

Celebrating
10 years

**Socio-Economic and
Farm Level Impact of
Bt Cotton in India,
2002 to 2010**

by

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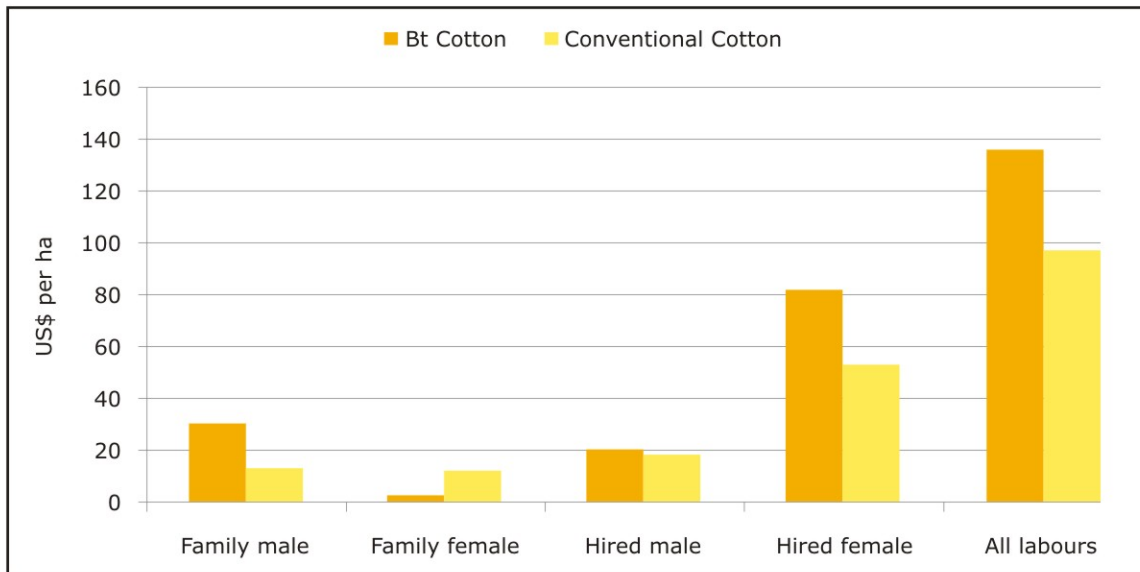
Summary

A legion of referenced and compelling independent studies confirm that Bt cotton has transformed cotton production in India by increasing yield, decreasing insecticide applications and through welfare benefits that contributed to the alleviation of poverty for 6.3 million small and resource-poor farmers in 2010 alone; the potential of biotech cotton in India for the future is enormous (James, 2010). The annual global study of benefits generated by biotech crops, conducted by Brookes and Barfoot (2010), estimates that India enhanced farm income from Bt cotton by US\$7.0 billion in the period 2002 to 2009 and US\$1.9 billion in 2009 alone. Typically, yield gains are approximately 31%, a significant 39% reduction in the number of insecticide sprays, leading to an 88% increase in profitability, equivalent to a substantial increase of approximately US\$250 per hectare (Gandhi and Namboodiri, 2006).

Impact and Benefits from Bt Cotton in India

In 2010, researchers at the University of Warwick published a research paper entitled “GM crops and gender issues” and another new report “The Impact of Bt Cotton on Poor Households in Rural India” taking into account the use of a microeconomic modelling approach and comprehensive survey data from India to analyse welfare and distribution effects in a typical village economy – this study places much more emphasis on the welfare benefits than the previous eleven socio-economic studies conducted from 1998 to 2009, (detailed later) which place more emphasis on direct benefits related to productivity of Bt cotton. The Warwick study noted that the use of Bt cotton in India has produced massive gains in women's employment and income in the country. “Planting of insect-resistant *Bacillus thuringiensis* toxin cotton generated not only higher income for rural workers but also more employment, especially for hired female labor,” reports the study (Subramanian, 2010). The report concluded that, Bt cotton generates additional employment, raising the total wage income by US\$40 per hectare, as compared with conventional cotton (Figure 1). The study also reported that since Bt cotton was introduced in India in 2002, higher yields compared with conventional cotton have led to additional labor employed to pick the increased production. The study reported that employment for cotton picking increased significantly for hired females who benefited 55% more than male laborers, which translates to about 424 million additional employment opportunities for female earners for the total Bt cotton area in India (Subramanian, 2010). The study noted that Bt cotton also improved female working conditions since less family male labor was needed for scouting and spraying for pests, making that labor available for other household economic activities traditionally done by female family members. Finally, the study concluded that the “overall, Bt cotton enhanced the quality of life of women through increasing income and reducing 'femmanual' work” (University of Warwick, 2010; Subramanian, 2010).

Figure 1. Returns to Labor from Bt Cotton and Conventional Cotton in Rural India, 2010



Source: Adopted from Subramanian, 2010

In addition to the 2010 Warwick Study referred to above, a collection of twelve other economic studies on the impact of Bt cotton, all conducted by public sector institutes over the period 1998 to 2010, covering both pre and post-commercialization of Bt cotton are referenced chronologically in Table 1. The first three studies were based on two sets of data to estimate the overall economic advantage of cotton including a field trial data set for 1998/99 to 2000/01 from the Department of Biotechnology analyzed by Naik (2001) and the second set was an ICAR field trial data set for 2001-2002 analyzed and published by ICAR (2002) and Qaim (2006). The other eight studies/surveys were conducted on large numbers of Bt cotton farmers' fields between 2002 to 2007, by different public sector institutions listed in Table 1. The studies have consistently confirmed 50 to 110% increase in profits from Bt cotton (compared with conventional), equivalent to a range of 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 ranged usually from 30 to 60% and the reduction in number of insecticide sprays averaged 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 during the eight year period 2002 to 2009.

Pre-commercialization Bt cotton data analyzed by Naik (2001) indicated that the overall economic advantage of Bt cotton in 1998/99 ranged from US\$76 to US\$236 per hectare, equivalent to an average 77% gain, compared with conventional cotton. Naik reported a 38% yield increase and 75% reduction in numbers of insecticides spray on Bt cotton over non-Bt counterparts.

Table 1. Twelve Studies Conducted by Public Institutes on the Benefits of Bt Cotton in India for the Years, 1998 to 2010.

Publication	1Naik 2001	2ICAR field 2002	3Qaim 2006 trials	4Bennet 2006	5IIMA 2006	6ICAR FLD 2005	7Andhra Unive 2006 2006	8CESS 2007 -rsity	9Subra- manian 2009	10Sada- shivappa & Qaim 2009	11Qaim et al. & Qaim	12Subra manian 2009& Qaim 2010
Period	1998	2001	2001	2002 &	2004	2005	2006	2004	2004	2006	1998	2006
Studies	-99 & 00-01		-2002	2003				-05	-05	-07	-06	-07
Yield	38%	60	34%	45	31%	30.9%	46%	32%	30	43%	37%	43%
increase		-90%		-63%					-40%			
Reduction	4 to 1	5-6 to	6.8 to	3 to	39%	-	55%	25%	50%	21%	41%	21%
in no. of	(75%)	1 spray	4.2	1								
spray		(70%)	(50%)									
Increased	77%	68%	69%	50% or	88%	-	110%	83%	-	70%	89%	134%
profit				more								
				gross								
				margins								
Average	\$76 to	\$96 to	\$118/	-	\$250/	-	\$223/	\$225/	\$156/	\$148/	\$131/	\$161/
increase	\$236/	\$210/	hectare	hectare	hectare	hectare	hectare	hectare	hectare	hectare	hectare	hectare
in profit/	hectare	hectare							or more	or more	or more	or more

Source: Compiled by ISAAA, 2010

The ICAR (2002) data set from large scale field trials in 2001 reported that the economic advantages for three Bt cotton hybrids (MECH-12, MECH-162 and MECH-184) tested under the All India Coordinated Cotton Improvement Project (AICCIP) from 1998/99 to 2000/01 was relatively high due to severe pest infestations confirming efficacy of Bt technology for targeted insect pests. The overall economic advantages of the three Bt hybrids ranged from US\$96 to US\$210 per hectare – a 29% to 86% increase compared to conventional cotton. Qaim (2006) analyzed multi-location field trials data generated by Mahyco and showed similar economic benefits – a 50% reduction in the number of sprays, a 34% yield increase resulting in a net profit of US\$118 per hectare. The magnitude of the economic advantages reported by Qaim (2006) was of the same order of magnitude as the 1998/99 data set analyzed by Naik (2001), and ICAR field trials data (2002). These pre-commercialization studies confirmed that Bt cotton resulted in a major economic advantage to cotton farmers by substantially increasing yield, reducing insecticide sprays and reduction in labor costs.

The first on-farm study by Bennett et al. (2006) confirmed that the principal gain from Bt cotton in India was 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 farm 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 reported a similar range of benefits, acknowledging that benefits will vary from year to year due to varying levels of bollworm infestations. The study by Gandhi and Namboodiri (2006), reported a yield gain of 31%, a significant reduction in the number of 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 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 a 66.3% increase over open-pollinated cotton varieties (OPV). Data in the study covered 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 (2006) 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. A 2007 study “Socioeconomic impact of Bt cotton”, conducted by the Centre for Economic and Social Studies (CESS), Hyderabad concluded that the Bt cotton technology was superior to the conventional cotton hybrids in terms of yield and net returns. The study was carried out in four districts; Warangal, Nalgonda, Guntur and Kurnool in Andhra Pradesh representing the four agro-climatic zones in 2004-2005, 2005-2006, and sponsored by the Andhra Pradesh Netherlands Biotechnology Program (APNBP) now known as Agri Biotechnology Foundation – a part of Seventh Framework Program of the European Union. Whereas the absolute cost of production for Bt cotton was 17% higher, the study reported that the expenditures on insecticides decreased by 18% (from 12 sprays on non-Bt cotton to 9 sprays) yield increased by 32% resulting in the overall cost of cotton per quintal decreasing by 11%. Thus, as a result of higher yield and reduced pesticide sprays, Bt cotton farmers improved their net income by 83% over non-Bt cotton. The study confirmed that Bt cotton generated 21% higher labor employment than non-Bt cotton of which female laborers were the major beneficiaries among casual laborers. The study concluded that small farmers elected to plant Bt cotton, rather than conventional because it was more profitable and allowed them and their families to enjoy improved living standards.

A recent paper “*Village-wide effects of agricultural biotechnology: The case of Bt cotton in India*”, featured a case study by Subramanian et al. (2009). The study analyzed the economy-wide effects of Bt cotton for rural households in semi-arid India. The study showed that Bt cotton technology increased yield between 30-40% and reduced insecticide quantities by about 50% on average, thus generating an additional income of US\$156 per hectare or more. More specifically, Bt cotton was associated with a substantial overall generation of rural employment with important gender implications. They concluded by noting that Bt technology generated more employment for females than males, ***“The aggregation of total wage income showed that females earned much more from Bt cotton than males. This was due to the fact that cotton harvesting is largely carried out by hired female laborers, whose employment opportunities and returns to labor improve remarkably. Pest control, on the other hand, is often the responsibility of male family members, so that Bt technology reduced their employment in cotton production. On average,***

the saved family labor could be reemployed efficiently in alternative agricultural and non-agricultural activities, so that the overall returns to labor increased, including for males. Similarly, studies published by Sadashivappa et al. (2009) (which analyzed Bt technology performance over the first five years of adoption, using panel data with three rounds of observations) concluded that on average, Bt adopting farmers realized pesticide reductions of roughly 40%, and yield advantages of 30-40% resulting in a higher net profit of 70% or US\$148 per hectare, or more.

Moreover, the recent studies by Qaim et al. (2009) analyzed the socio-economic effects of Bt cotton in India and demonstrated spillover effects of Bt cotton benefits for rural households in semi-arid states – Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu. The pre and post commercialization farm surveys conducted by Qaim et al. (2009) revealed that farmers adopting Bt cotton used 41% less pesticides and obtained 37% higher yields, resulting in an 89% or US\$135 per hectare gain in cotton profits. In spite of seasonal and regional variation, these advantages have been sustainable over time. These direct benefits of Bt cotton technology have also been reported by other farm surveys conducted by public sector institutions during the period 1998 to 2006. For the first time in a systematic survey, Qaim et al. (2009), demonstrated the indirect benefits of Bt technology in India. For instance, higher cotton yields provided more employment opportunities for agricultural laborers and a boost to rural transport and trading businesses. Income gains among farmers and farm workers resulted in more demand for food and non-food items, inducing growth and household income increases in other sectors locally. Their research noted that each dollar of direct benefits was associated with over US\$0.80 of additional indirect benefits in the local economy. In terms of income distribution, all types of households benefited, including those below the poverty line. Sixty percent of the gains accrued to the extremely and moderately poor. Bt cotton also generated increased net employment, with important gender implications. Compared to conventional cotton, Bt increased aggregated returns to labor by 42%, whereas the returns for hired female agricultural workers increased by 55%. This is largely due to additional labor employed for picking cotton, which is primarily a female activity in India. As is known, women's income has a particularly positive effect for child nutrition and welfare. These studies concluded that ***“In this case, at least, there is strong evidence that the trait in this crop is already contributing to poverty reduction in the subcontinent.”***

In 2010, the University of Warwick researchers published a study referred to earlier *“The Impact of Bt Cotton on Poor Households in Rural India”* in the Journal of Development Studies analysing the direct and spill-over effects of Bt cotton on poor households in rural India. The study shows that the main beneficiaries are vulnerable farmers, whose household income gains are 134 percent higher under Bt than under conventional cotton. Concluding that Bt cotton produces important benefits in large parts of rural India, the study also demonstrate that technology adoption entails

important positive socioeconomic effects in the small farm sector as generated income gains for all types of households, including those below the poverty line. Underscoring the UN Millennium Development Goals (MDG) of halving poverty by 2015, the study concludes that GM crop applications can help reduce poverty, as such has wider implications and might further the debate about the role of agricultural biotechnology for sustainable development (Subramanian & Qaim, 2010).

The only published impact studies of Bt cotton in 2008/09 was conducted by IMRB International (IMRB, 2009) which focused on the agronomic and economic benefits. The only published study specifically on the social impact of Bt cotton was conducted by Indicus Analytics in 2007 (Indicus, 2007).

The IMRB study “Samiksha-09” sampled 4,863 farmers selected from 400 villages from 27 districts in six States and interviewed 4,860 farmers representing both BG-I[®], BG-II[®] and non-Bt cotton farmers based on 2008 cotton cultivation. The IMRB study compared the economic benefits of BG-I[®] and BG-II[®] cotton hybrids versus non-Bt cotton hybrids. The study reported a 38% incremental yield for BG-I[®] hybrids and 46% incremental yield with BG-II[®] cotton hybrids over conventional cotton hybrids in 2008. Similarly, the study reported higher saving on the cost of pesticide sprays of Rs. 1,635 per hectare (US\$36) for BG-II[®] hybrids and Rs. 909 (US\$20) for BG-I[®] cotton hybrids over conventional cotton. As a result, BG-II[®] cotton farmers earned Rs. 23,374 per hectare (US\$520) and Rs. 17,082 (US\$378) for BG-I[®] cotton farmers over conventional cotton farmers. It is noteworthy that on average BG-II[®] cotton farmers earned an additional net income of Rs. 6,292 (US\$140) over BG-I[®] cotton farmers. This is consistent with the trend for farmers to increasingly adopt BG-II[®] cotton hybrids over BG-I[®] cotton hybrids in 2008 and 2009, and it is expected that BG-II[®] cotton hybrids will replace BG-I[®] cotton hybrids in the near term. On a cost benefit analysis, the study showed that BG-II[®] cotton hybrids offered 194% return on investment compared with 158% for BG-I[®] cotton hybrids and only 93% for non-Bt cotton hybrids. The study also revealed that 90% and 91% of BG-I[®] and BG-II[®] cotton farmers, respectively, were satisfied with the performance of Bt cotton technology irrespective of whether they were large, medium, or small and marginal farmers. The IMRB estimates for the 2008 season were higher than estimates for the previous years (2002 to 2007) due to higher prices of cotton, and the higher value of the Indian Rupee versus the US dollar. The IMRB study estimated that in 2008 Bt cotton technology helped farmers to increase cotton production nationally by 72 million quintals of seed cotton (42 million bales of lint), reduced pesticide usage by Rs. 1,813 crore (US\$403 million) and earned an additional income of Rs. 16,215 crore (US\$3.6 billion).

The latest parallel study to the IMRB studies, conducted by Indicus Analytics (Indicus, 2007) focused on Bt cotton in India in 2006 – it was the first study to focus entirely 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 benefited more from visits of government and private sector extension workers and were 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, and more use of professionals to assist with births at home. Similarly, children from Bt cotton households had higher proportion of children benefiting from vaccination (67% versus 62%) and they were more likely to be enrolled/registered in school. It is noteworthy that the socio-economic advantages enjoyed by Bt cotton households were already evident in 2006 despite the fact that the first Bt cotton was only adopted in 2002. Thus, the economic benefits associated with Bt cotton was already starting to have a welfare impact in 2006 that provides a better quality of life for Bt cotton farmers and their families in India.

The 2008 ISAAA Report (James, 2008) projected that the adoption rate of Bt cotton in India in 2009 would reach more than 80%, whereas the actual level in 2009 was 81% (James, 2009) which further increased to 86% in 2010. 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 and varieties in India is expected to continue to increase only modestly in 2011 since the current level of adoption at 86% is close to optimal, however should total plantings of cotton increase significantly, then a greater gain in Bt cotton hectares would follow. Despite the unprecedented high adoption rate of 86% of Bt cotton by 6.3 million farmers, the majority of whom have first-hand experience of up to nine years of the significant benefits it offers, and the consistent high performance of Bt cotton compared with conventional, anti-biotech groups still continue to vigorously campaign against biotech in India, using all means to try and discredit the technology, including filing public interest writ petitions and pursuing litigation in the Supreme Court contesting the biosafety of biotech products.

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