

ADOPTION AND UPTAKE PATHWAYS OF BIOTECH COTTON AMONG FARMERS IN SELECTED COTTON GROWING VILLAGES OF MAHARASHTRA, ANDHRA PRADESH, AND PUNJAB IN INDIA

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HIGHLIGHTS

A study to analyze the dynamics of adoption and uptake pathways of Bt cotton among small farmers in India was conducted by the Indian Society for Cotton Improvement (ISCI). Three cotton growing states namely Maharashtra, Andhra Pradesh, and Punjab were chosen as areas of study that represent three de-marketed but distinct cotton growing zones covering irrigated, semi-irrigated, and rainfed conditions. The research was supported by the John Templeton Foundation and the International Service for the Acquisition of Agri-biotech Applications (ISAAA).

Methodology

A total of 2,400 farmers were surveyed in three States using structured interviews to gather data on socio-demographic characteristics; farm related profile; aspects of Bt cotton farming; farmers' assets and income; health and environmental issues; and adoption and uptake pathways of Bt cotton. To meet the objectives of the study, ISCI sought the assistance of cotton experts from the Central Institute for Cotton Research (CICR) to identify experienced organizations in cotton sector that will undertake Bt cotton survey. Three partners were selected for each State: Society for Sustainable Cotton Development in Ludhiana, Punjab; Shiksha Mandal in Wardha, Maharashtra; and Dr. D. Rama Naidu Vigyana Jyothi Institute of Rural Development in Hyderabad, Andhra Pradesh.

The selection of districts, blocks, and villages were based on random sampling procedures to avoid any preferences and prejudices in identifying villages for the survey. Similarly, 1,000 farmers each from Maharashtra and Andhra Pradesh were identified for interactions based on the random selection techniques and the recommendation of village elected representative. The stratification of farmers was conducted to represent

Full report is available at http://www.isaaa.org/india/media/ISCI_FullReport_Small.pdf.

uniformity in survey by selecting 10 farmers each in 10 villages of 10 *talukas* (a group of villages), from 5 districts of Maharashtra and Andhra Pradesh. In Punjab, 400 farmers were selected with 10 farmers each from 5 villages of 2 *talukas* from 4 districts.

Major Findings of the Study

The following are the key results obtained from the study:

1. The adoption of Bt cotton has been widespread across rainfed, semi-irrigated, and irrigated areas of surveyed villages in the intensive cotton growing States of Maharashtra, Andhra Pradesh, and Punjab. Most of the farmers interviewed for the survey admitted growing Bt cotton for over a long period of time, with average period of 8-9 years in Maharashtra and Andhra Pradesh; and 6-7 years in Punjab. The adoption rate of Bt cotton was more than 95% across surveyed villages in both rainfed and irrigated conditions. The adoption pattern of Bt cotton at village level was in conformity with the information on Bt cotton adoption at national level tabled in the Lok Sabha of the Parliament of India, which reported the adoption of Bt cotton to be more than 93% in 2012, the year of the survey.
2. Regardless of farm and family size and demographic profile in surveyed villages, the adopters of Bt cotton included 50% or more of smallholder cotton farmers from other backward class (OBC) category in Maharashtra whereas similar percentage were from general category in Andhra Pradesh and Punjab. The categorization of Bt cotton farmers by social structure revealed an overwhelming number of farmers especially from lower strata including OBC and Scheduled Castes/Scheduled Tribes categories who are active in farming Bt technology and are at par with general category farmers. The survey confirmed that Bt cotton is a scale neutral technology that can be offered to anyone irrespective of the farmer's social status.
3. The survey revealed that decision making in overall farming operation of cotton is dominated by male farmers across cotton growing areas in the country. However, majority of respondents acknowledged a family-wide involvement in Bt cotton farming operation with distribution of work depending on the difficulty of the farm operation. Male farmer undertakes tough task of farm operation including land preparation and spraying whereas female farmer and children are involved in weeding, picking, and cleaning operation. Notably, the survey observed an overall amicable work distribution among rural farm families resulting in happy family life, social satisfaction, and community wide acceptance.

4. Another notable revelation from the survey is the significant involvement of young farmers in cotton farming contrary to the perception that young farmers are abandoning active farming. This is not the case of Bt cotton farming at least in all three States. More than 50% of respondent Bt cotton farmers were from the lower middle age group ranging from 21 to 40 years with mean average age of all respondents was 42 years in three States.
5. The survey demonstrated the doubling of cotton yield at farm level in both irrigated and rainfed conditions. On average, Bt cotton hybrids increased cotton yield from 4-5 quintals (400-500 kg) to 8-10 quintals (800-1000 kg) per hectare in rainfed condition whereas cotton yield showed a steep increase from 10-12 quintals (1000-1200 kg) per hectare to 22-24 quintals (2200- 2400 kg) per hectare in irrigated conditions. The yield increases were attributed to multiple factors driven by the large scale adoption of Bt technology resulting in saving of losses caused by bollworm, high vigor cotton genotypes, improved cropping practices and enhanced extension services to Bt cotton growers across three States.

Notably, the country has witnessed a shift in average national yield from less than 300 kg lint per hectare which lasted for decades to 500 kg lint per hectare within 10 years of the large scale adoption of Bt cotton hybrids. The survey reported almost a doubling of cotton yield in Vidharbha area of Maharashtra from an average yield of 150 kg lint per hectare to more than 300 kg lint per hectare in 2011-12. The progressive farmers of Punjab, Maharashtra, and Andhra Pradesh reported the maximum cotton yield of 14-15 quintals (1400-1500 kg) per hectare in rainfed condition and 25-28 quintals (2500-2800 kg) per hectare in irrigated conditions.

6. Most striking finding of the survey is a noticeable decrease in the use of chemical sprays to control insect-pests in cotton field across the three States. Two important observations related to chemical sprays on Bt cotton include an average 82.8% reduction in insecticides sprays while imparting 99.3% control to American bollworms in the surveyed States. The survey in Maharashtra reported 78% reduction in insecticide sprays, 82% in Andhra Pradesh and 98% in Punjab. In some cases, farmers reported increased use of chemical sprays to control sucking pests which ranges from 2-3 sprays primarily in irrigated cotton areas of Punjab. The overall trend of insecticide usage to control bollworm decreased drastically from an annual insecticide usage of 9,410 metric tons of active ingredient in 2001-02 to 222 metric tons of active ingredient in 2011 – a 40-fold decrease. Similarly, the Central Institute of Cotton Research (CICR) reported an

annual saving of Rs. 651.3 crore (Rs. 6.513 billion or US\$108.55 million) on insecticide sprays to control cotton bollworm in 2011 alone.

7. It was observed that Bt cotton reduced and changed the composition of the cost of cultivation of cotton across three States. After the introduction of Bt cotton in 2002, the total cost of production was around Rs. 35,000 (US\$ 583) per hectare and the variation in input cost was observed marginal among states. On average, Bt cotton farmers spent around 64% of total input cost on labor including farm operation, weeding and picking as shown in Figure 1. Fertilizers and irrigation accounted for 17% of total input costs followed by 12% on Bt cotton seeds and 7% on pesticides. The cost of pesticides used to be the highest input cost prior to Bt cotton, has been reduced significantly and now ranges from 5.9% in rainfed area and 8.3% in irrigated area. This is reported to be the lowest of all input costs. The investment on Bt cotton seeds ranged from 10% in rainfed area to 15.2% in irrigated area due to variation in seed rates, gap filling, and plant population.

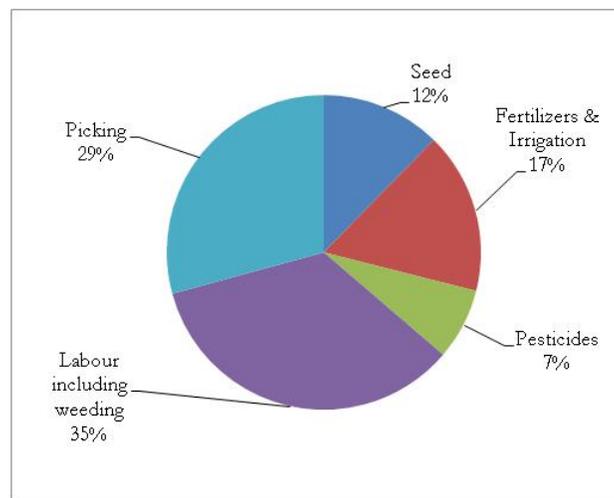


Figure 1. Input Cost Distribution of Cotton Cultivation after Bt Cotton Introduction

8. The interactions with Bt cotton farmers confirmed that more than 90% of farmers did not use non-Bt cotton packet for refuge plantings across three States. Most cotton farmers either discarded non-Bt cotton packet or sold it at a cheap price to local retailers. Remaining 10% farmers used non-Bt cotton refuge bag for gap filling and a very few percentage of them actually planted refuge around Bt cotton field. The unwillingness of farmers to plant non-Bt cotton refuge is a violation of the regulatory requirements of Bt cotton cultivation. It was observed that farmers

who received pigeonpea as refuge bag planted it along with Bt cotton particularly in Maharashtra state. Many farmers also complained about low quality of non-Bt cotton refuge bag and did not use it fearing it would attract insect pests and would result in not getting the desirable cotton yield. It is important to note that refuge bag is supplied as a non-Bt counterpart of 120 gm packaged separately in the Bt cotton hybrid seed bag.

9. None of the surveyed farmers reported the visual presence of American bollworm in Bt cotton field since the cultivation of Bt cotton in their respective fields. Farmers also reported that they stayed off insecticide sprays which used to be about 15 sprays to control American bollworm. The survey concludes that Bt cotton continues to provide effective protection against target insect-pest bollworm and there was no field level resistance development of the insect-pest to Bt. The observations on resistance management is in line with the reports of the Central Institute for Cotton Research (CICR) that has been implementing one of the most comprehensive resistance management program on Bt cotton in the world. Another finding of the survey is that majority of farmers (77.8%) across three States were growing double gene Bt cotton, more durable Bt cotton hybrids providing effective protection to insect-pests.
10. In spite of large numbers of Bt cotton hybrids approved between 2002 to 2012, cotton farmers across three States reported that they were selective in cultivating a few popular Bt cotton hybrids. The survey reported area-wise dominance of a few common Bt cotton hybrids planted across irrigated and rainfed conditions. Around 90% of the surveyed farmers were aware of denomination of Bt cotton hybrid and shared information about the brand name and seed company to which it belonged. The survey also showed a relatively quick turnabout of Bt cotton hybrids driven by farmers' preferences based on the quality and performance in the field. Punjab farmers showed a high degree of preference for new Bt cotton hybrids belonging to different seed companies such as Rasi seeds, Vibha seeds, Nuziveedu seeds, Bioseeds, Ankur seeds to Mahyco hybrid seeds. In addition, many farmers reported the unavailability of the preferred Bt cotton hybrids and in some cases they had to compromise planting of non-preferred Bt cotton hybrids in absence of pre-booked Bt hybrids with local retailers.
11. The surveyed farmers reported a substantial increase in net income in Bt cotton farming. However, farmers noted an annual fluctuation in net income of Bt cotton due to volatile market cotton prices, which fortunately remained above the Minimum Support Price (MSP) during the last couple of years, giving higher

return to Bt cotton farmers. The overall economics of Bt cotton cultivation was favorable to cotton farmers across three States. In 2011 Kharif season, the survey

reported an average net income of Rs. 41,837 (US\$697.28¹) per hectare at national level which was reported to be highest in Punjab at Rs. 52,839 (US\$880.65) per hectare followed by Rs. 39,786 (US\$663.10) in Andhra Pradesh and Rs. 35,826 (US\$597.10) per hectare in Maharashtra. Ironically, Maharashtra reported highest cost of cultivation whereas the reported yield was highest in Punjab and Andhra Pradesh (Table 1).

Table 1. Economics of Bt Cotton Cultivation in Maharashtra, Andhra Pradesh, and Punjab

	Maharashtra	Andhra Pradesh	Punjab	India
Seed cotton yield (Kg/ha)	1640	1875	2086	1867
Gross income (Rs/ha)	69,405	75,000	88,581	77,562
Cost of cultivation (Rs/ha)	36,520	35,214	35,442	35,725
Net income (Rs/ha)	35,826	39,786	52,839	41,837
*Average cotton price Rs.40-42 per kg				

12. With the positive experience of growing Bt cotton, farmers across the three States showed great interest and enthusiasm about the new technological breakthroughs in cotton. Throughout the survey, the farmers repeatedly raised the question “When will we get new ‘Bt type’ cotton”? Farmers also raised concerns about the unavailability and rising cost of labor not only for land preparation but also for weeding and picking operation throughout the cotton season. Farmers also reported that labor was becoming very expensive for farming as laborers often preferred to take advantage of the National Rural Employment Guarantee Act (NAREGA), which is much more convenient than working for eight hours in cotton farms.

13. The survey reported the absence of involvement of *Krishi Vigyan Kendras* (KVKs)—the front-line agricultural extension center financed by ICAR, and State

¹US\$1 = Rs. 60

agricultural departments in identifying and popularizing Bt cotton hybrids suitable for different areas in three surveyed States. However, farmers expressed satisfaction over handling of complaints and extension activities on Bt cotton by government agencies in recent years.

14. Most of the surveyed farmers acknowledged the contribution of progressive farmers who were the first to adopt and demonstrate the usefulness of Bt cotton hybrids. This gave rise to widespread adoption of Bt cotton by fellow farmers in three States.
15. Surveyed farmers also reported various communication and outreach activities on Bt cotton at village level by multiple stakeholders including private seed companies, dealers and retailers, media campaigns, advertisements, pamphlets distributions, and pasting of stickers about different Bt cotton hybrids across cotton villages.
16. Farmers and farm communities were the key driving force behind the quick and large scale adoption of Bt cotton across surveyed villages. The salient feature of the large scale adoption was the two-way communication channel among farmers at multiple levels including family, friends, *choupal* (gathering place), community, village, and between fellow farmers across different villages in the surveyed States.
17. The survey reported a growing understanding and interest among farmers and farm community about Bt cotton hybrids. Farmers acknowledged sharing of information about every aspect of cotton value chain, suitability, and unsuitability of Bt cotton hybrids. They shared learning about new farm practices and products in agriculture as well as the access to correct information about market price, resulting in higher income. Similarly in recent years, farmers showed keen interest in different private companies selling Bt cotton hybrids and in keeping track of new offering from news reports, advertisements in news papers, posters at community center and local bazaar. They also visited nearby KVKs to gain insight on new offering in agriculture.
18. Farmers across surveyed villages admitted that they realized for the first time, the true value of technology only after they commenced planting Bt cotton. They were convinced that technological breakthroughs can improve agriculture at farm level. Farmers voiced their support to “Bt type” technologies in agriculture and believed that technologies will play a key role in farming in the future.

19. Farmers reported to have high expectation to increase cotton yield year-after-year, after they realized a bountiful harvest due to Bt cotton hybrids over the last couple of years. However, they were concerned about not being able to increase cotton yield to a higher level due to lack of new high yielding cotton hybrids.
20. Farmers across three States echoed similar sentiments with regard to benefits of growing Bt cotton such as spending less time in the field, more time for family and doing other productive work, less exposure to pesticides, more income, and less worries about the possibilities of big losses caused by insect-pests.

Recommendations

For Farmers

1. Non-compliance of refuge is a major violation of recommended practices of Bt cotton across the country. Farmers should ensure that they plant sufficient quantity of non-Bt cotton seeds to prolong the life of this breakthrough technology.
2. Farmers should adopt and comply with the recommended practices of Bt cotton cultivation and should avoid modifications in order to obtain maximum yield potential of Bt cotton hybrids. Majority of surveyed farmers in Punjab complied with the recommended cropping practices whereas significant deviations were observed amongst the farmers of Maharashtra and Andhra Pradesh.
3. Bt cotton is a major breakthrough to control the insect pest *Helicoverpa armigera* (cotton bollworm). However, spraying of pesticides to control other insect-pests should be guided by the more objective science-based methodology of economic threshold levels to optimize cotton yield. Farmers should avoid spraying of pesticides based on the subjective assessment of visual presence which is often reported as over spraying of pesticides resulting into higher cost of production.
4. Given the availability of a large numbers of Bt cotton hybrids, farmers should exercise diligence in selecting the high yielding hybrid suitable for local agronomic conditions.
5. Farmers should also actively participate in outreach activities and should raise their understanding and awareness about cotton value chain. The major

recommendation of the survey is to empower farmers across the country with a slogan “An Alert Farmer is An Affluent Farmer”.

For Extension System

6. Cotton farmers reported the absence of farm related extension activities on Bt cotton across surveyed States. The farmers confirmed that the failure of the extension system was one of the reasons for non-compliance of refuge in Bt cotton fields. It was also reported that the weak extension system was responsible for the country-wide prevalence of confusion over the selection of suitable Bt cotton hybrids. The absence of recommended package of practices for cultivation of Bt cotton hybrids by SAUs/KVKs aggravated farmers’ woes and distress. Therefore, the survey strongly recommends that the extension system of SAUs, KVKs, State Agricultural Departments and public funded NGOs should turn on from “passive” to “active” mode and fulfill their responsibilities and duties of extension and outreach towards the farming community.
7. The extension system should be made active and functional in time bound manner and be accessible to Bt cotton farmers. The extension workers should be trained to acquire required level of skill and expertise in Bt cotton cultivation in order to properly counsel and guide Bt cotton farmers in the cotton growing areas of the country.
8. The extension system particularly SAUs/KVKs should organize field demonstration of different Bt cotton hybrids throughout the country and hold field days and fairs for farmers as well as recommend location specific Bt cotton hybrids for cultivation. This is important to overcome confusion over selection of market.
9. Bt cotton and other knowledge intensive seed technologies should be made an integral part of the annual *Kisan melas*, a farmer’s event organized by the SAUs in different parts of the country.
10. Farmers reported high expectation from the extension system in terms of demonstration of new cropping practices, innovative methods of crop intensification, and technology recommendations including ideal plant population to obtain expected yield of Bt cotton hybrids.
11. KVKs and SAUs should also seek suggestions and feedback from the farmers about their experiences in growing different Bt cotton hybrids in order to share

- correct knowledge and information about Bt cotton to a larger section of farming community.
12. Since local dealers and distributors are the most important players in dissemination, it is very important to formulate training modules similar to the one conducted for pesticide dealers. Given the important role of seed dealers and distributors, the survey recommends that the National Academy of Rural Development should formulate a short duration training course for seed dealers and distributors on the correct use of pesticides for dealers and distributors.
 13. The survey strongly recommends that SAUs should set awards and recognition for innovative cotton farmers that harvested and set a new benchmark in cotton yield at farm level.
 14. Finally, the survey strongly recommends that the country should consider collaborative extension system under public private partnership and promote hand holding of extension services of inputs companies and the public sector extension system.

For Policy Makers

15. The time has come for the Government of India, State agriculture departments, and public sector institutes to overcome public-private differences and take the ownership of Bt cotton technology for the benefits of small holders cotton farmers across the country.
16. The regulatory agencies should take another look at the conditions imposed during the commercial release of Bt cotton and incorporate a decade of experience of not planting ‘refuge’ for proper implementation of regulatory compliances at farm level. The regulatory agencies should regularly revise conditions or formulate new polices to avoid mass violation of regulatory requirements.
17. The cost of refuge paid by cotton farmers is enormous and the regulatory agencies must devise an alternative mechanism to ensure that farmers are bound to plant non-Bt cotton along with Bt cotton so as to prolong the life of this breakthrough technology.
18. The policy makers at State level should ensure that the quality and purity of Bt cotton hybrids marketed in the respective States meet the quality standard under the country’s Seed Act and corrective measures should be taken for those

supplying substandard Bt cotton hybrids to the farming community. The state agriculture departments should work in tandem with SAUs to proactively collect samples of Bt cotton hybrid seeds from the market every season to ensure quality of the supplied materials.

19. In spite of a successful decade of Bt cotton adoption, there is lukewarm attitude of elected representatives of different political parties at various levels. The survey recommends that the State should play an active role in acknowledging and popularizing the benefits of Bt cotton and should report these achievements through popular print and visual media for the public's appreciation of the positive outcomes of the technological revolution.

For Researchers

20. It is globally recognized that the durability of Bt technology would largely depend on the effective implementation of the resistance management program. The research community at Central Institute for Cotton Research has played a key role in implementing the integrated resistance management of Bt cotton and should continue their meticulous efforts on insect resistance management to safeguard Bt cotton.
21. The researchers should also devise new strategies and evaluate their proper implementation before suggesting new refuge strategy for Bt cotton hybrids in the country.
22. The researchers must fine tune the technologies for optimum use of Bt cotton keeping in view of the feedback received from farmers on seed rate, row-row and plant-plant distance, weeding technology, machine picking, and dryland suitable short duration hybrids.
23. The researchers should also suggest new ways and means to optimize crop rotation in Bt cotton cultivation areas.
24. In addition to Bt trait, the researchers must identify and work on other priority traits for cotton such as herbicide tolerant, lygus resistant, leaf curl virus resistant and drought tolerant and take up traits development on a time bound manner.

For Seed Companies

25. The private seed companies have done a commendable job in supplying Bt cotton hybrids to small holder farmers in the nook and corner of the country. Cotton hybrid was a distant dream for many farmers across surveyed States. However, many farmers have reported the quality concerns in Bt cotton hybrids supplied by selected companies. The private seed companies must strengthen quality control and purity checks and ensure that none of the substandard Bt cotton hybrid seed passes quality checks.
26. Bt technology is a breakthrough in agriculture worldwide. This kind of technology rarely enters farmers' field in developing countries. Therefore, the issues of technology stewardship and oversight should be of paramount importance for the sustainability of Bt technology in farmers' field. The private seed companies should ensure that the professionals involved in the value chain of seed production, supply, sales and marketing along with extension personnel and scientific community should continuously implement the regulatory requirements at farmers' field. The companies should also train and empower retailers, traders and farmers along with community members about the issues of stewardship that is critical for prolonging the life of Bt technology. The companies should also undertake large scale innovative extension programs for correct use of Bt technology and the new GM technologies.
27. The issues of Bt cotton hybrid seed prices have often been raised by Bt cotton farmers across the three States surveyed. Interestingly, farmers recognized the reduction of Bt cotton price over the time that allowed them to reduce the cost of cultivation. Based on interaction with farmers, the survey reported seed price of Bt cotton hybrid ranging from 10-12% of the total cost of cultivation and is one of the lowest components of the cost of cultivation of Bt cotton (Figure 1). However, the companies should ensure in the future that they should consider an amicable solution in consultation with the seed associations and suppliers in arriving at a reasonably acceptable price of such breakthrough technologies to escape public criticism and avoid unnecessary tussles with public establishments.
28. Seeing the value of this study, agronomic and socio-economic impact studies of other technologies should also be conducted prior to their commercialization. The seed companies should also ensure that these studies and their results are to be communicated to the broader section of society prior to large scale commercialization.