Pradesh	2	13	80	146	310	500	620
Northern Zone*	--	--	--	60	215	682	840
Karnataka	3	4	18	30	85	145	240
Tamil Nadu	2	7	5	27	45	70	90
Other	--	--	--	--	5	5	5
Total	**50**	**100**	**500**	**1,300**	**3,800**	**6,200**	**7,605**

* Punjab, Haryana, Rajasthan

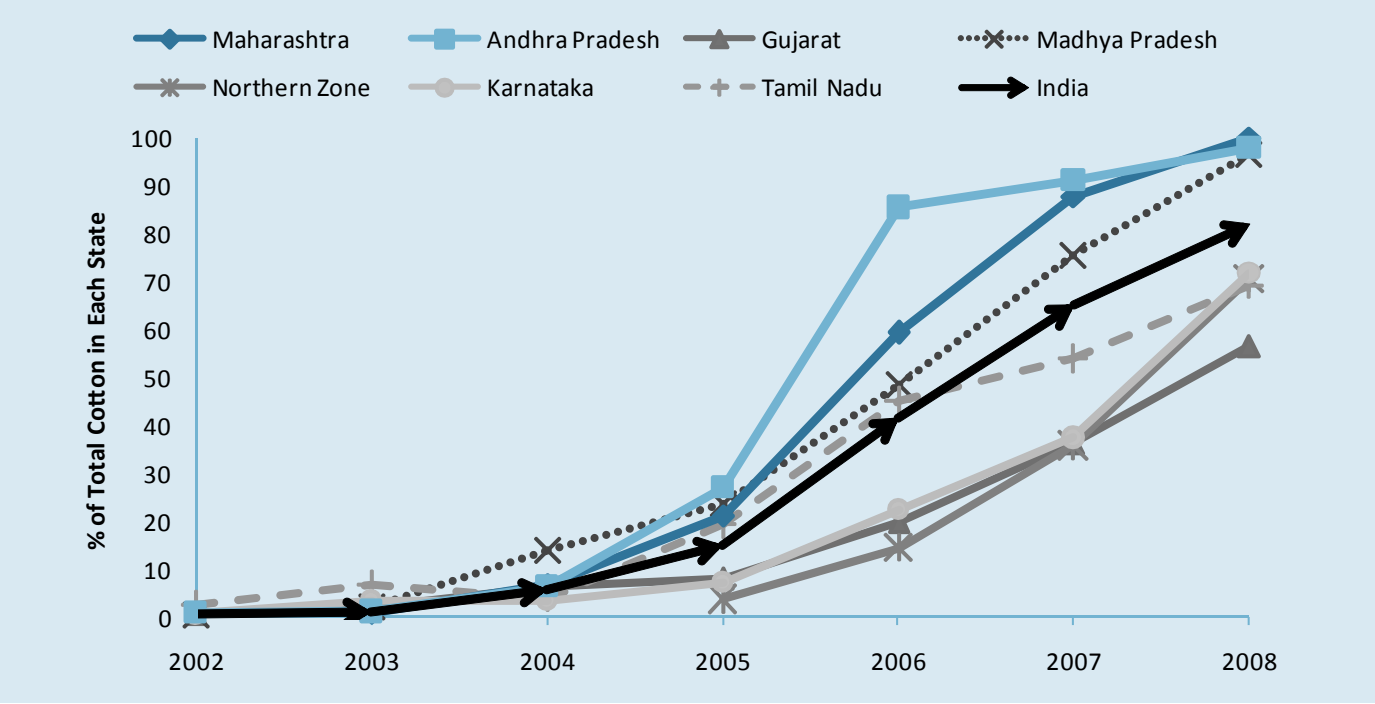
(Source: ISAAA, 2008)

hectares or 18%), Northern Zone (840,000 hectares or 11%), Madhya Pradesh (620,000 hectares or 8%), and the balance in Karnataka and Tamil Nadu and other states.

Number of Farmers Growing Bt Cotton Hybrids in India, 2002 to 2008

Based on the latest official data the average cotton holding per farm in India is 1.5 hectares (Table 1) and thus it is estimated that approximately 5 million small and resource-poor farmers, up from 3.8 million in 2007, 2.3 million farmers in 2006, to 3.8 million farmers in 2007 and to 5 million farmers in 2008; this is the largest increase in number of farmers planting biotech crops in any country in 2008. The 5 million small and resource-poor farmers who planted and benefited significantly from Bt cotton hybrids in 2008 represented approximately 80% of the total number of 6.2 million farmers who grew cotton in India in 2008. Given that only 82% of the cotton area is planted to hybrid cotton, the percentage adoption for the 7.6 million hybrid hectares alone in 2008 was 96%; this is approximately the same high level of adoption for biotech cotton in the mature biotech cotton markets of the USA and

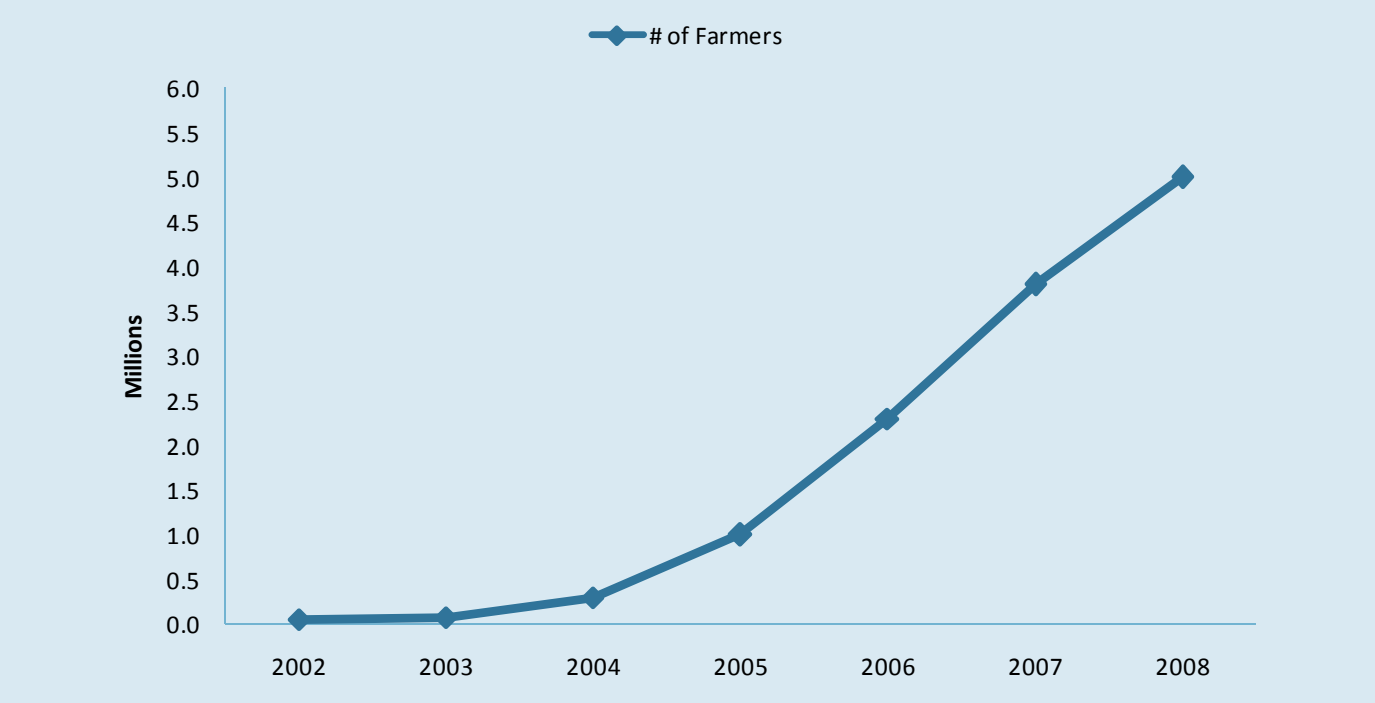
Figure 2. Percent Adoption of Bt Cotton in India and in Different States Expressed as Percentage Adoption within States and Nationally in India, 2002 to 2008



(Source: Compiled by ISAAA, 2008)

planted Bt cotton hybrids in 2008 (Figure 3). Thus, remarkably the number of farmers growing Bt cotton hybrids in India has increased from 50,000 in 2002 to 100,000 in 2003 300,000 small farmers in 2004, to 1 million in 2005, with over a two-fold increase of Australia. It is notable that the first Bt variety, as opposed to Bt hybrids, was approved in India in 2008 but not commercialized pending multiplication of seed for the 2009 season. Thus, the first Bt cotton variety will be planted in India in 2009 on the remaining 15% of

Figure 3. Number of Small Farmers Adopting Bt Cotton Hybrid in India, 2002 to 2008



(Source: Compiled by ISAAA, 2008)

cotton hectarage that is not occupied by hybrids.

Some of the critics opposed to Bt cotton in India have, without presenting supporting evidence, alleged that Bt cotton has contributed to farmer suicides in India. A recent paper (IFPRI, 2008) published by the International Food Policy Research Institute, based in the USA, could not find evidence to support the views of the critics. On the contrary, the paper concludes that: "In this paper, we provide a comprehensive review of evidence on Bt cotton and farmer suicides, taking into account information from published official and unofficial reports, peer-reviewed journal articles, published studies, media news clips, magazine articles, and radio broadcasts from India, Asia, and international sources from 2002 to 2007. The review is used to evaluate a set of hypotheses on whether or not there has been a resurgence of farmer suicides, and the potential relationship suicide may have with the use of Bt cotton.

We first show that there is no evidence in available data of a "resurgence" of farmer suicides in India in the last five years. Second, we find that Bt cotton technology has been very effective overall in India. However, the context in which Bt cotton was introduced has generated disappointing results in some particular districts and seasons. Third, our analysis clearly shows that Bt cotton is neither a necessary nor a sufficient condition for the occurrence of farmer suicides. In contrast, many other factors have likely played a prominent role" (IFPRI, 2008).

Savings of Insecticides due to Bt Cotton

Traditionally, cotton consumed more insecticides than any other crop in India and was a significant proportion of the total pesticide (insecticides, fungicides and herbicides) market for all crops. For example, of the total pesticide market in India in 1998 valued at US$770 million (Table 4), 30% was for cotton insecticides only

Picture 3. Farmer spraying insecticides on cotton field, Haryana

which were equal to 42% of the total insecticide market for all crops in India (Indian Chemical Industry, 2007). Subsequent to the introduction of Bt cotton, cotton consumed only 18% of the total pesticide market, in 2006, valued at US$900 million as compared to a much higher 30% in 1998. Similarly, the market share for cotton insecticides as a percentage of total insecticides declined from 42% in 1998 to 28% in 2006. This saving in insecticides between 1998 and 2006 coincided with the introduction of Bt cotton which occupied 3.8 million hectares equivalent to 42% of the hectarage of the cotton crop in 2006. More specifically, the sharpest decline in insecticides occurred in the bollworm market in cotton, which declined from US$147 million in 1998 to US$65 million in 2006 – a 56% decrease, equivalent to a saving of US$82 million in the use of insecticides to control cotton bollworm in 2006. Thus, insecticides use for control of bollworm dropped by half at the same time when approximately half the cotton area (3.8 million hectares) was benefiting from controlling bollworm with Bt cotton.

The trends in decreased use of insecticides on cotton noted by the chemical industry in India (Indian Chemical Industry, 2007), based on the value of confirmed savings from Bt cotton, are similar to the trend noted and supported by the data from the Indian Ministry of Agriculture based on consumption of pesticides (active ingredient in metric tons) during the period 2001 to 2006 (Table 5). Since the introduction of Bt cotton in 2002, the consumption of pesticides as measured in active ingredient, has exhibited a consistent

Table 4. Value of the Total Pesticide Market in India Relative to the Value of the Cotton Insecticide Market, 1998 and 2006

Item/Year	1998	2006
Total pesticides market (in million US$)	Valued at $770 million	Valued at $900 million
Cotton insecticides as % of total pesticide market	30%	18%
Cotton insecticides as % of total insecticide market	42%	28 %
Value in US$ millions of cotton bollworm market & (savings due to Bt cotton) in 2006 over 1998	US$147 million	US$65 million (Savings of US$82 million, or 56 %, compared with 1998)

(Source: Indian Chemical Industry, 2007)

downward trend as adoption of Bt cotton has increased at unprecedented rates to reach 82% of all cotton hectarage in India in 2008. The data in Table 5 confirms a consistent downward trend of pesticide consumption from 48,350 metric tons in 2002, the year Bt cotton was first introduced to 37,959 metric tons in 2006 when 3.8 million hectares occupied 42% of the total hectarage of cotton in India. The decrease in pesticide usage is equivalent to a 22% reduction over only a short period of five years. Pesticide usage statistics for India for 2007 and 2008 are not yet published but based on the steep decline between 2001 and 2006 the downward trend would be expected to continue as percentage adoption of Bt cotton has steadily increased to reach 82% of all cotton in 2008. It is noteworthy that the decline in pesticide usage between 1998 and 2006 has occurred when the total hectarage of cotton in India has actually increased slightly from 8.7 million hectares in 1998 to 9.2 million hectares in 2006.

Table 5. Consumption of Pesticides in India, 2001 to 2007 (Metric Tons of Technical Grade or Active Ingredient)

Year	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07
Total Pesticide	47,020	48,350	41,020	40,672	39,773	37,959

(Source: Central Insecticides Board and Registration Committee (CIBRC), Ministry of Agriculture, 2008)

In summary, the adoption of Bt cotton in 2002 in India has led to a significant decrease in insecticide usage for the control of cotton bollworm, which in 2006 was estimated at a minimal 20% reduction of approximately 9,000 tons of active ingredient valued at approximately US$80 million in 2006.

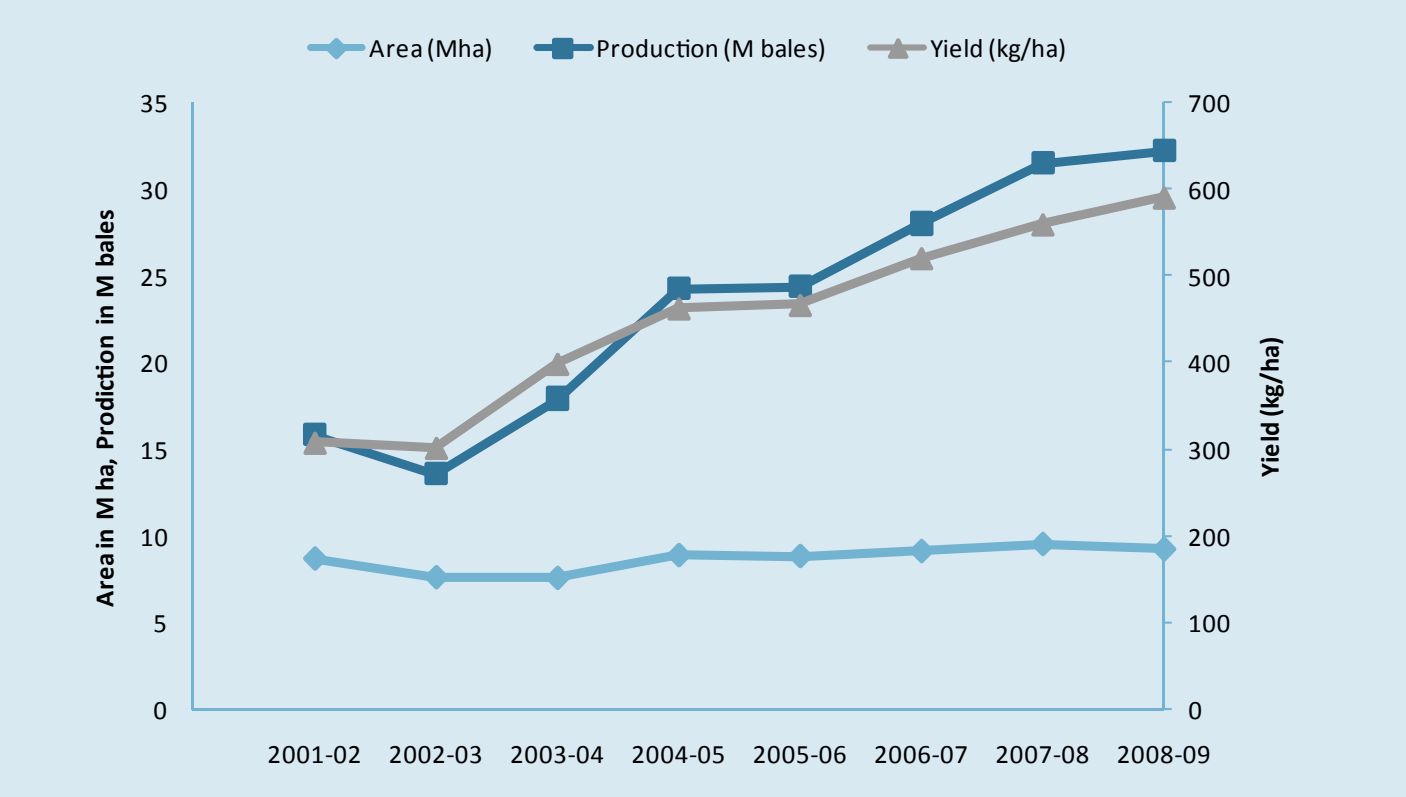
Cotton Production, Yield and Imports Exports, 2001 to 2008

Coincidental with the steep increase in adoption of Bt cotton between 2002 and 2008, the average yield of cotton in India, which had one of the lowest yields in the world, increased from 308 kg per hectare in 2001-02, to 560 kg per hectare in 2007-08 and projected to increase to 591 kg per hectare in 2008-09 season, with 50% or more of the increase in yield, attributed to Bt cotton (Figure 4). Thus, at a national level, Bt cotton is a major factor contributing to higher cotton production which increased from 15.8 million bales in 2001-02, to 24.4 million bales in 2005-06, to 28 million bales in 2006-07 to 31.5 million bales in 2007-08, which was a record cotton crop for India (Cotton Advisory Board, India, 2008). The Cotton Advisory Board projects 32.2 million bales of production in 2008-09 despite the fact that the total cotton hectarage in India decreased slightly by 3% from 9.6 million hectares in 2007 to 9.3 million hectares in 2008. This quantum leap in cotton production since 2002-03 has been triggered by improved seeds and particularly the ever-increasing plantings of improved Bt cotton in the ten cotton-growing states (Ministry of Textile, 2008). While the public sector continues to play a dominant role in production and distribution of low-value high volume seeds like cereals, pulses and oilseeds, the private seed sector is growing high-value, low-volume segments like vegetables, horticultural and

cash crops like cotton. The private seed industry's role in promoting genetically modified (Bt) cotton has been particularly significant. India is now a mega cotton producing country as noted in the Economic Survey of 2006-07. The Annual Economic Survey 2007-08 of the Ministry of Finance also reports an increase in production and productivity of cotton during the Tenth Five Year Plan (2002-2007), which coincides with the introduction of Bt cotton in India in 2002 (Ministry of Finance, 2008).

With the boom in cotton production in the last seven years, India has become transformed from a net importer to a net exporter of cotton. Exports of cotton have registered a sharp increase from a meager 0.05 million bales in 2001-02 to 5.5 million bales in 2006-07 to 8.5 million bales in 2007-08 (Figure 5). The Cotton Advisory Board of the Government of India expects a further decrease in cotton imports to 0.5 million bales.

Figure 4. Cotton Hectarage, Production and Yield in India, 2001 to 2008



(1 bale = 170 kg)
(Source: Ministry of Textile, Government of India 2008)

Notably, cotton is the major raw material for the domestic textiles industry, which is predominantly in favor of cotton, compared with other fibers. With the dismantling of the Multi Fiber Agreement (MFA) under the aegis of the World Trade Organization, this will favor cotton relative to synthetic fibers. Thus, as a result of the boom in cotton, India's Ministry of Textile has projected that the value of the Indian textile industry will grow from US$47 billion in 2005-2006 to US$95 billion by 2010. In 2012, it is expected to escalate further to US$115 billion comprising the domestic market of US$60 billion and US$55 billion for exports. The cotton textiles, which constitute more than two-thirds of all textile exports of India, reached US$4.49 billion

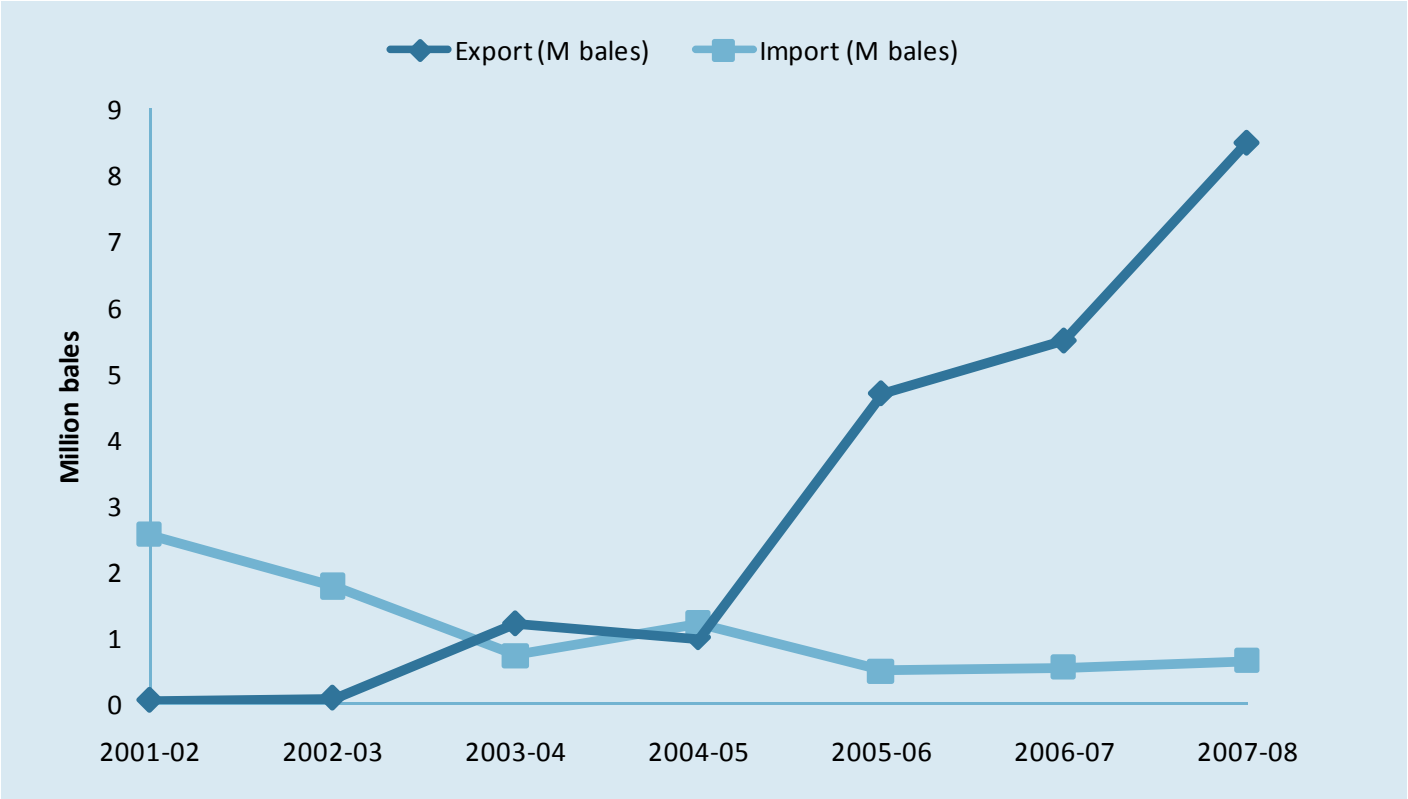
in 2005-06 recording a substantial increase of 26.8% over 2004-2005. The significant increase in cotton production during the last five or six years has increased the availability of raw cotton to the domestic textiles industry at affordable prices, and provided the textile industry with a competitive edge in the global market (Ministry of Textile, 2007).

Concurrent with the boom in cotton production, the Indian biotech and seed industry has also been growing at an unprecedented rate with high year-on-year growth because of the high adoption of Bt cotton by Indian farmers. In 2006-07, the Indian biotech sector exceeded the US$2 billion benchmark with industry reporting nearly 31% growth over 2005-06. According to the survey conducted by BioSpectrum-ABLE (Biospectrum, India, 2008) in 2007-08, the Indian biotech industry reached US$2.5 billion in revenues, recording 30.98% growth, over the previous year's US$2.08 billion and is projected to be a US$5 billion industry by 2010. More specifically the agricultural biotech (BioAgri) sector grew 54.9% in 2006-07, 95% in 2005-06 and increased twelve-fold from US$26.8 million in 2002-2003 to US$300 million in 2007-2008.

Approval of Events and Bt Cotton Hybrids in India

The number of events, as well as the number of Bt cotton hybrids and companies marketing approved hybrids have all increased significantly from 2002, the first year

Figure 5. Export and Import of Cotton in India, 2001 to 2008



(1 bale = 170kg)
(Source: Ministry of Textile, Government of India, 2008)

Picture 4. Bt cotton harvest in Bhatinda Mandi, Punjab

of commercialization of Bt cotton in India. In 2008, the number of Bt cotton hybrids increased by more than two-fold to 274 from 131 hybrids in 2007; this followed a doubling of the number of hybrids from 62 in 2006 to 131 in 2007. Importantly, this increase in number of hybrids has provided much more choice in 2008 than in previous years to farmers in the North, Central and Southern regions, where specific hybrids have been approved for cultivation in specific regions (Figure 6). In 2008, a total of four events were approved for incorporation in a total of 274 hybrids with fifth event in Bt cotton variety, popularly known as Bikaneri Narma (BN) Bt which was approved for commercial cultivation in 2008 (Table 6).

The first event, MON 531, Bollgard®I (BG®I), featuring the cry1Ac gene was developed by Maharashtra Hybrid Seed Company Ltd. (Mahyco), sourced from Monsanto, and approved for sale in 2008, for the seventh consecutive year, in a total of 141 hybrids for use in the North, Central and South zones – this compares with 96 BG®I hybrids in 2007 and 48 BG®I hybrids in 2006.

The second event, MON15985, Bollgard®II (BG®II) was also developed by Mahyco and sourced from Monsanto, featured the two genes *cry1Ac* and *cry2Ab*, and was approved for sale for the first time in 2006 in a total of seven hybrids for use in the Central and South regions. This event was approved for commercial cultivation for the first time in the Northern region in 2007 and the number of hybrids for sale increased from 7 in 2006 to 21 in 2007, and further increased to 94 BG®II cotton hybrids in 2008 in the North, Central and South regions

Table 6. Commercial Release of Different Bt Cotton Events in India, 2002 to 2008

No	Crop	Event	Developer	Status	Year of approval
1	Cotton*	MON 531	Mahyco/Monsanto	Commercialized	2002
2	Cotton*	MON15985	Mahyco/Monsanto	Commercialized	2006
3	Cotton*	Event-1	JK Agri-Genetics	Commercialized	2006
4	Cotton*	GFM Event	Nath Seeds	Commercialized	2006
5	Cotton**	Cry1Ac Event	CICR (ICAR) & UAS, Dharwad	Commercialized	2008

* Bt Cotton Hybrid , ** Bt Cotton Variety

(Source: Compiled by ISAAA, 2008)

Figure 6. Approval of Events and Bt Cotton Hybrids in India, 2008

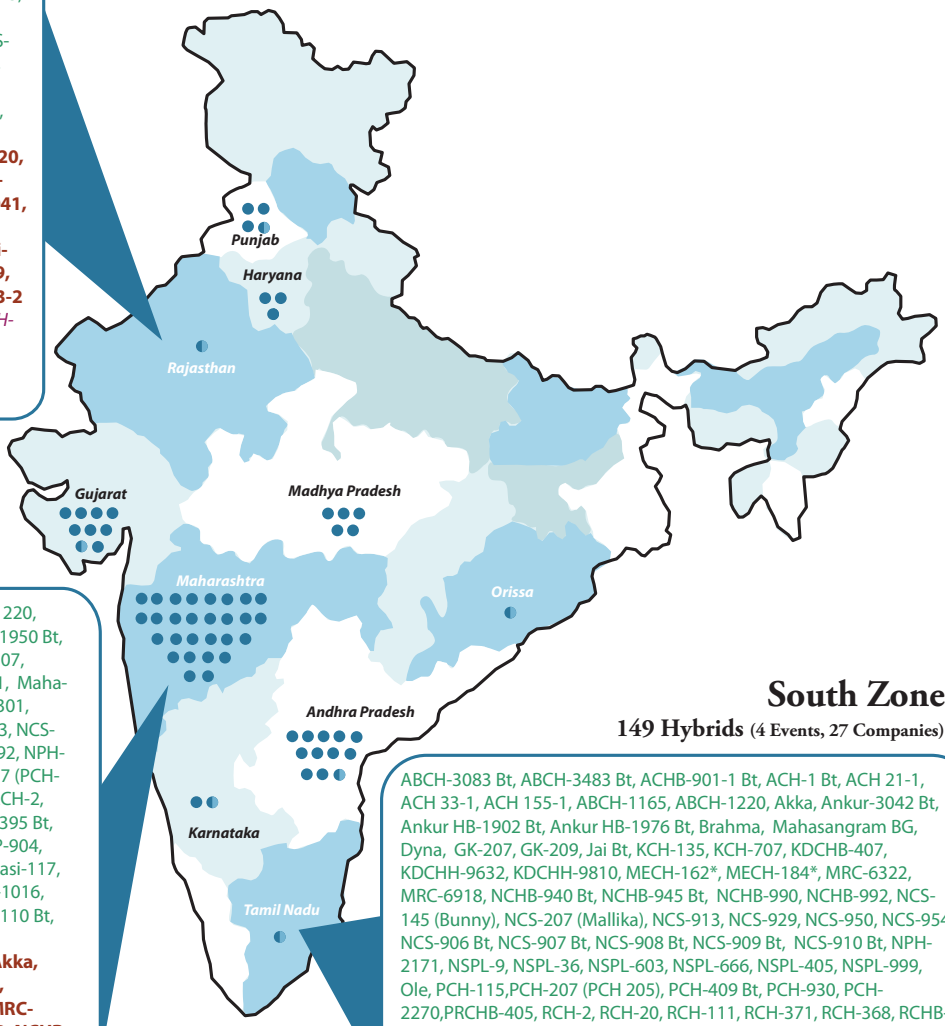
North Zone
62 Hybrids (4 Events, 15 Companies)

Ankur-651, Ankur-2226, Ankur-2534, GK-206, IT-905, KDCHH-9810, MRC-6025, MRC-6029, MRC-6301, MRC-6304, NAMCOT-402, NCS-138, NCS-913, NCS-950, Ole, PCH-406, RCH-134, RCH-308, RCH-314, RCH-317, , SDS-9, SDS-1368, Sigma, VBCH-1006 BG, VBCH-1008 BG, VICH-11 BG, 6317 Bt, 6488 Bt

ACH 33-2, ANKUR-5642, ANKUR-8120, GK-212, Jassi, KCH-707 Bt, KDCHH-441, MRC-7017, MRC-7031, MRC-7041, MRC-7045, NCS-145 (Bunny), RCH-134, SDS-9, SDS-36, Tulasi-4, Tulasi-45, VBCH-1501, VBCH-1504, VICH-9, VICH-11, 569, 6488- 2, 2510-2, 2113-2

JKCH-1945 Bt, JKCH-1947, JK-1050, JKCH-226 Bt

Navkar-5 Bt, NCEH-6R NCEH-26 Bt, NCEH-31 Bt, UPLHH-1



Central Zone
148 Hybrids (4 Events, 27 Companies)

ACH 33-1, ACH 155-1, ACH-177-1, ABCH-1165, ABCH-1220, Akka, Ankur-9, Ankur-651, Ankur-3032 Bt, Ankur HxB-1950 Bt, Brahma, Dyna, GK-204, GK-205, Jai Bt, KCH-135, KCH-707, KDCHH-786, KDCHH-9632, KDCHH-9810, KDCHH-9821, Mahasangram BG, MECH-12, MECH-162, MECH-184, MRC-6301, NCS-138, NCS-145 (Bunny), NCS-207 (Mallika), NCS-913, NCS-929, NCS- 950, NCS-954, NCS-955, NCHB-991, NCHB-992, NPH-2171, NSPL-36, NSPL-405, NSPL-999, PCH-115, PCH-207 (PCH-205), PCH-923, PCH-930, PRCH-102, PRCH-31, Rudra, RCH-2, RCH-118, RCH-138, RCH-144, RCH-377, RCH-386, RCH-395 Bt, Sarju-BG, Sigma, SP-499, SP-503, SP-504 (Dhanno), SP-904, SP-923, SWCH-4314, Tulasi-4, Tulasi-5 Bt, Tulasi-9, Tulasi-117, VBCH-101, VBCH-1006,VBCH-1009, VBCH-1010, VBCH-1016, VBCH-1017,VCH-111, VICH-5, VICH-9, VICH-15, 322 Bt, 110 Bt, 6188 Bt, 563 Bt

ACH-111-2, ACH-177-2 , Ajeet-11-2, Ajeet-155-2, Akka, Amar-1065 Bt, Atal, GK-205, KCH-707, KDCHH-441, KDCHH-621, KDCHH-9632, KCH-135, MLCH-317, MRC-7301, MRC-7326, MRC-7347, MRC-7351, MRC- 7918, NCHB-945 Bt, NCS-145 Bt 2, NCS-207 (Mallika), NCS-854 Bt 2, NSPL-36, NSPL-405, NSPL-999, Paras Lakshmi, PCH-2171 Bt 2, PCH-205 Bt 2, PRCH-504, PRCH-505, RCH-2, RCH-515, RCH-578, RCH-584, SP-504 , Tulasi-4, Tulasi-9, Tulasi-118, VBCH-1501, VBCH-1503 , VBCH-1505, VICH-5 Bt, VICH-15, 311-2, 557-2

JKCH-99, JKCH-226, JKCH-666, JK-Durga Bt, JK- Indra Bt, JK-Varuna ACH-1019, Dhruv Bt, GBCH-01, Kashinath, Monsoon Bt,

Navkar-5, NCEH-2R, NCEH-3R, NCEH-21, NCEH-23, NCEH-14, NCEH-34 Bt, UPLHH-2Bt, ZCH-50005, ZCH-50072 Bt

South Zone
149 Hybrids (4 Events, 27 Companies)

ABCH-3083 Bt, ABCH-3483 Bt, ACHB-901-1 Bt, ACH-1 Bt, ACH 21-1, ACH 33-1, ACH 155-1, ABCH-1165, ABCH-1220, Akka, Ankur-3042 Bt, Ankur HB-1902 Bt, Ankur HB-1976 Bt, Brahma, Mahasangram BG, Dyna, GK-207, GK-209, Jai Bt, KCH-135, KCH-707, KDCHB-407, KDCHH-9632, KDCHH-9810, MECH-162*, MECH-184*, MRC-6322, MRC-6918, NCHB-940 Bt, NCHB-945 Bt, NCHB-990, NCHB-992, NCS-145 (Bunny), NCS-207 (Mallika), NCS-913, NCS-929, NCS-950, NCS-954, NCS-906 Bt, NCS-907 Bt, NCS-908 Bt, NCS-909 Bt, NCS-910 Bt, NPH-2171, NSPL-9, NSPL-36, NSPL-603, NSPL-666, NSPL-405, NSPL-999, Ole, PCH-115,PCH-207 (PCH 205), PCH-409 Bt, PCH-930, PCH-2270,PRCHB-405, RCH-2, RCH-20, RCH-111, RCH-371, RCH-368, RCHB-708, Rudra, Sigma, SP-503, SP-504 (Dhanno), SP-700, SWCH-4531Bt, Tulasi-9 Bt, Tulasi-4, Tulasi-45 Bt,Tulasi-117, Tulasi-118 Bt, VBCHB-1010 BG, VBCH-1016 Bt,VBCH-1018 Bt, VBCHB-1203,VICH-5, VICH-9, VCH-111, 340 Bt, 6188 Bt

ABCH-1065 Bt, ABCH-1020 Bt, ACH-33-2, ACH-177-2, ACH-155-2, Akka, Ankur-5642, Ankur-10122, Brahma, GK-217, KCH-135 Bt, KDCHH-441, KDCHH-621, KDCHH-9632, MLCH-318, MRC-7160, MRC-7918, MRC-7201, MRC-7347, MRC-7351, MRC-7929, NAMCOT-612, NAMCOT-607, NCS-854, NCS-207, NCS-145 (Bunny), NSPL-405, NSPL-999, PCH-2270, PCH-105, PRCH-504, PRCH-505, RCH-2, RCH-530, RCH-533, RCH-596, SP-1037, Tulasi-7, Tulasi-9, Tulasi-118, VICH-5 Bt,VICH-15 Bt, VBCH-1501, VBCH-1505, VBCH-1506, 322-2, 113-2, 340-2

JK-Durga, JKCH-99, JKCH-634 (JK-Iswar), JKCH-2245 Bt, JK Chamundi Bt, JK-Indra Bt, JK- Gowri Bt

Dhruv Bt, Kashinath, Monsoon Bt, NCEH-2R, NCEH-3R, NCEH-13 Bt, NCEH-34 Bt, SBCH-292 Bt, UPLHH-12 Bt, UPLHH-5 Bt, ZCH-50072 Bt

****Mech-162 & Mech-184 are not approved for AP.***

Event	Color Code
BG-I	Normal
BG-II	**Bold**
Event-1	*Italic*
GFM Event	***Italic Bold***

For 100,000 hectares of Bt Cotton
For <100,000 hectares of Bt Cotton

(Source: Complied by ISAAA, 2008)

The third event, known as Event 1 was developed by JK Seeds featuring the *cry1Ac* gene, sourced from IIT Kharagpur, India. The event was approved for sale for the first time in 2006 in a total of four hybrids for use in the North, Central and South regions. Whereas this event was approved in only four hybrids in 2006, in 2008 it quadrupled to 15 hybrids.

The fourth event is the GFM event which was developed by Nath Seeds, sourced from China, and features the fused genes *cry1Ab* and *cry1Ac*. It was approved for sale for the first time in a total of three hybrids in 2006, one in each of the three regions of India. In 2008, the number of hybrids for sale increased eight-fold from 3 to 24 in 3 regions.

In contrast to the above four events, which were all incorporated in cotton hybrids, notably the fifth event was approved in an indigenous cotton variety named Bikaneri Narma (BN) expressing the *cry1Ac* protein. It was approved for commercial release in the North, Central and South cotton growing zones in India during Kharif, 2008. This is the first indigenous Bt cotton event developed by the Central Institute of Cotton Research (CICR) – one of the premier public sector institute of the Indian Council of Agricultural Research (ICAR) – along with University of Agricultural Sciences, Dharwad, Karnataka. The approval of the Bt cotton variety will help farmers in varietal growing areas which were previously disadvantaged because they were unable to benefit from the insect resistant Bt cotton hybrids cultivated widely across all three cotton growing zones.

The deployment for commercialization of these four events in hybrids in India is summarized in Table 7, and their regional distribution is detailed in Table 8. The variety Bikaneri Narma was approved in 2008 and will be commercialized by CICR, Nagpur and the University of Agricultural Sciences (UAS), Dharwad in the three zones of North, Central and South India in 2009.

The number of Bt cotton hybrids as well as the number of companies offering Bt cotton hybrids in India has increased dramatically over the last 7 years since the first commercialization in 2002. In 2008, the number of Bt cotton hybrids doubled to 274 from 131 in 2007 with 30 companies marketing those hybrids in three cotton-growing zones in 2008.

By contrast in 2007, only 24 companies offered 131 hybrids, up from 15 companies offering 62 hybrids in 2006. The following 30 indigenous seed companies and one public sector institution from India, listed alphabetically, offered the 274 hybrids for sale in 2008 and one variety was approved and will be commercialized in 2009; Ajeet Seeds Ltd., Amar Biotech Ltd., Ankur

Table 7. Deployment of Approved Bt Cotton Events/Hybrids by Region in India, 2008

Event	North (N)	Central (C)	South (S)	North/ Central (N/C)	North/South (N/S)	Central/ South (C/S)	N/C/S	Total Hybrids
BG®I[1]	21	36	39	3	1	38	3	141
BG®II[2]	19	24	24	2	4	20	1	94
Event-I[3]	4	4	5	0	-	2	0	15
GFM Event[4]	5	8	4	0	-	7	0	24
Total	**49**	**72**	**72**	**5**	**5**	**67**	**4**	**274**

[1,2] Mahyco [3] JK Seeds [4] Nath Seeds

(Source: Compiled by ISAAA, 2008)

Table 8. Deployment of Approved Bt Cotton Events/Hybrids by Companies in India, 2002 to 2008

Zone	2002	2003	2004	2005	2006	2007	2008
NORTH ZONE Haryana Punjab Rajasthan				6 Hybrids 1 Event 3 Companies	14 Hybrids 3 Events 6 Companies	32 Hybrids 4 Events 14 Companies	62 Hybrids 4 Events 15 Companies
CENTRAL ZONE Gujarat Madhya Pradesh Maharashtra	3 Hybrids	3 Hybrids	4 Hybrids	12 hybrids One Event 4 Companies	36 Hybrids 4 Events 15 Companies	84 Hybrids 4 Events 23 Companies	148 Hybrids 4 Events 27 Companies
SOUTH ZONE Andhra Pradesh Karnataka Tamil Nadu	3 Hybrids	3 Hybrids	4 Hybrids	9 Hybrids 1 Event 3 Companies	31 hybrids 4 Events 13 Companies	70 Hybrids 4 Events 22 Companies	149 Hybrids 4 Events 27 Companies
Summary **Total no. of hybrids** **Total no. of events** **Total no. of companies**	 **3** **1** **1**	 **3** **1** **1**	 **4** **1** **1**	 **20** **1** **3**	 **62** **4** **15**	 **131** **4** **24**	 **274** **4** **30**

(Source: ISAAA, 2008)

Seeds Pvt., Bayer Biosciences Ltd., Bioseeds Research India Pvt. Ltd., Ganga Kaveri Seeds Pvt. Ltd., Green Gold Pvt. Ltd., J. K. Agri Genetics Ltd, Kaveri Seeds Pvt. Ltd., Krishidhan Seeds Ltd., Mahyco, Monsanto India Pvt. Ltd., Namdhari Seeds Pvt. Ltd., Nandi Seeds Pvt. Ltd., Nath Seeds Ltd., Navkar Hybrid Seeds Pvt. Ltd., Nuziveedu Seeds Ltd., Prabhat Agri Biotech Ltd., Pravardhan Seeds Ltd., Rasi Seeds Ltd., Safal Seeds and Biotech Ltd., Seed Works India Pvt. Ltd., Solar Agrotech Pvt. Ltd., Tulasi Seeds Pvt. Ltd., Uniphos Enterprises Ltd., Vibha Agrotech Ltd., Vikki Agrotech, Vikram Seeds Ltd., Yashoda Hybrid Seeds Pvt. Ltd., Zuari Seeds Ltd., CICR, Nagpur, and the University of Agricultural Sciences (UAS), Dharwad.

The deployment of the four events in 274 hybrids in 2008 is summarized in Table 8 and Figure 7, as well as the corresponding distribution of hybrids in 2002, 2003, 2004, 2005 and 2006. In 2008, the Genetic Engineering Approval Committee (GEAC) approved 143 new Bt cotton hybrids for commercial cultivation in the 2008 season, in addition to the 131 Bt cotton hybrids approved for sale in 2007, for a total of 274 hybrids. This provided farmers in India's three cotton-growing zones significantly more choice of hybrids for cultivation in 2008. Of the 274 Bt cotton hybrids approved for commercial cultivation, 62 hybrids featuring four events were sold by 15 companies in the Northern zone, 148 hybrids featuring four events were sold by 27 companies in the Central Zone, and 149 hybrids featuring four events were sold by 27 companies in the Southern Zone (Table 8).

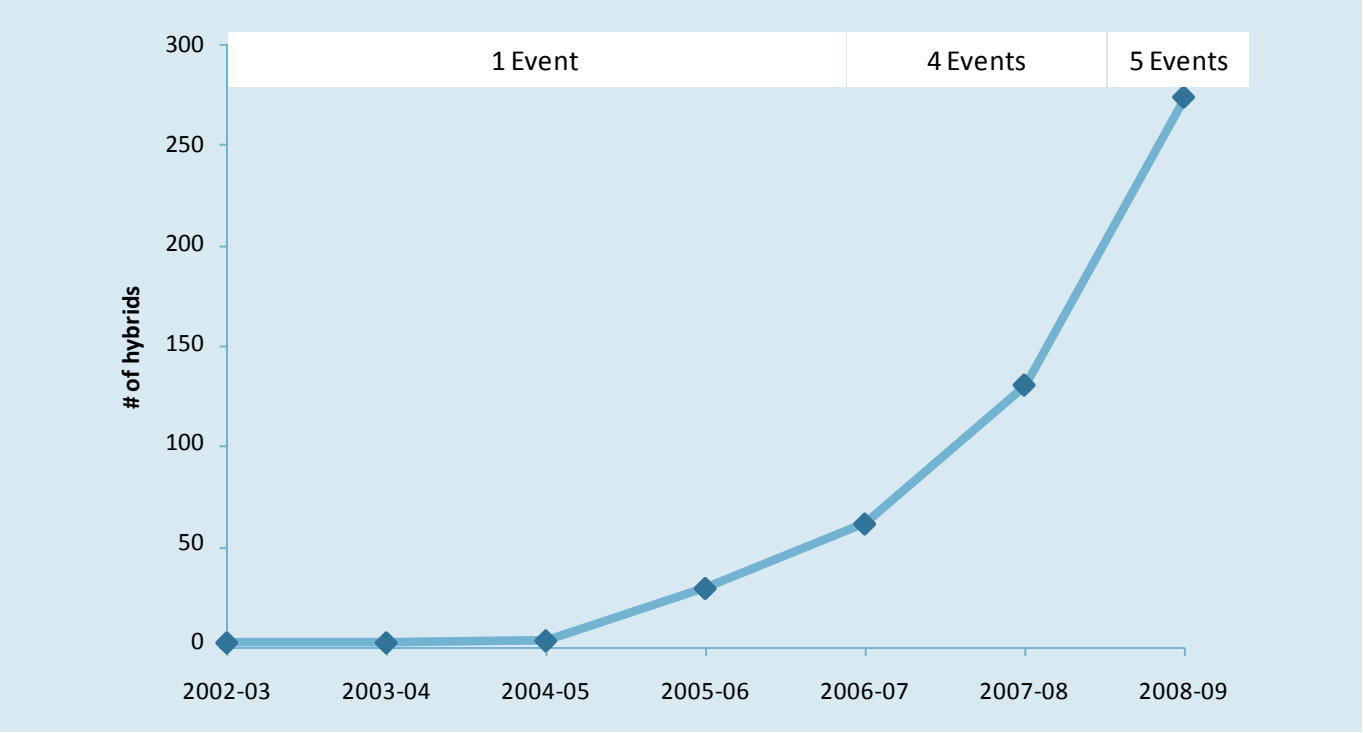
There has been a substantial increase in the number of hybrids with two genes for pest resistance, the BG®II event, in 2008. The BG®II cotton hybrids quadrupled to 94 in 2008 from 21 hybrids in 2007. This trend is due to the multiple benefits that double genes offered in terms of more effective control of more than one insect pest. For this reason the BG®II hybrids are preferred by farmers across all three different cotton-growing zones. The BG®II hybrids protect cotton crops from both *Helicoverpa armigera* and Spodoptera insects and offer an effective tool in insect resistant management to Indian cotton farmers.

Similarly, the distribution of the 131 hybrids approved for 2007 is summarized in Table 8 as well as the 62 hybrids approved for 2006, the 20 hybrids approved for 2005, the four hybrids offered for sale in 2004 and the three hybrids approved for both 2003 and 2002. In 2002, Mahyco was the first to receive approval for three

estimates that India enhanced farm income from Bt cotton by US$3.2 billion in the period 2002 to 2007 and US$2.0 billion in 2007 alone.

A sample of seven economic studies on the impact of Bt cotton, all conducted by public sector institutes

Figure 7. Release of Bt Cotton Hybrids in India, 2002 to 2008



(Source: Compiled by ISAAA, 2008)

Bt cotton hybrids, i.e. MECH 12, MECH 162 and MECH 184, for commercial cultivation in the Central and Southern cotton growing zones in India. The rapid deployment of hybrids during the period 2002 to 2008 reaching 274 Bt cotton hybrids in 2008 as well as their respective events in the three regions is summarized and illustrated in the map in Figure 6 and in Figure 7.

Benefits from Bt Cotton in India

The global study of benefits generated by biotech crops conducted by Brookes and Barfoot (2009, forthcoming),

over the period 1998 to 2006 are referenced in Table 9. The studies have consistently confirmed 50 to 110% increase in profits from Bt cotton, equivalent to US$76 to US$250 per hectare. These profits have accrued to small and resource-poor cotton farmers in the various cotton growing states of India. The yield increases range usually from 30 to 60% and the reduction in number of insecticide sprays average around 50%. It is noteworthy that the benefits recorded in pre-commercialization field trials are consistent with the actual experience of farmers commercializing Bt cotton in the last five years.

More specifically, the work of Bennett *et al.* (2006) confirmed that the principal gain from Bt cotton in India is the significant yield gains estimated at 45% in 2002, and 63% in 2001, for an average of 54% over the two years. Taking into account the decrease in application of insecticides for bollworm control, which translates into a saving of 2.5 sprays, and the increased cost of Bt cotton seed, Brookes and Barfoot (2008) estimated that the net economic benefits for Bt cotton farmers in India were US$139 per hectare in 2002, US$324 per hectare in 2003, US$171 per hectare in 2004, and US$260 per hectare in 2005, for a four year average of approximately US$225 per hectare. The benefits at the farmer level translated to a national gain of US$2.0 billion in 2007 and accumulatively US$3.2 billion for the period 2002 to 2007. 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 study by Gandhi and Namboodiri (2006), reports a yield gain of 31%, a significant reduction in the number of

Table 9. Seven Studies Conducted by Public Institutes on the Benefits of Bt Cotton in India for the Years, 1998 to 2008

Publication	[1]Naik 2001	[2]ICAR field trials 2002	[3]Qaim 2006	[4]Bennet 2006	[5]IIMA 2006	[6]ICAR FLD 2006	[7]Andhra University 2006
Period studied	1998-99 & 00-01	2001	2002-2003	2002 & 2003	2004	2005	2006
Yield increase	38%	60-90%	34%	45-63%	31%	30.9%	46%
Reduction in no. of sprays	4 to 1 (75%)	5-6 to 1 spray (70%)	6.8 to 4.2 (50%)	3 to 1	39%	—	55%
Increased profit	77%	68%	69%	50% or more gross margins	88%	—	110%
Average increase in profit/hectare	**$76 to $236/ hectare**	**$96 to $210/ hectare**	**$118/hectare**	—	**$250/hectare**	—	**$223/hectare**

(Source: Compiled by ISAAA, 2008)

1. Naik, G. 2001. "An analysis of socio-economic impact of Bt technology on Indian cotton farmers," Centre for Management in Agriculture, IIMA, Ahmedabad (2001).

2. Indian Council for Agricultural Research (ICAR), 2002. "Report on 2001 IPM trial cost benefit analysis," ICAR, New Delhi (2002).

3. Qaim, M. 2006. "Adoption of Bt cotton and impact variability: Insights from India", Review of Agricultural Economics, 28: 48-58 (2006).

4. Bennett, R. et al., 2006. "Farm-level economic performance of genetically modified cotton in Maharastra, India," Review of Agricultural Economics, 28 (2006): 59-71 (2006).

5. Gandhi, V. and Namboodiri, N.V. 2006. "The adoption and economics of Bt cotton in India: Preliminary results from a study", IIM Ahmedabad working paper no. 2006-09-04, pp 1-27, Sept 2006.

6. ICAR 2006. Front line demonstrations on cotton 2005-06. Mini Mission II, Technology Mission on Cotton, Indian Council for Agricultural Research (ICAR), New Delhi, India (2006).

7. Ramgopal, N. 2006. Economics of Bt cotton vis-à-vis Traditional cotton varieties (Study in Andhra Pradesh)," Agro-Economic Research Center, Andhra University, A.P. (2006).

pesticide sprays by 39%, and an 88% increase in profit or an increase of US$250 per hectare for the 2004 cotton growing season.

A Front Line Demonstration (FLD) study on cotton for 2005-06 recently released by the Indian Council of Agricultural Research (ICAR, 2006) reconfirms a net 30.9% increase in seed yield of Bt cotton hybrids over non-Bt hybrids and 66.3% increase over open-pollinated cotton varieties (OPV). Data in the study covers 1,200 demonstration and farmers' plots in 11 cotton-growing states in India. In the demonstration plots, the Bt cotton hybrids proved to be highly productive with an average yield of 2,329 kg/ha of seed cotton compared to the non-Bt cotton hybrids (1,742 kg/ha) and varieties (1,340 kg/ha). Similarly, the average yield of Bt cotton hybrids was higher in farmers' plots at 1,783 kg/ha compared to non-Bt cotton hybrids (1,362 kg/ha) and OPV in farmers' field (1,072 kg/ha).

A study in 2005 by University of Andhra (2005) concluded that Bt cotton farmers earned three times more than non-Bt cotton farmers in Guntur district and eight times more in Warangal district of Andhra Pradesh, India. The Government of Andhra Pradesh commissioned the study three years ago to examine the advantages, disadvantages, cost of cultivation and net return to Bt cotton as compared to other cotton varieties in selected districts. The study confirmed that the average Bt farmer had a 46% higher yield and applied 55% less pesticides than the non-Bt cotton farmer in Guntur district. Bt cotton farmers in Warangal district applied 16% less pesticides and reaped 47% more cotton as compared to non-Bt farmers. Farmers noted that Bt cotton allowed earlier picking due to less pest susceptibility, and the boll color was superior.

The only published impact studies of Bt cotton in 2006-07 was conducted by IMRB International (IMRB, 2008) which focused on the agronomic and economic benefits and a parallel study conducted by Indycus Analytics (2007) on the social impact of Bt cotton.

The IMRB study sampled 6,000 farmers from 37 districts and interviewed 4,188 farmers growing Bt cotton and 1,793 farmers who grew non-Bt cotton in 9 cotton-growing states in India. The IMRB study reported that Bt cotton (versus non-Bt cotton) resulted in a 50% increase in yield, a reduction of 5 insecticide sprays and a 162% increase in profit equivalent to US$475 per hectare. This estimate for the 2006 season was higher than estimates for the previous years (2002 to 2005) and took into account the higher prices of cotton, the higher value of the Indian Rupee versus the US dollar, and the most recent cost savings associated with Bt cotton in 2006. The IMRB study estimated that the value of Bt cotton at the national level in 2006 was US$1.7 billion. The IMRB study also reported that 90.6% of farmers who planted Bt cotton in 2005 also elected to repeat the planting of Bt cotton in 2006 because they were satisfied with the performance of Bt cotton in 2005. Thus, 9 out of 10 farmers who planted Bt cotton in 2005 also elected to plant Bt cotton in 2006 – this is a very high level of repeat adoption for any technology in agriculture by any industry standard and reflects the trust and confidence that farmers have in Bt cotton. The projected repeat figure for planting of Bt cotton from 2006 to 2007 is 93.1%, even higher than that for 2005-06, and is consistent with the remarkably high adoption rate of Bt cotton by small and resource-poor farmers in India.

The parallel study conducted by Indicus Analytics (2007) on Bt cotton in India in 2006 is the first study to focus on the social impact as opposed to the economic impact. The study involved 9,300 households growing Bt cotton and non-Bt cotton in 465 villages. The study reported that villages growing Bt cotton had more social benefits than villages growing non-Bt cotton. More specifically, compared with non-Bt cotton villages, Bt cotton villages had more access to permanent markets

(44% versus 35%), and banking facilities (34% versus 28%). Bt cotton farmers also benefit more from visits of government and private sector extension workers and are more likely to adopt recommended practices such as improved rotation, and change in the use of the first generation Bt cotton hybrids for improved second generation Bt cotton hybrids. Notably, there was also a consistent difference between Bt cotton households and non-Bt cotton households in terms of access and utilization of various services. More specifically compared with non-Bt cotton household, women in Bt cotton households had a higher usage of antenatal check ups, more and higher use of professionals to assist with births at home. Similarly, children from Bt cotton households had a higher proportion, which had benefited from vaccination (67% versus 62%) and they were more likely to be enrolled in school. It is noteworthy that the socio-economic advantages enjoyed by Bt cotton households are already evident despite the fact that the first Bt cotton was only adopted in 2002. Thus, the economic benefits associated with Bt cotton is already starting to have a welfare impact that provides a better quality of life for Bt cotton farmers and their families in India.

The only published impact study of Bt cotton in India in 2007-08 was conducted by IMRB International (IMRB, 2008), which focused on the agronomic and economic benefits, and the social impact of Bt cotton or Samiksha (IMRB), 2008. The study surveyed a large sample of 6,600 farmers, from over 600 villages in 9 major cotton growing states in India in 2007-08. The study revealed that on average the single gene BG®I cotton farmers earned Rs. 8,669 (US$222) and cotton farmers who used BG®II with the stacked genes gained Rs. 10,009 (US$256) additional incomes per acre compared to conventional cotton farmers. The BG®II cotton hybrids offered a 126% return on investment compared with 117% from BG®I and a mere 12% from conventional cotton. At the national level, Bt cotton farmers gained US$288 million (Rs. 1,127 crores) from reduced pesticide usage and contributed US$3.23 billion (Rs. 12,608 crores) as additional income to the Indian economy in 2007. Socio-economic and welfare benefits are also considered important by Bt cotton farmers. The IMRB study reports that 41% of India's Bt cotton farmers spent less time in the field, allowing more quality time to spend with their family, 35% reported enjoying peace of mind, 24% were able to invest more in their children's education, and 23% reported that they were able to repay long-pending debts during Kharif 2007.

The 2007 ISAAA Report (James, 2007) projected that the adoption rate of Bt cotton in India in 2008 would reach approximately 80% or more, whereas the actual level was 82%. Given the significant and multiple agronomic, economic and welfare benefits that farmers derive from Bt cotton in India, the adoption of approved Bt cotton hybrids in India is expected to continue to increase only modestly in 2009 since the current level of adoption at 82% is close to optimal. Despite the unprecedented high adoption of Bt cotton by 5 million farmers, the majority of whom have first-hand experience of up to seven years of the significant benefits it offers, anti-biotech groups continue to vigorously campaign against biotech in India, using all means to try and discredit the technology, including filing public interest writ petitions in the Supreme Court contesting the biosafety of biotech products.

The approval and adoption of Bt cotton by the two most populous countries in the world, India (1.1 billion people) and China (1.3 billion people), can greatly influence the approval, adoption and acceptance of biotech crops in other countries throughout the world, particularly in developing countries. It is noteworthy that both countries elected to pursue a similar strategy by first exploring the potential benefits of crop biotechnology with a fiber crop, Bt cotton, which has already generated significant and consistent benefits in China, with the same pattern evident in India, the largest grower of

cotton in the world. In 2008, India had more biotech cotton under cultivation (7.6 million hectares) than China (3.8 million hectares) whereas the number of farmers benefiting from Bt cotton was higher in China (7.1 million) than India (5.0 million) because the average cotton holding per farm in China (0.6 hectare) is smaller than in India (1.5 hectare).

Biotech Crops: Emerging Investment Opportunities

India is a country with first-hand experience of the life-saving benefits of the Green Revolution in wheat and rice. Yields in both wheat and rice are now plateauing

Picture 5. Pusa RH10 hybrid rice, IARI

and the conventional technology currently used in wheat and rice and other crops will need to be supplemented to feed a growing population that will increase by 50% to 1.5 billion people by 2050. Accordingly, the Government of India, through the Department of Biotechnology (DBT) in the Ministry of Science and Technology, established six centers of plant molecular biology in 1990 and subsequently established new institutes, the National Institute for Plant Genome Research and Rajiv Gandhi Centre for Biotechnology, to focus on genomics and strengthen plant biotechnology research in the country. The increased public sector investments in crop biotechnology in India are complemented by private sector investments from a large number of indigenous Indian seed companies and subsidiaries of multinationals involved in biotech crops.

Although there are no published estimates of the research and development (R&D) expenditures on crop biotechnology in India, the high level of activity in both the public and the private sector indicates that the fast-growing investments are substantial with India ranking third after China and Brazil in developing countries. Crop biotech investments, from both the public and private sectors in India have increased significantly in recent years. Public sector investments alone in crop biotechnology were estimated to be US$1.5 billion over the last five years, or US$300 million per year. Private sector investments are judged to be somewhat less than the public sector at up to US$200 million making the current total of public and private sector investments in crop biotechnology in India at the order of US$500 million per year. Current R&D in crop biotechnology in India is focused on the development of biotech food, feed and fiber crops that can contribute to higher and more stable yields and also enhanced nutrition. Given that rice production in India is vital for food security, much emphasis has been assigned to genomics in rice and the development of improved varieties tolerant to the abiotic stresses of salinity and drought, and the biotic stresses associated with pests. Field trials with biotech Bt rice are already underway. Reduction of post-harvest losses, particularly in fruits and vegetables, through delayed ripening genes, is also a major thrust. Reflecting the

Picture 6. Upcoming seed processing facility of Vibha Seeds, Jedcherla, Mahaboobnagar, Andhra Pradesh

emphasis on improved crop nutrition, two international collaborative projects involve Golden Rice™, and mustard with enhanced levels of beta-carotene plus an initiative to enhance the nutritional value of potatoes with the ama1 gene. Research in Germany (Stein *et al*., 2006) predicts a positive impact of Golden Rice-2 in India. Under an optimistic scenario, the burden of disability adjusted life years (DALYs) would be reduced by a significant 59% and by 9% under a pessimistic scenario.

Bt Brinjal: A Promising New Product

A recent publication, ISAAA Brief 38, (Choudhary and Gaur, 2009) on "The Development and Regulation of Bt brinjal in India" highlights the important role that improved seeds, including biotech seed, have played in crop production in India. Improved seeds have been a key contributing factor to quantum increases in crop productivity and production in India during the last 50 years. Three significant developments in improved seed and crop technologies have changed the face of Indian crop production and contributed to food security, and the alleviation of poverty and hunger.

The first major development was the green revolution in the 1960s and 1970s which resulted in unprecedented increases in food production from the high yielding, open-pollinated varieties (OPVs) of semi-dwarf wheat and semi-dwarf rice which literally saved millions from hunger in India. Dr. Norman Borlaug was awarded the Nobel Peace Prize in 1970 for developing the semi-dwarf wheats, which were credited with saving 1 billion lives in Asia, the majority in India. Dr. Borlaug's counterpart in India was Dr. M. S. Swaminathan recipient of the first World Food Prize in 1987.

The second development was more modest and associated with the introduction of hybrid seeds, which replaced

Picture 7. Conventional brinjal hybrid MHB39, Jalna, Maharashtra

OPVs in the 1980s and 1990s, primarily in selected vegetable crops, such as tomato, capsicum, brinjal, okra, chili, cabbage and in field crops such as maize, sorghum, pearl millet, and cotton. Whereas hybrid seeds need to be replaced by farmers every year, they offer an attractive incentive to farmers because of the significant yield gains from hybrid vigor and moreover they provide an important technology platform for enhancing productivity in a sustainable manner for the longer term. The third major development was in 2002, which featured the application of biotechnology to crops which led to the approval and commercialization of the first biotech crop in India featuring the Bt gene in hybrid cotton which confers resistance to the critically important lepidopteran insect pest, cotton bollworm. The Bt cotton experience in India is a remarkable story, which has clearly demonstrated the enormous impact that can be achieved by adopting biotech crops. In the short span of seven years, 2002 to 2008, cotton yields and production doubled, transforming India from an importer to an exporter of cotton. These gains in crop production are unprecedented which is why 5 million small farmers in India in 2008 elected to plant 7.6 million hectares of Bt cotton which represented 82% of the total national area of cotton, 9.3 million hectares, which is the largest area of cotton in any country in the world.

Importantly, one common element in all of the three above developments in improved seed was the willingness, indeed the eagerness, of small resource-poor farmers in India to embrace, change and adopt these new technologies, in order to quickly overcome production constraints and to increase their income

to sustain their livelihoods and escape poverty. Thus, Indian farmers have not only been receptive but proactive in the adoption of all the new technologies, as and when they were made available to them, though the pace of introduction of new technologies has been slow in agriculture compared to any other sector because of onerous regulation requirements. These regulatory constraints have been exacerbated by procedural delays precipitated by activists who are well resourced and mobilized in national campaigns to unnecessarily delay the adoption of biotech crops which are subject to a very rigorous science-based regulation system. Despite the intensive actions of activists, Bt cotton has achieved unparalleled success in India simply due to the multiple and significant benefits it consistently delivers to farmers and reflected in the unprecedented 150-fold increase in Bt cotton hectarage between 2002 and 2008. The vote of confidence of farmers in Bt cotton is also reflected in the "litmus-test" for "Trust" which confirms that more than 9 out of 10 farmers who planted Bt cotton in 2005 also elected to plant Bt cotton in 2006 and the figure was even higher in 2006-2007 and projected to continuously increase in the future. This is a very high level of repeat adoption for any crop technology by industry standards and reflects the level of conviction in the technology by small resource-poor farmers who have elected to make the additional investment in Bt cotton because of the superior returns and benefits it offers over conventional hybrid cotton and even more over open-pollinated varieties.

Not surprisingly, the remarkable success of Bt cotton in India and the support of farmers for the technology, has led to widespread strong political support to emulate the success of Bt cotton in other food crops. Whilst India has already approved the initial field testing of Bt rice, with drought and saline tolerant rice under development, it is Bt brinjal, (eggplant or aubergine) which is the most advanced biotech food crop, for which approval for experimental seed production was granted

Picture 8. Mahyco's MHB99 Bt brinjal hybrid fruits, Coimbatore, Tamil Nadu

for 2008-2009 in anticipation of commercialization in the near-term. Thus, Bt brinjal is of special significance because it is the most probable first biotech food crop to be approved for commercialization in India.

Several public institutions and private companies in India have projects to develop improved varieties of the drought tolerant and important perennial eggplant, known locally as brinjal; it occupies more than 0.5 million hectares, is the main source of cash, and supplies 25% of calories to many resource-poor farmers. The goal of the project is to improve resistance to fruit and shoot borer which is a very important pest that requires intensive insecticide applications, every other day in some cases, costing US$40 to US$100 per season's worth of insecticides, with

environmental and health implications, since eggplant is a food crop. These eggplant projects are all geared to deliver biotech products for evaluation and approval by the government in the near-term, and Bt brinjal will probably be India's first biotech food crop. Mahyco developed an eggplant in which the cry1Ac gene confers resistance to the fruit and shoot borer. The product has been tested in large scale field trials with good results, and the Genetic Engineering Approval Committee (GEAC) approved experimental seed multiplication in 2008-2009 in anticipation of commercialization in the near-term. ABSP-II, the agri-biotechnology program of USAID executed by Cornell University, is supporting Mahyco's request for approval and working with public institutions in India, Bangladesh and the Philippines to incorporate the technology in varieties that would complement Mahyco's activities in hybrids; the work in the Philippines is being conducted in conjunction with ISAAA. It is noteworthy that this private-public partnership aims to generate affordable seed for resource-poor farmers, which will substantially reduce, by approximately half, the applications of insecticides required, with positive and significant implications for the environment and the health of farmers. Given that the Bt eggplant will significantly reduce application of insecticides, this in turn will reduce insecticide residues in soil and groundwater. Similarly, reducing broad-spectrum insecticides, which typically kill both bad and good insects, will contribute to a greater diversity of beneficial insects. Studies on gene flow have not detected any negative effects on wild species of eggplant and this monitoring will continue.

The ISAAA study on Bt brinjal (Choudhary and Gaur, 2009) estimates that the average small and resource-poor farmer in India cultivates 0.40 hectare of eggplant. ABSP II projections indicate that the potential benefits that the technology offers resource-poor farmers in India are significant and include the following: a 45% reduction in the number of insecticide sprays, applied usually by hand sometimes twice a week, with positive implications for health, the environment and a significant reduction in production costs; a 117% increase in yield with implications for more affordable vegetables; an estimated US$411 million per annum increase in net benefits to Indian eggplant producers and consumers at the national level (ABSP II 2007, James, 2007). These economic benefits could make important contribution to the alleviation of poverty by increasing the income of resource-poor farmers growing eggplant and providing a more affordable source of vegetables for poor consumers. Another study conducted by Tamil Nadu Agricultural University (Ramasamy, 2007) projects similar benefits to the above study by ABSP II. The Tamil Nadu

Picture 9. Monsanto's corn processing facility-sorting of wet ears, Shameerpet, Andhra Pradesh

Agricultural University study on the "Economic and environmental benefits and costs of transgenic crops: Ex-ante assessment" estimates the enormous benefits, welfare and distribution effects of Bt eggplant at the

national level. The net estimated benefit of Bt eggplant to Indian farmers and consumers ranges from US$25-142 million per annum assuming only 10% adoption of Bt brinjal in the first year of commercialization (Ramasamy, 2007).

The ISAAA study also concluded that the commercialization of Bt eggplant has the potential to benefit up to a total of 1.7 million small farmers in the three countries of India (550,000 hectares farmed by 1.4 million small farmers), Bangladesh (57,747 hectares farmed by approximately 300,000 farmers) and the Philippines (21,000 hectares farmed by 30,000 farmers). The collective area of 630,000 hectares of eggplant represents a quarter of the total vegetable area in these three countries and therefore the potential impact of this project is significant. Eggplant is grown all-year round and supplies 25 calories per serving, and its "meaty" texture makes eggplant a perfect staple for vegetarians.

It is evident that Bt eggplant will be a very important new biotech crop for India and will complement the Bt cotton hybrids that are already approved and other Bt cotton varieties being developed by both the public and

Table 10. Status of Field Trials of Biotech/GM Crops in India, 2008

No.	Crop	Organization	Transgene/Event
1.	Brinjal	IARI, New Delhi Sungro Seeds, New Delhi Mahyco, Jalna TNAU, Coimbatore UAS, Dharwad Bejo Sheetal, Jalna	cry1Aabc cry1Ac cry1Ac cry1Ac cry1Ac cry1Fa1
2.	Cabbage	Nunhems, Gurgaon Sungro Seeds, New Delhi	cry1Ba and cry1Ca cry1Ac
3.	Castor	Directorate of Oilseeds Research (DOR), Hyderabad	cry1Aa and cry1Ec
4.	Cauliflower	Sungro Seeds, New Delhi Nunhems, Gurgaon	cry1Ac cry1Ac, cry1Ba and cry1Ca
5.	Corn	Monsanto, Mumbai	Mon89034, NK603
6.	Groundnut	ICRISAT, Hyderabad	Rice chit and DREB
7.	Okra	Mahyco, Mumbai Sungro Seeds, Delhi Bejo Sheetal, Jalna Arya Seeds, Gurgaon	cry1Ac cry1Ac cry1Ac CP-AV1
8.	Potato	CPRI, Shimla NCPGR, Delhi	RB ama1
9.	Rice	IARI, New Delhi TNAU, Coimbatore MSSRF, Chennai DRR, Hyderabad Mahyco, Mumbai Bayer CropScience, Hyderabad Avesthagen	cry1Aabc, DREB, GR-1 & GR-2 (Golden Rice) chi11 MnSOD cry1Ac cry1Ac, cry2Ab cry1Ac, cry1Ab, bar NAD9
10.	Tomato	IARI, New Delhi Mahyco, Mumbai Avesthagen	antisense replicase, osmotin, DREB cry1Ac NAD9

(Source: Indian GMO Research Information System (IGMORIS), 2008 and Department of Biotechnology, 2008)

private sectors in India. Biotech crops in development by the public sector include the following 15 crops: banana, cabbage, cassava, cauliflower, chickpea, cotton, eggplant, mustard/rapeseed, papaya, pigeon pea, potato, rice (including basmati), tomato, watermelon and wheat. In addition, the private sector in India has the following nine biotech crops under development:

Picture 10. Bt cotton field ready for rich harvest

cabbage, cauliflower, cotton, maize, mustard/rapeseed, okra, pigeon pea, rice, and tomato. There are now 10 biotech crops in field trials in India and these are listed in Table 10. In India, an estimated 12 million farmers grow over 6 million hectares of maize – India is the fifth largest maize country in the world after the USA, China, Brazil and Mexico. Clearance was given recently by the Indian Government for field trials of stacked traits maize (MON89034, NK603) which, subject to regulatory approval could be deployed commercially within 5 years.

It is clear that India will be in a position to commercialize several biotech food crops in the near term, thus an awareness initiative to inform the public of the attributes of biotech crops is both timely and important. A recent survey by the Indian Institute of Management (IIM, 2007) addressed the issues of consumer awareness, opinion, acceptance and willingness to pay for GM foods in the Indian market place. The survey, conducted by IIM, Ahmedabad in collaboration with Ohio State University, revealed that 70% of India's middle class is prepared to consume genetically modified food. The study also revealed that on average, consumers were willing to pay 19.5% and 16.1% premiums for Golden Rice and GM edible oil, respectively. The study suggested that consumer education societies, government ministries, and food companies create awareness about GM foods amongst Indian consumers.

Experiences of Bt Cotton Farmers in India

Experience of three Bt cotton farmers from Andhra Pradesh:

Mrs. Aakkapalli Ramadevi, is a woman cotton farmer from Thimmampeta Village, Duggondi Mandal of Warangal District, Andhra Pradesh, India. She is a typical small and resource-poor farmer who owns only 3 acres of land (1.3 hectares) in her village. Prior to the introduction of Bt cotton she said that:

"My entire family had to stay in the farm and we had to spend 50% of the yield on pesticides alone. The yields were very low and used to incur losses, so we were perpetually losing money. Our family suffered a great deal and I had to go for labor work. My children also worked in the farm. We always looked forward to the rice distributed by government public distribution system. To sum it up, we were very badly off and not able to afford anything properly."

"Initially, I used to hate Bt cotton because there were NGOs who protested very loudly against Bt cotton. NGOs were pulling out any trials planted in the farms. Despite the protest, the good effects of the technology were very visible and I noticed it. I decided to experiment with it since I observed that it was able to control pests and reduce spraying considerably. I could also see the benefits being reaped by fellow farmers and the profits that were coming with usage of Bt cotton. I somehow managed to convince my husband and told him that it was worth a try. Due to financial reasons I couldn't get into agriculture but in 2005-06, I got into it with determination and planted Bt cotton in three acres.

First and foremost, our yield increased drastically. We got a profit of Rupees 10,000-15,000 per acre. The work in the farm decreased a lot bringing comfort. Because I also work as a daily wage-worker for 10-12 days in a month, I am able to also earn additional Rs. 500-600 per month. Now I am able to send my boy to school and actually spend some additional money on his new education per year. Finally, cotton cultivation has actually turned profitable" (Ramadevi, 2007).

Mr. Bolla Kumara Swamy is a seasoned cotton farmer cultivating cotton for the last 12 years. He lives in Sivaji Nagar Village, Duggondi Mandal, Warangal District of Andhra Pradesh.

"I have been cultivating cotton for the last 12 years. During non-Bt days I was spraying chemicals on cotton for 15-20 times, of that 14 -16 rounds were exclusively for controlling Spodoptera and pink bollworm costing more than Rs. 6,000 per acre. The average yields were not crossing 5-6 quintals per acre, and I was not able to meet the expenses of the input cost.

I cultivated Bt cotton seeds for the first time during 2003, and my pesticide spraying reduced considerably to 2-3 rounds for sucking pest and 2 more rounds on Spodoptera. The average yield increased to 11 quintals per acre, apart from a net savings of Rs. 4,000 on pesticide costs. During 2006 and 2007, I went for Bt cotton in three acres and got 40 quintals. With the income earned from Bt cotton cultivation over the years, I installed a pipe line for irrigating the rainfed land and constructed a small house in 2006.

In 2007, I cultivated BG®II cotton hybrids on two acres, and because of better retention of bolls, I got 2-3 quintals more yield per acre when compare to BG®I cotton hybrids. In addition, I also got an additional savings of Rs. 1,200 from reduced pesticide application cost" (Swamy, 2008).

Mr. Chinthi Reddy Vijeyandhar Reddy has been cultivating cotton on 7 acres of land for the last 15 years. He is from a small village 'Kantathmakur', Parakal Mandal, Warangal District of Andhra Pradesh.

Picture 11. Chinthi Reddy with his wife and daughter in their pucca house, Andhra Pradesh

"During non-Bt cotton days the average pesticide cost used to range between Rs. 5,000-6,000 per acre. We suffered both physically and mentally during those days. Because of pink bollworm attack we were not able to harvest quality yields.

For the first time I cultivated Bt cotton hybrids in 2003 and the number of sprays came down drastically to 2-3 sprays. There was a clear increase of 4 quintals yield with Bt cotton in addition to Rs. 4,000 savings in pesticides sprays. I have planted BG®II cotton hybrids this year. BG®II cotton gave me a savings of Rs. 1,000 more on pesticide sprays. The average yields of BG®II cotton was 14 quintals compared to 12 quintals in BG®I cotton hybrids.

With the income earned from Bt cotton, I send my children to private schools and purchased a two wheeler in 2006. This year, I purchased a fridge for house hold purpose and land for cattle shed construction. I am among a very few in my village who has fridge in the house. With Bt cotton cultivation, my financial situation is rapidly improving. We hope that in the future, we will get this kind of technology in vegetables as well as other technology to control weeds" (Reddy, 2008).

Picture 12. Balbir Khichad with his house full of Bt cotton harvest, Haryana

Experience of a farmer and local leader from Haryana:

Mr. Balbir Khichad is a seasoned cotton farmer and the local people representative of a small village Bansudhar located in Sirsa district of Haryana State in India. He is in his late 50's and the head of an extended family (Mukhya of Khichad) comprising 3 principals who own 52 acres of land (17 acres per person). The following is his story of cotton farming which he is proud to narrate with a smiling face.

"I started cotton farming in 1966. Over the years I grew some variety called LS-320, which used to yield a meager 4.5-5 quintal per acre. Later when I changed to LH-900 variety, I got only a marginal increase in yield. However, I had to spray near 12-15 sprays for controlling bollworm (Sundi) and some additional sprays for other insects and pests. The cotton farming was very costly.

In 1990s, my family suffered unmanageable losses as boll eating sundi invaded my cotton crop. As a result, my cotton yield reduced to just 1-2 quintal although I sprayed additional pesticides of more than Rs. 3,000 per acre. At times there was no cotton left for picking. This type of farming led to huge debts to me and my fellow farmers. We used to approach local money lenders for household needs such as marriage of children, construction of house or to do any other needs. We had to pledge our land to the money lender.

But in the last three years, Bt cotton has dramatically transformed cotton farming. I planted Bt cotton in 2005 when the government approved the same in my region. Today I am convinced that cotton farming can be profitable because my 15 acres of Bt cotton farm on an average yielded 8-10 quintals per acre in 2005. Bollworm infestation is well controlled and I needed few sprays to control sucking pests.

Last year I have planted Bt cotton in 48 acres which yielded

11-12 quintals per acre. Today I earn a net profit of around Rs. 10,000 per acre after meeting all expenses. However, my fellow farmers who are yet to adopt the Bt cotton are still running losses. Bt cotton farming has not only improved cotton farming but also changed my life" (Khichad, 2007).

Experiences of a cotton farmer and local leader from Punjab:

Mr. Gulab Singh is a cotton farmer and a village 'Sarpanch' a local people representative of Gurusar Jodha village of Muktsar district, Punjab.

"I have a total of 15 acres of land, where 12 acres is under BG®II cotton and 3 acres under BG®I cotton hybrids. BG®II cotton hybrids gave me incremental yield of 1.5 quintals per acre as compared to BG®I cotton hybrids. With BG®I, I went for 2 sprays to control Spodoptera pest, while in BG®II, I did not use a single spray for Spodoptera. I also earned an incremental income of Rs. 4,200 per acre in BG®II cotton and an additional Rs. 1,400 per acre reduction in cost of sprays. Thereby, I earned higher income of Rs. 5,600 per acre due to adoption of BG®II cotton hybrids.

Punjab farmers are thankful to Bt cotton technology that helped us to increase yields, reduced pesticides and earned higher income. Pre-Bt cotton days, we used to spray 18-20 sprays for control of bollworm. This resulted in an expenditure of Rs. 8,000-10,000 per acre. We used to incur loss from cotton crop. Now with Bt cotton, we are earning more income and as a result I bought a new Farmtrac Tractor recently" (Singh, 2008).

Experiences of a cotton farmer from Tamil Nadu:

Mr. R. Kulandai Vel cultivates cotton farm and lives in Chinna Punal Vaasal Perievu Road, Naduvalur Post, Gengavalli Taluk, Salem District in Tamil Nadu

Picture 13. Gulab Singh and his children with new tractor, Punjab

"I have been cultivating cotton for the last 25 years. I have started growing Bt cotton since its introduction in 2002. Bt cotton was very effective in controlling bollworm. However, in BG®I cotton I had to spray 2 rounds of chemicals to protect the crop from Spodoptera and I incurred around Rs. 1,700/ acre. This year, I cultivated BG®II cotton in 5 acres of land as well. What I have noticed that BG®II cotton protect my cotton crop from both bollworm and Spodoptera and I saved additional Rs. 1,700 per acre from Spodoptera sprays. As a farmer, I never got any considerable profit from ordinary non-Bt cotton. However, there has been a total turn-around with Bt cotton as I now earn higher income. Bt cotton cultivation helped me to buy additional two acres of land and I also got my son married recently. I tell my other fellow cotton farmers to cultivate Bt cotton, particularly BG®II cotton and get a good prosperous life" (Vel, 2008).

Experiences of a cotton farmer from Madhya Pradesh:

Mr. Vinod Kanhaiyalal Patidar belongs to Jhapadi

village in Maheshwar Tehsil of Khargone District, Madhya Pradesh.

"Since 2002, I have been planting Bt cotton hybrids on my field. With Bt cotton, I have experienced a drastic reduction in pesticide sprays, resulting in higher yield and quality cotton. I adopted BG®II cotton hybrids in 2007 that further increased cotton yields and better control of bollworm and Spodoptera. In 2008, I planted BG®II cotton hybrids in my entire 8 acres farm.

BG®II cotton is better than BG®I cotton, which gave me higher yields, pesticide savings and higher income. It has changed my standard of living. With the income earned, I have constructed a pucca house and introduced drip irrigation on my 8 acres farm to cultivate some vegetables. My children study in an English medium school and most importantly, I enjoy peace of mind. I no longer need to go to money lender for any loans. I have been requesting all my fellow farmers to adopt Bt cotton technology" (Patidar, 2008).

Experiences of two cotton farmers from Gujarat:

Mr. Yogeshbhai Chimanbhai Patel cultivates cotton in his farm located at Dhawat village, Karjan Taluka of Vadodara district, Gujarat.

"I have been growing cotton for the past few years but it was only after the introduction of Bt cotton that my yields have doubled. I used to harvest 6-7 quintals per acre which was almost doubled to 11-12 quintals per acre after I planted Bt cotton hybrids from 2002 onward. With BG®II technology, cotton yields have further increased up to 12-15 quintals per acre. In addition, I get approximately 50% of pesticide savings, as of now I do not have to spend much on bollworm control, which used to be my major input cost.

Bt cotton helped me to get higher yields, pesticide savings, better insect control and earn higher income, which has enabled me to purchase new four acres of land. I have also built a tube well in my farm and purchased a new tractor. I have earned the respect of my fellow farmers and I also became the Chairman of the Jai Kisan Cooperative Society last year" (Patel, 2008).

Mr. Thakurbhai Balubhai is a cotton farmer and Director of a cooperative society. He lives in Dhawat village, Karjan Taluka of Vadodara district, Gujarat.

Picture 14. Yogeshbhai driving his new tractor, Gujarat

"I have been farming for the last 20-25 years and cotton is my main crop. Before the introduction of Bt technology we used to cultivate cotton hybrid seeds. But due to severe pest pressure, pesticide expenses increased drastically and resulted in cotton farming becoming unprofitable. With the introduction of Bt cotton technology, we are very happy as we get consistent higher yields and freedom from worry of crop damage from bollworms. Bt cotton helped us to get huge pesticide savings, as pesticide sprays contribute to 70% of total pesticide expenses. I yielded more than 19 quintals

per acre with BG®I cotton this year. Bt cotton really helped me to earn a lot of income, which enabled me to purchase new tractor, build a new pucca home and also raise our standard of living. This helped me to earn more respect in my village. So I can proudly say that Bt cotton has increased farmers wealth and profit in cotton farming" (Balubhai, 2008).

Experiences of two cotton farmers from Maharashtra:

Mr. Ashok Waregade has 9 acres of land of which 5 acres is irrigated and the rest is rainfed. He cultivates cotton and owns a grocery shop in his village. He lives in Elakeli village of Yavatmal district, Maharashtra.

"I used to cultivate conventional cotton seeds on my fields. At maximum, I used to get 4 quintals yield per acre and spent between Rs. 3,000-3,500 per acre on pesticide sprays. The pesticide sprays alone was almost more than half of our total cotton cultivation costs. Thus, farming cotton with conventional seeds was a complete loss.

In 2004, first time I cultivated Bt cotton on my farm. I harvested yield of 9 quintals per acre and pesticide expenditure was reduced. I saved Rs. 2,500 on pesticides in addition benefiting from higher yields. I had to incur Rs. 1,000 per acre sprays to control other pests. Bt cotton farming became profitable for me which was not the case for dry land farmers like me who had no option but cultivate cotton on my farm.

In 2006, I planted BG®II cotton seeds which controlled all kind of bollworms. I saved Rs. 4,000 in total on pesticide sprays and yields increased to 12-14 quintals per acre. With the additional income, I was able to marry-off my daughter and I also opened a general store shop for my younger brother in the village. I am also planning to open a small business for my son" (Waregade, 2008).

Picture 15. Ashok Waregade with his family and bounty of Bt cotton, Maharashtra

Mr. Krushan Rao Bhanderkar is from Wardha district of Maharashtra.

"I have been doing farming for the last 20 years and been planting cotton for the last 15 years. Before 2004, I used to cultivate conventional cotton seeds and my yield was maximum 3-4 quintals per acre. The pesticides cost was between Rs. 3,000 - 4,000 per acre. Due to a lot of farming expenses, I was getting financially weaker.

In 2004, I cultivated my farm with Bt cotton which effectively controlled bollworms and increased cotton yields. Cotton yield jumped to 9-10 quintals per acre. Due to the good quality cotton, I also got a good market price for my cotton and earned an income of Rs. 19,000-20,000. With this income, I constructed a pucca house in my farm.

In 2007, I learned that BG®II cotton controls all types of bollworms. I planted BG®II cotton hybrids in 2007 when a pest called Spodoptera created havoc in soybean crop in Vidarbha, but no damage was seen on my BG®II cotton farm. This year, I am fully confident of getting a higher yield of 13-14 quintals per acre and if good market price

prevails I should earn around Rs. 30,000 this year as well.

"Bt cotton is a blessing in disguise for the farmers in Vidarbha region. This year, I have planned to install drip irrigation system in my field and also purchase one motorcycle. I will utilize some money for my children's education. I am very happy as my financial situation is improving" (Bhanderkar, 2008).

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