Adoption and Uptake Pathways of Bt Cotton in India

C.D. Mayee
Bhagirath Choudhary

October 2013

Authors details:

Dr. C.D. Mayee
President, ISCI, Mumbai
Indian Society for Cotton Improvement

&

Bhagirath Choudhary
Director, ISAAA South Asia Office, New Delhi
International Service for the Acquisition of Agri-Biotech Applications

Cover photo: Courtesy 123RF Royalty Free Stock Photos

Adoption and Uptake Pathways of Bt Cotton in India

C.D. Mayee
Bhagirath Choudhary

October 2013

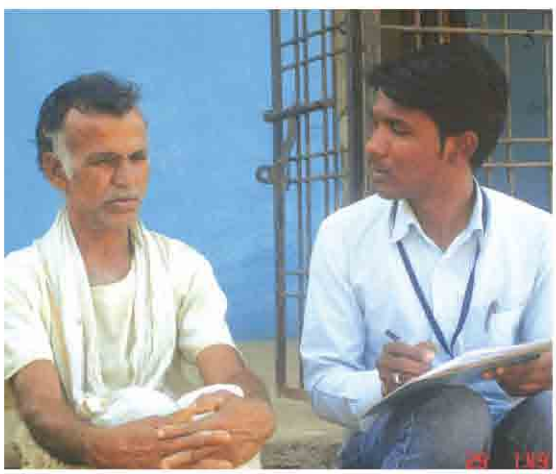
Testimonials of Small holder Bt Cotton Farmers of Maharashtra, Andhra Pradesh and Punjab


1


2


3

4


5


6

Dedicated by the authors to
Padma Bhushan Dr. B.R. Barwale

The man who envisioned the power of technology in seed sector
for the welfare of millions of Indian farmers

Caption: Dr. B.R. Barwale receiving the World Food Prize in 1998 from John Ruan III, Chairman of the World Food Prize Foundation, John Ruan, Sr. Chairman Emeritus of the Word Food Prize Foundation and Dr. Norman Borlaug, Nobel Peace Laureate and Founder of the World Food Prize Foundation.

Source: Trust in the Seed, 2008

Dr. B.R. Barwale
The Man Behind the Bt Cotton Technology in India

Dr. B.R. Barwale, who left education half way to jump in to freedom movement of the country in his youth, led another struggle to free farmers of India from recurring losses and perpetual poverty after the independence of the country. As a practicing farmer in the most backward dry land region of Maharashtra - the Marathwada region, he was guided by the vision of what the seed could do for the farmers and the nation. It is from this vision that Mahyco was born on November 11, 1964. He brought the first ever green revolution in dry land agriculture by delivering the genetics of hybrid technology and heterosis breeding through the seeds of sorghum, pearl millet and maize. Through Mahyco, he introduced the concept of production and supply of quality seed to farmers across the country. This led to expansion of seed sector as an industry for serving the farmers and the nation.

Dr. Barwale triggered the beginning of the second green revolution by bringing the "Transgenic Technology" in cotton at the door step of farmers in the form of Bt cotton, when the farmers were struggling to control the dreaded pest, American bollworms. The biotechnology coupled with the new genetics was again delivered to farmers through the seed, which revolutionized the cotton production in a short period of ten years from 2002-03 to 2011-12. As a pioneer in the seed industry, he is a stellar example of what is involved in R&D, production and timely delivery of the quality seeds of proven genetic performance. His efforts and perseverance resulted in the unprecedented growth of the Indian seed industry over last five decades and received recognition worldwide. In the citation given to honour him with the 12th World Food Prize, John Ruan, the Chairman of the World Food Prize Foundation stated, "*Mr Barwale's vision, leadership and personal efforts in the development of a private seed industry in India can be an example of what can be done in other developing countries. His entrepreneurial spirit is an inspiration to others*".

Caption: Dr. B.R. Barwale receiving the Padma Bhushan from Dr. K.R. Narayanan The President of India on 21 March 2001 at New Delhi, India.

Citation: Mayee, C.D. and Choudhary, B., 2013. Adoption and Uptake Pathways of Bt Cotton in India, Indian Society for Cotton Improvement (ISCI), Mumbai, India, Oct. 2013.

Published by: Indian Society for Cotton Improvement (ISCI), Mumbai, India.

Dr. A.J. Shaikh
Secretary
Indian Society for Cotton Improvement (ISCI)
C/o Central Institute of Research on Cotton Technology (CIRCOT)
Adenwala Road, Matunga
Mumbai – 400019, India

ISCI registration no. 31840/76

ISSN 0920-308x

Price: Rs 500/- (including postage charges for delivery within India)

Publication order: isci@rediffmail.com or charumayee@yahoo.co.in

PHOTO CAPTIONS

1. Bt cotton farmers interacting with each other in Akola District, Maharashtra
2. Bt cotton farmer in his field in Kurnool District, Andhra Pradesh
3. Bt cotton farmer in his field in Nagpur District, Maharashtra
4. Surveyor interviewing Bt cotton farmer in Wardha District, Maharashtra
5. Surveyor interviewing Bt cotton farmer in Wardha District, Maharashtra
6. Surveyor interviewing Bt cotton farmer in Wardha District, Maharashtra
7. Dr.C.D. Mayee and Dr. Arjuna Rao interacting with students in Medak District, Andhra Pradesh
8. Meeting of Templeton project team from India, China and the Philippines at CCAP, China in May 2012
9. Dr. Clive James releasing India Bt cotton survey report in Manila, the Philippines in Oct 2013
10. Training of surveyors by experts in Maharashtra
11. Interaction with Sh. Ravi Kashikar, Chairman, Ankur Seeds, Nagpur
12. Bt cotton farmer in his field in Parbhani District, Maharashtra
13. Group of Bt cotton farmers in Ranga Reddy District, Andhra Pradesh
14. Bt cotton survey India team with Atul Sharma and team of Shiksha Mandal, Wardha
15. Dr. C.D. Mayee making presentation on the findings of Bt cotton survey to AICCIP at MPUAT, Udaipur in April 2013
16. Team of Bt cotton surveyors in Andhra Pradesh
17. Surveyor interacting with group of Bt cotton farmers in Wardha District, Maharashtra
18. Bt cotton farmer in his field in Guntur District, Andhra Pradesh
19. Bt cotton farmer in his field in Nagpur District, Maharashtra
20. Surveyor interviewing Bt cotton farmer in Wardha District, Maharashtra
21. Dr. Ashok Dhawan interacting with Bt cotton farmers in Punjab
22. Surveyor interviewing Bt cotton farmer in Wardha District, Maharashtra
23. Surveyor interviewing Bt cotton farmer in Wardha District, Maharashtra
24. Bt cotton field in Nagpur District, Maharashtra
25. Dr. C.D. Mayee making presentation on the findings of Bt cotton survey during Borlaug 50 Pact meeting of BISA, CIMMYT and ICAR in August 2013,New Delhi
26. Bt cotton field in Warangal District, Andhra Pradesh
27. Group of Bt cotton farmers in Ranga Reddy District, Andhra Pradesh
28. Meeting of Bt cotton farmers in Punjab
29. Surveyor interviewing Bt cotton farmer in Wardha District, Maharashtra
30. Bt cotton field in Bhatinda District, Punjab
31. Surveyor interviewing Bt cotton farmer in Wardha District, Maharashtra
32. Meeting of Bt cotton farmers in Punjab
33. Surveyor interviewing Bt cotton farmer in Chandrapur District, Maharashtra
34. Farmer Vijay Ingle from Akola District Maharashtra making presentation during the International conference on biotech crops, Manila, the Philippines, April 2013

शरद पवार
SHARAD PAWAR

D.O. No.3025/AM
कृषि एवं खाद्य प्रसंस्करण उद्योग मंत्री
भारत सरकार
MINISTER OF AGRICULTURE &
FOOD PROCESSING INDUSTRIES
GOVERNMENT OF INDIA
21 OCT 2013

MESSAGE

The first and the only genetically engineered crop Bt cotton has been commercialized in this country in 2002. It is now over a decade that Bt cotton is being cultivated by small, medium and large farmers in different agro-climatic and soil conditions across the country. In the last 11 years the rate of adoption of this technology is considered unparalleled in the recent history of technology in agriculture sector. Commencing with just a few hectares in 2002, Bt cotton occupies nearly 93 percent of the total acreage of 12 million hectares. In spite of this, the opponents of the new technologies have not ceased the question of the wisdom of promoting Bt cotton by the Government of India. Bt cotton has also stirred an acrimonious debate on the merits and demerits of genetically engineered crops at multiple levels.

The wider adoption of Bt cotton has emerged out of sheer benefits to farmers, successful control of the dreaded bollworm pests, benefits to Indian seed industry and the nation through enhanced export and protection of environment by way of reduction in pesticide use. This, however, has not deterred those who are not directly involved in either cotton farming or general farm life to continuously drum beating against the benefits of the technology. Many of such reports have not even taken the farmer's opinion on the issue. Considering these issues, Dr. Mayee and his associates have conducted a farmer survey in 2012-2013 cotton seasons by interviewing 2400 farmers from Maharashtra, Andhra Pradesh and Punjab asking their direct opinion on Bt cotton. The report on this project has been very encouraging to note that a large number of young farmers are cultivating Bt cotton and they are the ones who are eager for adoption of new technologies. The report confirms the earlier findings by several state governments on the benefits of the new cotton and brings out several pragmatic recommendations for all the stakeholders. I am happy to share that the based on encouraging findings of this project, my Ministry has already commissioned the country-wise survey to measure the perception and the contribution of Bt cotton technology. My Ministry would also like to promote the concept of empowering farmers by adopting a knowledge led campaign of "An Alert Farmer is An Affluent Farmer".

I congratulate Dr. Mayee and his co-workers for publishing these findings for the benefit of all.

(SHARAD PAWAR)

Office : Room No. 120, Krishi Bhawan, New Delhi-110 001 Tel.: 23383370, 23782691 Fax : 23384129
Resi. : 6, Janpath, New Delhi-110 011 (India) Tel. : 011-23018870, 23018619 Fax : 011-23018609
E-mail : sharadpawar.sp@gmail.com


7


8


9


10


11

डा. एस. अय्यप्पन
सचिव एवं महानिदेशक
Dr. S. AYYAPPAN
SECRETARY & DIRECTOR GENERAL

भारत सरकार
कृषि अनुसंधान और शिक्षा विभाग एवं
भारतीय कृषि अनुसंधान परिषद
कृषि मंत्रालय, कृषि भवन, नई दिल्ली 110 001

GOVERNMENT OF INDIA
DEPARTMENT OF AGRICULTURAL RESEARCH & EDUCATION
AND
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
MINISTRY OF AGRICULTURE, KRISHI BHAVAN, NEW DELHI 110 001
Tel.: 23382629; 23386711 Fax: 91-11-23384773
E-mail: dg.icar@nic.in

FOREWORD

After a decade of cultivation of the biotech crop; Bt cotton, if somebody still puts up a question as to whether Bt cotton is successful in India, the simple answer would be 'yes' . It has indeed been successful on one count that the farmers have endorsed the technology in a vast majority, as more than 90 per cent cotton farmers cultivate Bt cotton. The kind of biotechnology generated crops in general, and Bt cotton in particular have been at the center of debate. Critics have time and again raised a number of issues against this biotech cotton in India which being devoid of scientific evidence have failed to gain ground. The single test of this is the wide spread adoption of Bt cotton in all the nine major cotton growing states. The area in 2002, when it was commercialized, was 50,000 ha which grew to more than 10,00,000 ha.

Why did farmers adopt the technology so fast? It is the freedom from 'Spray or Pray' to save cotton from bollworm attack. The technology comes as safest alternative to the previously used hazardous concoction of insecticides mixtures. Bt cotton cultivation has relieved the farmers from the arduous task of repeated sprays thereby causing pollution, allergy, ecological changes by killing the beneficial insect and disturbing the microbes.

The Indian Society for Cotton Improvement, Mumbai under its President, Dr. C. D. Mayee, Former Chairman, ASRB, has taken up the project on 'Adoption and Update Pathways of Biotech Cotton among Farmers of India' to understand directly the current perception of cotton farmers. How do they come to adopt the crop even before unknowing its benefit? Who influenced their adoption? What are the dynamics of knowledge seeking and sharing among them? The questions have been directly posed to 2400 farmers from three major cotton growing states; Maharashtra, Andhra Pradesh and Punjab. The answers to these questions shall capture the process that farmers go through as they acquire and eventually apply the knowledge and practices pertaining to cultivation of Bt cotton. The study, thus, is extremely useful in formulating models of technology transfer for cutting edge technologies which are knocking at door of farmers.

I am sure this is the first authentic account of field realities, elegantly brought out by Dr. C.D. Mayee, with his life long association with the Coop. I congratulate Dr. C. D. Mayee and the ISCI for doing an excellent job of bringing the report on this study for benefit of all.

(S. Ayyappan)

Place : New Delhi
Date : 3rd August, 2013


12


13


14


AL GROUP MEETING
TED COTTON IMPROVEMENT PROJECT
Y OF AGRICULTURE AND TECHNOLOGY, UDAIPUR
RICULTURAL RESEARCH, NEW DELHI
10th April 2013
15


16

PREFACE

The Indian Society for Cotton Improvement (ISCI), Mumbai - an apex cotton society in the country was in a dilemma as to how it can make a meaningful contribution to the socio-economic research and extension activities of Bt cotton in rainfed cotton growing areas of the country. When the members were convinced that such research projects should be included in the mandate and objectives of the society, we were invited by the International Service for the Acquisition of Agri-biotech Applications (ISAAA) to be a part of the Asia project on *"Adoption and Uptake Pathways of GM/Biotech Crops by Small-Scale, Resource-Poor Asian Farmers: Comparative Studies in China, India and the Philippines"* supported by John Templeton Foundation. India is one of the three Asian countries including China and the Philippines that were identified for the implementation of the project. All three counties are growing biotech crops for more than ten years in Asia. China approved Bt cotton in 1997 followed by India planting Bt cotton in 2002 and Bt maize was approved for planting in the Philippines in 2003. Bt cotton and Bt maize are the fastest adopted crop technology in recent history in these countries. Notably, Bt cotton has already reached total saturation in terms of acreages in the last decade in India. With the precise objectives of understanding the technology uptake process and its impact, the project invited the society to undertake a scientific study on Bt cotton in India. The idea of studying the adoption and uptake pathways of Bt cotton in India presented an opportunity for the society to assess the performance and spread of Bt cotton and gain insights as to how, why, when, where farmers accept new technologies. The society, therefore, decided to accept the project as an Asian partner for a broader comparison of adoption and uptake pathways of biotech crops in India, China and the Philippines.

The project gave the society an opportunity to interact with 2400 farmers across three major cotton growing States particularly 400 farmers in Punjab and 1000 each in Maharashtra and Andhra Pradesh. The selection of States that were surveyed was based on the criterion of intensive cotton growing areas corresponding to rainfed and irrigated situations. The project aimed at measuring the perception of farmers based on a series of questions, has been the first of its kind effort on such a large scale to understand the process of adoption and uptake pathways of Bt cotton in India. The project reminded authors of their childhood memories of working as a son of a cotton farmer who spent considerable amount of time on the seed cotton – filled bullock carts taken to the nearest cotton mandi which was 60 km away from village, for selling and returning the loan taken from a ginner. We were lucky to interview the farmers ourselves in different villages of Vidharabha area of Maharashtra. There has been a sea change in cotton production and procurement and the roles of the cotton value chain wherein ginners continue to play an important role as a creditor to cotton farmers.

The insect resistant Bt cotton imparts an effective protection against control bollworms - the most dreaded pest of the cotton in India. Bt cotton has succeeded in controlling bollworms infestation for 11 successive years and hence it was exciting to study the farmers' understanding as to how they adopted and continued with Bt cotton technology. The study, therefore, presents a new pathway of technology transfer from lab to land as and when such technologies are made available to fellow farmers in our country in the future.

Last but not the least, we were very keen to note that the findings of the survey reinforced the age old practice of field demonstration and active role of risk taking farmers as the most effective tool of wider dissemination of Bt cotton in the country. In order to recognise the contribution of knowledge sharing in the adoption and rapid uptake of Bt technology, the survey calls on the governments in developing countries and particularly in India at Central and State governments to empower farmers with a knowledge centric campaign of "**An Alert Farmer is An Affluent Farmer**", in Hindi "सर्तक किसान, समृद्ध किसान", In Punjabi "ਚੁਸ਼ਿਆਰ ਕਿਸਾਨ, ਖੁਸ਼ਹਾਲ ਕਿਸਾਨ", In Marathi "**सावध शेतकरी, सधन शेतकरी**" and in Telugu "శ్రద్ధగల రైతు సంపన్న రైతు".

C. D. Mayee
Bhagirath Choudhary

ACKNOWLEDGEMENTS

Indian Society for Cotton Improvement (ISCI), Mumbai and the Nagpur chapter of the ISCI express their sincere appreciation to the following organizations that collaborated in implementing the project in Punjab, Maharashtra and Andhra Pradesh. We extend our deep sense of gratitude to scientists and staff from our collaborative partners who devoted considerable amount of time, resources and hard work in successfully implementing the project under the guidance and supervision of Dr. C. D. Mayee, Ex-Chairman ASRB, New Delhi and President of ISCI. The society acknowledges and is grateful to the individuals of the collaborating partners including:

1. **The Society for Sustainable Cotton Development, Ludhiana, Dr. A. K. Dhawan (Punjab)**
2. **Shiksha Mandal, Wardha, Shri Atul Sharma (Maharashtra)**
3. **Dr. D. Rama Naidu Vigyana Jyothi Institute of Rural Development, Hyderabad; Dr. Arjuna Rao (Andhra Pradesh)**
4. **Central Institute for Cotton Research, Nagpur; Dr. M. V. Venugopalan, Principal** Scientist; Dr. A. R. Reddy, Senior Scientist and Mrs. Mukta Chakrabarty, Scientist (Maharashtra)

Special thanks are to Dr. Keshav Raj Kranthi, Director, CICR, Nagpur for guidance in the formulation, implementation and report writing of the project. The help and support of Ms Kadambini Gaur of ISAAA in the overall implementation of the project is duly acknowledged. The society is also grateful to Dr. S. K. Chattopadhyay, Director, CIRCOT, Dr. A. J. Sheikh, Secretary of ISCI and Dr. R. H. Balasubramanya, Joint Secretary of ISCI for support from the Mumbai office of the society. Help rendered by Ms. Rita Dhanole and Mr. P. Gokulpure of CICR in secretarial assistance is duly acknowledged. The society also acknowledges the help and support extended by Mr. Sanjay Deshpande of Mahyco. The Society is extremely grateful to the John Templeton Foundation for financially supporting the project in India. Last but not the least, the society is thankful to Dr. Clive James, Chairman ISAAA, Dr. Randy A. Hautea, ISAAA Global Coordinator and Dr. Mariechel Navarro, Director of the Global Knowledge Centre on Crop Biotechnology for extending help, guidance and support from time to time. Finally, the society is indebted to cotton farmers who participated in the survey and shared their individual experience and insight on the adoption and spread of Bt cotton in their respective areas.

TABLE OF CONTENTS

EXECUTIVE SUMMARY 1

GENERAL OBSERVATIONS AND REVELATIONS 4

STAKEHOLDER SPECIFIC RECOMMENDATIONS 10

SNAPSHOTS OF THE SURVEY 15

- Demographic and Social Profile 15
- Farm and Farming Profile 15
- Adoption of Bt Cotton 16
- Innovation Tree Exercise: Measuring Uptake Pathways 18
- Bt Cotton Cultivation Behavior 19

INTRODUCTION 21

- Indian Cotton Scenario 21
- Bt Cotton in India 22
- Rationale of the Study 23
- Objectives of the study 26
- Significance of the study 27
- Limitations of the study 28

REVIEW OF LITERATURE 30

- Current Status of GM Crops in India 31
- Social and Economic Contribution 33
- Environmental Considerations 34
- Biosafety and Environmental Safety Regulation 36

METHODOLOGY 39
- **Research Design** 39
- Location of the Study 39
- Organizational Set up for the Survey 46
- **Respondents and Sampling** 47
- **Data Collection Methods** 49
- **Farmers' Attitude and Cultivation Behavior** 49
- **Innovation Tree Exercise** 50
- **Data Codification and Analysis** 51

RESULTS AND DISCUSSION 53
- Distribution of Respondents 53
- Socio-Demographic Profile 54
- Farm Profile and Farm Holding 58
- Benefits from Adoption of Bt Cotton 71
- Economics of Bt Cotton Cultivation 79
- Cultivation Behavior of Cotton Farmers 84

INNOVATION TREE EXERCISE 87
- Uptake Pathways of Bt Cotton 87
- **Innovation Tree Exercise: Buldhana District Cluster Formation** 87
- **Innovation Tree Exercise: Akola District Village Hub Model** 90

ANALYSIS OF RESULTS 93
- **Innovation Tree Exercise** 93

CONCLUSION 99

REFERENCES 101

ANNEXURES

Annexure 1. List of Villages Selected As Sample Area for the Survey in Maharashtra 104

Annexure 2. List of Villages Selected As Sample Area for the Survey in Andhra Pradesh 107

Annexure 3. List of Villages Selected As Sample Area for the Survey in Punjab 110

Annexure 4. Questionnaire for the Survey in Maharashtra, Andhra Pradesh and Punjab 111

LIST OF TABLES

Table 1. Summary of Bt Cotton Survey Conducted in Maharashtra, Andhra Pradesh and Punjab

Table 2. Economics of Bt Cotton Cultivation in Maharashtra, Andhra Pradesh and Punjab

Table 3. GEAC's Approval for Commercial Release of Different Bt Cotton Events in India, 2002 to 2012

Table 4. Nation-Wide Adoption and Commercial Release of Bt Cotton Hybrids, 2002-03 to 2011-12

Table 5. List of Districts and Blocks/Talukas Identified as Sample Area for Survey

Table 6. Area, Number of Farmers and Sample Size for Survey of Bt Cotton in India

Table 7. Socio-Economic Profile of Cotton Farmers in Maharashtra, Andhra Pradesh and Punjab

Table 8. Farm Profile and Farm Holdings of Cotton Farmers

Table 9. Source of Capital, Farm Income and Marketing Avenues for Cotton Farmers

Table 10. Farm Activities Performed by Farmers and Their Families

Table 11. Classification of Bt Cotton Events Used by Cotton Farmers

Table 12. Dominant Bt Cotton Hybrids of Different Seed Companies in Three States

Table 13. Number of Years of Planting Bt Cotton

Table 14. Agronomic, Economic and Social Factors for Adoption of Bt Cotton by Farmers

Table 15. Mode of Adoption of Bt Cotton by Farmers

Table 16. Benefits from Adoption of Bt Cotton

Table 17. Credible Sources of Information Obtained by Farmers on Bt Cotton

Table 18. Knowledge Sharing Amongst Bt Cotton Farmers in India

Table 19. What Information/Knowledge Shared by Bt Cotton Farmers to Others

Table 20. Participation in Capacity Building Activities on Bt Cotton Technology

Table 21. Services Received and Expected in Future for Bt Cotton

Table 22. Cost of Cultivation of Bt Cotton

Table 23. Economics of Bt Cotton Cultivation

Table 24. Willingness of Farmers to Continue Cultivation of Bt cotton

Table 25. Extra Income Utilization by Bt Cotton Farmers

Table 26. Constraints in the Adoption of Bt Cotton

Table 27: Awareness About Other Biotech Crops and Traits

Table 28. Farmers Interest in Specific Traits in Future Biotech Crops

Table 29. Measuring Attitude of Farmers Towards Bt Cotton

LIST OF FIGURES

Figure 1. Average Distribution of Cost of Cultivation of Bt Cotton in Three States

Figure 2. Map of India Indicating Major Cotton Growing States Selected for the Survey

Figure 3. Map of Maharashtra Showing Districts Selected for the Survey

Figure 4. Map of Andhra Pradesh Showing Districts Selected for the Survey

Figure 5. Map of Punjab Showing Districts Selected for the Survey

Figure 6. Organizational Set Up for the Implementation of the Survey

Figure 7. Average Distribution of Cost of Cultivation of Bt Cotton in Three States

Figure 8. Uptake Pathway of Bt Cotton Among Farmers of Buldhana District, Maharashtra

Figure 9. Uptake Pathway of Bt Cotton Among Farmers of Akola District, Maharashtra

Figure 10. Uptake Patterns of the Adoption of Bt Cotton Among Farmers

CONVERSIONS

1 Bale	=	170 kg
1 Hectare	=	2.47 acres
1 US$	=	Rs. 60
1 Lakh	=	100,000
1 M	=	10 Lakh
1 Crore	=	10M

ACRONYMS

Bt	*Bacillus thuringiensis*
CAB	Cotton Advisory Board
CICR	Central Institute for Cotton Research
CIRCOT	Central Institute for Research on Cotton Technology
DOCD	Directorate of Cotton Development
EPA	Environmental Protection Act
FAO	Food and Agricultural Organization
FGD	Focus Group Discussion
GEAC	Genetic Engineering Approval Committee
GOVT	Government
IBSC	Institutional Biosafety Committee
ISAAA	International Service for the Acquisition of Agri-biotech Applications
ISCI	Indian Society for Cotton Improvement
KVK	Krishi Vigyan Kendra
MOA	Ministry of Agriculture, Government of India
SAU	State Agriculture University
Mahyco	Maharashtra Hybrids Seeds Company
NAREGA	National Rural Employment Gurantee Act
RCGM	Review Committee on Genetic Manipulation
WHO	World Health Organization

"An Alert Farmer is An Affluent Farmer"


17


18

EXECUTIVE SUMMARY

Amongst the biotech crops under development in India, Bt cotton was the first and only genetically modified crop that was approved for commercial cultivation in India in 2002. Over the eleven years period, Bt cotton stirred an acrimonious debate about the merits and demerits of genetically modified crops at multiple levels that can be characterized as follows;

- farmers enthusiastically adopted Bt cotton
- seeds growers produced sufficient quantity of Bt cotton hybrid seeds
- private companies maintained quality and supplied seeds in the nook and corner of the country
- scientific community effectively monitored resistance management
- NGOs raised some real concerns and hyped many others
- regulators continued fire-fighting on various issues and
- policy makers remained indifferent resulting in widespread general misconception of Bt technology in the country

Small holder cotton farmers drove the adoption and uptake of Bt cotton in spite of the dominance of small to medium land holdings in the majority of cotton growing area across the country. The commercial adoption of Bt cotton has been one of the most striking examples of technology diffusion in the recent history of Indian agriculture. From a mere few thousand hectares of Bt cotton in 2002 - the first year of official permission for commercialization, the technology has spread to nearly 10.8 million hectares equivalent to 93% of the total cotton area of 12.1 million hectares in 2011-12. The process of adoption of Bt cotton surpassed many controversies and hurdles of agitations, legal cases and prejudices by a section of society opposed to introduction of genetically modified crops in the country.

It is well known that the adoption and uptake pathway of Bt cotton were influenced by several factors and therefore it was necessitated to take up a study to analyze the dynamics of adoption and uptake pathway of this technology in the country. The study was conducted in India as a part of the global project *"Adoption and Uptake Pathways of GM/Biotech Crops by Small-Scale, Resource-Poor Asian Farmers: Comparative Studies*

in China, India and the Philippines" **executed by the Indian Society for Cotton Improvement (ISCI) and supported by the John Templeton Foundation. In India, the investigation was directed at adoption and uptake pathway of Bt cotton in three cotton growing states including Maharashtra, Andhra Pradesh and Punjab that represent three de-marketed but distinct cotton growing zones covering irrigated, semi-irrigated and rainfed conditions.**

To achieve the objectives of the study, ISCI conveyed meetings of cotton experts at the Central Institute for Cotton Research (CICR) in mid 2012 to identify organizations experienced in cotton sector to undertake Bt cotton survey in Punjab, Maharashtra and Andhra Pradesh respectively. Three partners were selected each for Punjab, Maharashtra and Andhra Pradesh which include the Society for Sustainable Cotton Development, Ludhiana, Punjab; Shiksha Mandal, Wardha, Maharashtra and Dr. D. Rama Naidu Vigyana Jyothi Institute of Rural Development, Hyderabad, Andhra Pradesh. A total of 2400 farmers were surveyed in three States employing a uniform method of structured interviews scheduled to gather data on socio-demographic characteristics, farm related profile, all aspects of cotton crop, farmers' assets and income, health and environmental issues, adoption and uptake pathways of Bt cotton. The selection of districts, blocks and villages were based on the random sampling procedures to avoid any preferences and prejudices in indentifying villages for the survey. Similarly, 1000 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 were done to represent uniformity in survey by selecting 10 farmers each in 10 villages each of 10 talukas from 5 districts of Maharashtra and Andhra Pradesh. In Punjab, 400 farmers were selected with 10 farmers each from 5 villages each of 2 talukas from 4 districts. Sh. Atul Sharma of Shiksha Mandal, Wardha led the survey in Maharashtra whereas Dr. Arjuna Rao of Dr. D. Rama Naidu Vigyana Jyothi Institute of Rural Development and Dr. A.K. Dhawan of the Society for Sustainable Cotton Development executed the survey in Andhra Pradesh and Punjab respectively. A summary of Bt cotton survey conducted in Maharashtra, Andhra Pradesh and Punjab is enumerated in Table 1.

Table 1: Summary of Bt Cotton Survey Conducted in Maharashtra, Andhra Pradesh and Punjab

State	Principal investigator	Collaborating institute	Districts identified	Taluka's surveyed	Nos of village visited	Nos of farmers surveyed
Maharashtra	Sh. Atul Sharma	Shiksha Mandal, Wardha	5	20	100	1000
Andhra Pradesh	Dr. Arjuna Rao	Dr. D. Rama Naidu Vigyana Jyothi Institute of Rural Development, Tuniki Village, Medak	5	12	100	1000
Punjab	Dr. A.K. Dhawan	Society for Sustainable Cotton Development, Ludhiana	4	10	40	400

Dr. C.D. Mayee and Mr. Bhagirath Choudhary frequently visited collaborating institutes, trained surveyors and monitored the execution of survey in three States. The data generated during the survey were compiled and codified with the help of trained personnel of ISCI office located at CICR, Nagpur. Subsequently, the data were suitably compiled and analyzed for understanding the reasons of Bt cotton adoption in diverse agro-climatic conditions in the villages surveyed in three States. Simultaneously, the innovation tree exercise was carried out especially in two villages of Maharashtra to understand factors responsible for driving the uptake pathways of Bt cotton in the Vidharabha area of Maharashtra. The adoption, cultivation behavior and uptake pathways were analyzed in two cotton growing situations based on group interactions with 250 farmers. The outcome of the survey is divided into two sets of recommendations; general observations & revelations and stakeholder specific recommendations, which are described as below;

GENERAL OBSERVATIONS AND REVELATIONS

First, 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 over a long period of time, in most cases 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 surveyed year.

"Bt cotton technology has attracted young farmers to cotton farming across the surveyed States".

Second, irrespective of farm and family size and demographic profile in surveyed villages, the adopters of Bt cotton included 50% or more small holder 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 SC/ST category who were active in farming adopted Bt technology at par with general category farmers. The survey confirmed that Bt cotton is a scale neutral technology that offers similar level of protection to dreaded bollworm irrespective of who cultivates Bt cotton.

Third, there is gender bias in decision making in overall farming operation of cotton by male farmers across cotton growing areas in the country. However, majority of the respondents acknowledged a family-wide involvement in Bt cotton farming operation with distribution of work depending on the severity of the farm operation. Male farmer undertakes tough task of farm operation including land preparation and spraying whereas female famer 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.

Fourth, Bt cotton technology has attracted young farmers to cotton farming across the surveyed 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.

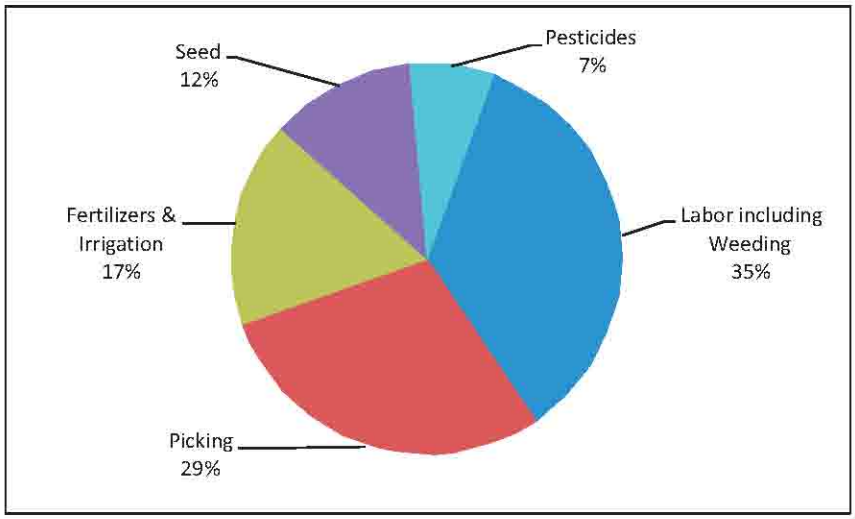
"Bt cotton technology is equally useful for small and large farmers across rainfed and irrigated areas".

Fifth, Bt cotton contributed to 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 per hectare to 8-10 quintals per hectare in rainfed condition whereas cotton yield showed a steep increase from 10-12 quintals per hectares to 22-24 quintals per hectares 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 vigour 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 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 per hectares in rainfed condition and 25-28 quintals per hectares in irrigated conditions.

Sixth, there was a noticeable decrease in chemical sprays to control insect-pests in cotton field across the three States. Two important observations related to chemical sprays on Bt cotton included an average 82.8% reduction in insecticide sprays while imparting 99.3% control to American bollworms in the surveyed States. Farmers in Maharashtra reported 78% reduction in insecticide sprays whereas 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 9410 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 Rupees 651.3 crore on insecticides sprays to control cotton bollworm in 2011 alone.

Seventh, Bt cotton reduced and changed the composition of the cost of cultivation of cotton across three States. In the post-Bt cotton period, the total cost of production was around Rs. 35,000 per hectare and the variation in inputs cost was observed marginal among states. On an average, Bt cotton farmers spent around 64% of total inputs cost on labor including farm operation, weeding and picking as shown in Figure 1. Fertilizers and irrigation accounted for 17% of total inputs costs followed by 12% on Bt cotton seeds and 7% on pesticides. The cost of pesticides which used to be the highest input cost prior to Bt cotton was reduced significantly and now ranges from 5.9% in rainfed area and 8.3% in irrigated area, which is reported to be the lowest of all input cost. 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. Average Distribution of Cost of Cultivation of Bt Cotton in Three States



Eighth, Bt cotton farmers confirmed that more than 90% of farmers did not use non-Bt cotton packet for refuge plantings across three States. It was shocking to note that most of the cotton farmers either discarded non-Bt cotton packet or sold it at a cheap price to local retailers. The remaining 10% of 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 didn't use it fearing it would attract insect-pests and would not produce desirable cotton yield. It is important to note that refuge bag is supplied as a non-Bt counterpart of 120gm packaged separately in the Bt cotton hybrid seed bag.

Ninth, there was no reported visual presence of American bollworm in Bt cotton field since the cultivation of Bt cotton in their respective fields. Farmers also reported that they staved off insecticides sprays which used to require about 15 sprays for the control of American bollworm. Bt cotton continued to provide effective protection against targeted insect-pests bollworm and there was no field level resistance development of the insect-pests to Bt cotton. The observations on resistance management was 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 was that majority of farmers (77.8%) across three States were growing double gene Bt cotton, the more durable Bt cotton hybrids providing effective protection to insect-pests.

"Bt technology has decreased pesticides usages, increased cotton productivity and increased farmers' income and contributed significantly to poverty alleviation".

Tenth, in spite of large numbers of Bt cotton hybrids approved between 2002 to 2012, cotton farmers across three State reported that they were selective in cultivating a few popular Bt cotton hybrids. There was 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 of Bt cotton hybrids 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 and Nuziveedu seeds to Mahyco, Bioseeds and Ankur 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.

Eleventh, the surveyed farmers reported a substantial increase in net income of Bt cotton farmers. 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**

per hectare at national level which was reported to be highest in Punjab at Rs. 53,139 per hectare followed by Rs 39,786 in Andhra Pradesh and Rs. 32,885 per hectare in Maharashtra. Ironically, Maharashtra reported highest cost of cultivation whereas the reported yield was highest in Punjab and Andhra Pradesh (Table 2).

Table 2. 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)	32,885	39,786	53,139	41,837
*Average cotton price Rs.40-42 per kg				

Twelfth, replete with the experience of growing Bt cotton, farmers across three State showed great interest and enthusiasm about the new technological breakthroughs in cotton in the future. Throughout the survey, the farmers repeatedly raised the question "when would we get new 'Bt type" cotton? Farmers also raised concerns about the unavailability and raising cost of labour not only for land preparation but also for weeding and picking operation throughout the cotton season. Farmers also reported that labour was becoming very expensive for farming as laborers often preferred to take advantage of NAREGA, which is much more convenient than working for 8 hours in cotton farms.

Thirteenth, the survey reported the absence of involvement of KVKs and State 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 Govt agencies in recent years.

Fourteenth, 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 before widespread adoption of Bt cotton by fellow farmers in respective three States.

Fifteenth, 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.

Sixteenth, farmers and farm community 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 level, friend's level, choupal level (gathering place), community level, village level and between fellow farmers across different villages in the surveyed States.

Seventeenth, there was 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, shared learning about new farm practices and products in agriculture and most importantly access to the 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 kept track of new offering from news reports, advertisements in news papers, posters at community centre and local bazaar and often visited nearby KVKs to gain insight on new offering in agriculture.

Eighteenth, farmers across surveyed villages realized for the first time, the true value of technology only after they commenced plantings of Bt cotton and were convinced that technological breakthroughs can improve agriculture at farm levels. Farmers voiced their support for "Bt type" technologies in agriculture and believed that technologies will play a key role in farming in the future.

Nineteenth, farmers reported high expectation in increase in cotton yield year-after-year after as they realized a bountiful harvest due to Bt cotton hybrids over last couple of years. However, they were concerned for not being able to increase cotton yield to a higher level due to lack of new high yielding cotton hybrids.

Finally, farmers across three States echoed the same sentiments about welfare benefits of growing Bt cotton in terms of spending less time in the field, more time for family and doing other productive work, less exposure to pesticides & reaped more income and were no longer worried about the possibilities of big losses of cotton by insect-pests.

STAKEHOLDER SPECIFIC RECOMMENDATIONS

For Farmers

1) Non-compliance of refuge is a major violation of recommended package of 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 package of practices of cultivation of Bt cotton 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 *Helicoverpa armigera* insect-pest, 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 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 campaign "**An Alert Farmer is An Affluent Farmer**".
In Hindi, "सर्तक किसान, समृद्ध किसान".
In Punjabi, "ਚੁਸ਼ਿਆਰ ਕਿਸਾਨ, ਖੁਸ਼ਹਾਲ ਕਿਸਾਨ".
In Marathi, "**सावध शेतकरी, सधन शेतकरी**".
In Telugu, "శ్రద్ధగల రైతు సంపన్న రైతు".

"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 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 right 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 Depts and public funded NGOs should turn on from "sleep" 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 approachable 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 of 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 and recommend location specific Bt cotton hybrids for cultivation - a must to overcome confusion over selection of desirable Bt cotton hybrids amongst a large number of hybrids available in the market.

9) Bt cotton and other knowledge intensive seed technologies should be made an integral part of the annual Kisan melas 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 intensifications and suggest packages of practices including improving plant populations to improve yield realization of Bt cotton hybrids.

11) KVKs and SAUs should also seek suggestions and feedback from the farmers about their experiences of growing different Bt cotton hybrids in order to improve the delivery of 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 courses for their training and knowledge upgradation on the similar pattern as has been done 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 pattern of course designed on the correct use of pesticides for dealers and distributors.

13) The survey strongly recommends that SAUs should commission awards and recognize 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 Govt of India, Sate agriculture depts 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 relook 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 timely revise conditions or formulate new policies 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 alternate 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 norms under the Seed Act and corrective measures should be taken for those supplying substandard Bt cotton hybrids to the farming community. The state agri depts 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 people of the country to know and appreciate 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 CICR has played a key role in implementing the integrated resistance management of Bt cotton and should continue their meticulous efforts on IRM 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 their optimum use of Bt cotton keeping in view the feedback received from farmers on seed rate, row-row & 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 in farmers' field in developing countries. Therefore, the issues of technology stewardship and oversight should be a 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 the 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 ranges 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) Finally, the interactive studies with the Bt cotton growers suggested that benefits of such technologies go beyond the intended use and therefore, it is necessary to have the agronomic and socio-economic impact studies to be thoroughly investigated whenever such technologies are to be commercialized. The seed companies should also ensure that such studies and their results are communicated to the broader section of society prior to large scale commercialization.

SNAPSHOTS OF THE SURVEY

Demographic and Social Profile

Of the 2,400 surveyed Bt cotton farmers, most of them were male farmers married with 2-3 children and fairly young across surveyed States. The average age for surveyed farmers was 39-40 years in Punjab, which was reported to be the lowest among three surveyed States. Nearly 63 per cent farmers had education upto 10th standard, which is considered literate. As per Indian social categorization for the purpose of reservations and upliftment, Punjab and Andhra Pradesh farmers by and large fell in general unreserved category. Very few cotton farmers belonged to schedule caste or schedule tribe category in Punjab and Andhra Pradesh. However, in Maharashtra where several castes are clubbed in a category called 'Other Backward Class (OBC)', had the highest respondents from this section. The survey also reported that the majority of farmers were members of some social, community based, cooperative and farmer's organization. Bt cotton farming was a dominant profession of farmers in Maharashtra whereas majority of Punjab farmers were engaged in other entrepreneurial activities such as dairy, poultry, bee keeping, mushroom and other activities whereby generating additional income for the farm families.

Farm and Farming Profile

Bt cotton farmers were seasoned cultivators as majority were in farming profession for more than 20 years. However, nearly 47% farmers of Maharashtra averaged at 16 years in farming indicating the passing of ancestral mantle to the young ones. In Punjab, more than 79% farmers were engaged in farming for more than 20 years. The average farm size was 2.6 hectare for all India, however small farm holding of 2.1 hectares were reported in Maharashtra and 3.2 hectares in Andhra Pradesh and Punjab. Farmers in Punjab had full access to irrigation whereas it was completely rainfed farming in Maharashtra and 44% of Andhra Pradesh farmers had access to either full or partial irrigation. Interestingly, majority of farmers were involved in cotton farming for more than 10 years in all three surveyed States. Average annual net income of Bt farmers from all sources ranged from Rs. 78,000 to Rs. 92,000 per annum. Punjab farmers reported highest net income of Rs 1,21,000 per annum and lowest of Rs. 69,000 per annum in Maharashtra. Farming activities were carried out mostly by male members with the help of hired labour with active support of family members in activities like weeding, picking, threshing, winnowing and storing etc.

Adoption of Bt Cotton

Although the experience of planting Bt cotton averaged five years, many farmers were ignorant about different events of Bt cotton approved for plantings in the country. Farmers across three States were aware of BG-I and BG-II Bt cotton hybrids and often paid higher price for popular hybrids of these categories due to heavy demand during the Kharif season. Nearly 85 percent of the farmers did not pay attention to which company they belonged but were able to remember the brand name because of attractive names and resemblance of these names to Goddesses.

The adoption of Bt cotton was highly influenced because of effective control of bollworm that liberated farmers from 'Pray or Spray' regimes. Additionally, the adoption was further triggered when farmers realized an enhanced yield as a consequence of effective insect-pests control coupled with better market prices after 2006-07 season. In general, the agronomic performance and economic consideration were two dominating factors that accelerated adoption of Bt cotton in India. Social factors like status in society due to use of new technology mattered among surveyed farmers in Maharashtra. However, several other factors like seeing Bt cotton demonstration, witnessing the success of fellow farmers, easy picking due to healthy bolls, reduced spraying were other factors that contributed to the adoption of new technology. Majority of farmers avoided using refuge because of the cumbersome process in planting boarder areas and imminent loss of cotton crops due to real damage of non-Bt cotton by insect-pests. Farmers showed ignorance toward the scientific rationale behind the refuge planting. Many farmers complained about low quality of non-Bt cotton refuge bag and avoided planting refuge because of perceived threat of insect-pests returning to Bt cotton field and imminent loss of cotton yield. Similarly, farmers followed the recommended package of practices of cotton cultivation however with Bt cotton hybrids they adjusted and customized their own modified packages with changed seed rate, fertilizers, pesticides, weeding and agronomic practices. Majority of the farmers from Punjab adopted the fully to partially packages of practices. The variations in implementing the recommended package of practices were observed in Maharashtra and Andhra Pradesh particularly with respect to nutrients schedule and protective irrigation.

Farmers across Maharashtra and Andhra Pradesh reported the adoption of Bt cotton based on the promotional activities of private seed companies through retailers and dealers in each district. Contrary, the government of Punjab took proactive steps to seek approval for Bt cotton for Northern region and vigorously promoted Bt cotton in Punjab. In general, the governments in Maharashtra and Andhra Pradesh were initially hesitant to take ownership of Bt cotton technology and thus dissemination of the technology was mostly undertaken by seed companies until 2007. The adoption rate of Bt cotton was so

dramatic in these States that the government and university officials realized the value of technology and resorted to the ground realities. Subsequently, the government and public sector institution teamed up and introduced an appropriate intervention and suggested the suitability of local packages of practices for different agro ecological zones. The private seed companies continued their market outreach activities and organized local 'farmers mela' - a special farmers gathering to discuss the cultivation issues and exchange their views and experiences which were attended by large number of progressive farmers. Despite these efforts, the survey revealed that only one fourth of the total farmers actually participated in the trainings organized by mostly seed companies and dealers. Farmer to farmer dissemination of information greatly influenced the uptake of the technology in three surveyed States. The experiences of farmers indicated that once farmers planted Bt cotton seeds they continued sowing year-after-year with very high repeat adoption of Bt cotton hybrids across three States. During the survey, a large number of farmers, around 70% showed keen interest in attending training, seminars, exhibitions and workshops on Bt technology and their expectations need to be met by large scale extension activities of SAU's and govt extension services in the future.

The private seed industry, fellow farmers, retailers and to a lesser extent public extension system influenced the farmers to take up Bt cotton cultivation. However, the most influential factor in the adoption of Bt cotton was "seeing is believing" of Bt cotton demonstration fields. Fellow farmers, neighboring farmers and small farmers visited Bt cotton field of progressive farmers while progressive farmers visited Bt cotton field demonstration organized by private companies in respective areas. The judgment of individual farmers was the key driver of the adoption of Bt cotton across various States. The farmers received credible information from private seed companies and other progressive farmers of the village and information mostly concerned on inputs which they shared with fellow farmers and retailers.

On the whole, there was a limited support extended to Bt cotton farmers by banks, cooperatives, retailers and dealers mainly for initial capital for farming. The survey found that a group of cotton ginners have been to some extent at the forefront to provide support in terms of initial capital to cotton farmers. Most of the surveyed Bt cotton farmers expected a great deal of support for credit, investment and technical knowledge for cotton farming. Farmers demanded access to irrigation across the State of Maharashtra and to some extent in Andhra Pradesh. Notably, farmers expressed tremendous dissatisfaction over the rising cost of labour for weeding and picking and were furious about the unavailability of the labor during the peak cotton season, which they used to get easily in the past.

It is noteworthy to report that the efforts of farmers paid a rich dividend and culminated

into decreasing cost of cultivation of Bt cotton and substantially increasing net income across rainfed and irrigated areas. The survey revealed that the net income from Bt cotton cultivation ranged from Rs. 32,885 to Rs. 53,139 per ha. The maximum net income was reported by farmers in Punjab whereas farmers in Andhra Pradesh reported average net income of Rs. 39,786 per ha. On the contrary, many farmers expressed dissatisfaction over cost of seed, lack of quality seed, lack of technical support and low market price at the time of harvest. Bt cotton farmers also expected support from government agencies towards cotton crop at par with food crops. Despite these challenges, farmers across cotton growing areas continued to grow Bt cotton and expressed their desire to have access to cotton products that are tolerant to different traits in order of their priorities including weeds, leaf curl virus, diseases and drought stress.

Innovation Tree Exercise: Measuring Uptake Pathways

The Innovation Tree Exercise was successfully conducted in one village each in Buldhana and Akola district of Vidharbha, Maharashtra. The initial effort to convene meeting of farmers in Wardha district was discontinued due to lack of participation from farmers and irrelevant answers to questions designed for innovation tree exercise. The farmer meetings in Buldhana and Akola were conducted with different approaches to get maximum response from the participating farmers. However, the conclusion of both meetings was almost similar on the uptake pathways of Bt cotton.

The major outcome from both meetings indicated that the starting point of the uptake pathway of Bt cotton was by the private seed company officials and technicians, Mahyco in this case, who introduced Bt cotton in both the locations by conducting large scale demonstrations in 2001 and 2002 respectively. The farm level demonstrations attracted and influenced the progressive farmers, retailers, dealers and distributors in respective locations. Fellow farmers chose to cultivate Bt cotton once they saw the benefits of Bt cotton in others field. Subsequently, farmers determinedly took up cultivation, which resulted in the penetration of Bt technology into villages. Interestingly, farmers reported the formation of "cluster" around Bt cotton in different villages in Buldhana and Akola districts. The replication of Bt cotton clusters were reported across the surveyed farmers. In the spirit to learn from the neighboring farmers, farmers in the village of Akola reported to follow the lead farmer – the first to cultivate Bt cotton and began cultivation of Bt cotton one-by-one covering the entire village in 4 years. The information from one Bt cotton cluster led to formation of cluster in another village and so on and so forth. The chain of clusters became apparent within few years of the first planting of Bt cotton in Vidharbha of Maharashtra. In essence, the demonstrations conducted by private seed companies and facilitated by progressive farmers received endorsements by public sector institutions led to the credence and prominence of Bt cotton technology across the villages by 2007. The innovation tree exercise

demonstrated that the power of technology can break the conventional discipline of technology dissemination and can reach to the poorest of the poor farmers. The adoption and uptake pathways of Bt cotton in India showed that the scalability and sustainability of new technology can be achieved with proper technology demonstration, training and awareness among farmers.

Bt Cotton Cultivation Behavior

In nutshell, the survey measured the attitude and cultivation behavior of Bt cotton farmers, revealed that nearly 90% small holder farmers were in farmer of Bt technology in irrigated and rainfed farming system. Some farmers reported yearly fluctuations in yield and timely unavailability of preferred Bt cotton hybrid seeds as constraints for further adoption. However, farmers reported the benefits of Bt cotton outweighed the constraints and majority expressed opinion that they will continue with the technology.

“सतर्क किसान समृद्ध किसान”


19

20

INTRODUCTION

Indian Cotton Scenario

Cotton is an immensely important crop for the agriculture economy of India. It is also recognized as one of the most preferred commercial cash crop ensuring the livelihood of millions of small holder cotton farmers in the country. Of the 32 million hectares of cotton crop globally, India represents one third of the total cultivated cotton area of 12 million hectares in 2012. India accounts for 21% of the global cotton produce, currently ranking second after China. India's contribution to global cotton production increased from 14% in 2002 to 24% in 2011-12. The production increased from a meager 2.3 million bales (170 kg lint/bale) in 1947-48 to a previous record production of 17.6 million bales in 1996-97 and an all time highest record of 35 million bales during 2011-12. Cotton contributes about 65% of the total raw material needs of textile industry in India. Cotton and textile exports account for nearly one-third of total foreign exchange earnings each year at a recent estimate of US$ 20,000 million. India has achieved significant breakthrough in cotton yarn exports besides increasing its global market share in cotton textiles and apparels. Cotton provides employment and sustenance to a population of nearly 60 million people, who are involved directly or indirectly in cotton production, processing, textile and related activities. It is estimated that more than 8 million farmers cultivate cotton in India and about additional 4 million persons are employed directly by the textile industry. There are more than 1.7 million registered looms, 1500 spinning units, and an estimated 280 composite mills in the value chain of cotton across India. Therefore, cotton production in India is considered to have a wide reaching impact not only on the livelihood of farmers and economy of the country but also on international trade.

India has a unique distinction of being the only country in the world to cultivate all the four cultivable Gossypium species, *G. arboreum* (desi cotton) and *G. herbaceum* (Asian cotton), *G. barbadense* (Egyptian cotton) and *G. hirsutum* (American upland cotton) as well as hybrid cotton. There are total of 50 Gossypium Species in the world, comprising 45 diploid (2n=2x=26) and five allotetraploid (2n=4x=52) species distributed throughout the arid and semi arid regions of the Africa, Australia, Central and South American and the Indian sub-continent. Of the 95 Gossypium species, only four are cultivated commercially. *Gossypium hirsutum* represents 90% of the hybrid cotton in India and all the current Bt cotton hybrids are *G. hirsutum*. Notably, *G. hirsutum L.* (American cotton) and *G. barbadense L.* (Egyptian cotton) have superior fibre quality. *G. hirsutum L.* is most widely cultivated because of its wide range of adaptability and high yield potential whereas *G. barbadense L.* is planted for its fine and unique fiber quality. Desi or Asiatic cottons have coarse and short fibre.

Cotton is grown in varied soils, climates and agricultural practices both under irrigated and rainfed situations. Approximately 65% of India's cotton is produced under rainfed conditions and 35% on irrigated lands. Cotton is cultivated in three distinct agro-ecological regions (North, Central and South) of the country. The northern zone is almost totally irrigated, while the percentage of irrigated area is much lower in the central (23%) and southern zones (40%). Under the rainfed growing conditions, annual rainfall ranges from 400 to 900 mm coupled with aberrant precipitation patterns over the years leading to large-scale fluctuations in cotton production in rainfed area. Cotton in the Northern India is grown in about a million hectare in the three States including Punjab, Haryana and Rajasthan. The Central zone accounts the largest area under cotton nearly 62 percent of total area in the country distributed across Maharashtra, Gujarat and Madhya Pradesh. South zone consisting of Andhra Pradesh, Karnataka and Tamil Nadu occupies around 21 per cent of the 12 million ha cotton area in the country (DAC, 2012).

Bt Cotton in India

The Central Institute for Cotton Research thoroughly reviewed the entire development of Bt cotton in India before it was approved for commercial cultivation by the Genetic Engineering Approval Committee (GEAC) of the Ministry of Environment and Forests (MOEF) in 2002. Three Bt cotton hybrids namely MECH-2, MECH-162 and MECH-184 were approved for commercial cultivation in the Central and Southern cotton-growing zones of India. Subsequently, GEAC approved additional hybrid RCH-2 Bt cotton for cultivation in the Central and Southern zones in 2004. In 2005, GEAC approved additional 16 Bt cotton hybrids in 2005 including the approval of 6 Bt cotton hybrids for the first time for Northern cotton growing zone. By 2005, a total of 20 Bt cotton hybrids of which 6 Bt cotton hybrids for North, 12 for Central and 9 for South India were approved for cultivation thus making Bt cotton technology available for the entire country. Realizing the immense potential of Bt technology, several private seed companies in India became sub-licensees and acquired the rights to incorporate the *cry1Ac* gene into their own popular cotton hybrids. Within next five years, the total number of Bt cotton hybrids reached more than 700 marketed across the country by 30 small and medium private seed companies. These included the commercial approval of Bt cotton hybrids expressing two other events GFM event of Nath Seeds and Event-1 of JK seeds. Similarly, the area under Bt cotton has increased from 29,307 hectares in 2002 to an estimated 10 million hectares by 2011-12, 80% of the total cotton area of 12 m ha. In addition, GEAC approved Bollgard-II event Bt cotton hybrids in 2006, which express two genes *Cry1Ac* and *Cry2Ab* imparting a broader protection to bollworm complex. Subsequently, the public sector event BNLA Bt was approved in 2008 but discontinued due to problems in commercialization. In 2009, GEAC approved another event MLS-9124 expressing synthetic *cry1C* gene developed by Metahelix Life Sciences, which was not placed on market for cultivation until 2012. Table 3 shows GEAC approval for

commercial release of different Bt cotton events in India from 2002 to 2012 (James, 2012).

Table 3. GEAC's Approval for Commercial Release of Different Bt Cotton Events in India, 2002 to 2012

No.	Crop	Gene(s)	Event	Developer	Status	Year of Approval
1	Cotton*	*cry1Ac*	MON-531	Mahyco/ Monsanto	Commercialized	2002
2	Cotton*	*cry1Ac* and *cry2Ab2*	MON-15985	Mahyco/ Monsanto	Commercialized	2006
3	Cotton*	*cry1Ac*	Event-1	JK Agri-Genetics	Commercialized	2006
4	Cotton*	fused genes *cry1Ab* and *cry1Ac*	GFM Event	Nath Seeds	Commercialized	2006
5	Cotton**	*cry1Ac*	BNLA-601	UAS, Dharwad & CICR (ICAR)	Discontinued	2008
6	Cotton*	synthetic *cry1C*	MLS-9124	Metahelix Life Sciences	Approved, Not placed to market yet	2009

*Bt cotton hybrid; ** A hybrid and a variety of Event BNLA-601 discontinued since 2010

Rationale of the Study

The approval and adoption of Bt cotton is a unique case in Indian agriculture. No technology including semi-dwarfing wheat and rice technology during the green revolution period has been adopted at such a rapid pace as Bt cotton. The spread of technology is the first of its kind and adoption is considered unparalleled in the history of any technology adoption in agriculture. It was felt that the classical interventions to decipher the growth path of technology adoption of Bt cotton would be worth understanding. Similarly, the horizontal spread amongst culturally diverse farmers with diametrically opposite dialect spread across 2500 km from Northern to Southern cotton growing areas was worth investigating. Simultaneously, it was worth to examine how Bt

cotton technology scaled up vertically and what triggered the mobilization of policy support at a higher level and possible institutionalization. To study the horizontal and vertical scaling up of the technology, it was decided to measure various factors that influenced the adoption of Bt cotton technology, community actors who influenced the uptake of the technology, how did they influence the adoption of the technology and what changes occurred in their lives as a result of Bt cotton adoption.

As with any technology, the adoption process of Bt cotton in India was riddled with a series of constraints. There were groups in the society who were opposed to the introduction of such technology in agriculture. They existed during the green revolution and continued every time when new technologies were introduced in Indian agriculture. Notwithstanding controversies during the green revolution, there was a vociferous opposition to hybrid technology introduced in dry land field crops such as pearl millet and sorghum in late sixties. The activist groups alarmed the society with false propaganda that the hybrid technology would induce sterility in humans and animals. Therefore, it was expected that these groups would generate similar agenda with biased, subjective and irrational discourse and misinform the society during the introduction and adoption of Bt cotton in the country. The public perception of Bt cotton varied on several issues such as biosafety, effects of Bt on human and animal health, effects of soil microbes and loss of biodiversity. Several environmental issues were deliberately brought out to create confusion in the minds of public. There were and still are divergent views on several issues such as Bt cotton is unsuitable for rainfed agriculture, insecticides uses have increased, use of water and fertilizers have doubled, new pests have emerged on cotton and so on and so forth. Over the years, the public and private sector institutions made efforts to demystify the myths surrounding these questions and reported to the regulators from time-to-time for any such false reports that lacked scientific credence in establishing an apparent cause-effect relationship. Contrary to the activist propaganda, cotton farmers who were the ultimate beneficiaries of Bt technology did not pay attention to unwarranted criticism. Farmers not only adopted the technology but substantially increased the scope of cultivation across the cotton growing areas after realizing the desired benefits. In this context, it was noteworthy to consider undertaking an exercise to generate concrete datasets, collate farmers' field level experience and understand how the rapid expansion of Bt cotton unfolded in the country side. Interestingly, Dr. T.M. Manjunath (Manjunath, 2011) wrote a very useful book with 85 questions and answers on Bt cotton in India. Similarly, Dr. K.R. Kranthi (Kranthi, 2012) – a renowned cotton entomologist took up a totally different set of hundred questions and answers on Bt cotton after a decade of cultivation of Bt cotton by farmers. However, this study attempted to gather the field level experiences from those farmers who decided to cultivate Bt technology, to understand why they risked to cultivate Bt cotton, to examine who influenced them to cultivate Bt cotton and to understand why they are glued to Bt cotton for such a long time. The study also posed challenging questions to farmers on

socio-economic aspects, demographics factors and psychological reasons for adopting Bt cotton. The answers to these questions in the Survey would emanate from those who are technology users and not those who are technology advisors and therefore it would be extremely useful to integrate their opinions on the new generation of biotechnology to the overall agriculture development of the country.

It is well known that commercial adoption of Bt cotton technology has been one of the most rapid cases of technology diffusion in the country. On one side, the trend of adoption of Bt cotton by farmers shows the advantages of technology while on the other side, there are demonstrations and agitations, misinformation on safety and long term health implication, legal cases against companies selling biotech based seeds and the concerns raised repeatedly for biosafety and environment. The agenda driven campaigns on science and safety of GM crops, which are the regulated subject matters by experts of the government of India, are willfully heightening public concerns about the potential of GM crops and therefore generating resistance among the public resulting in delay in the process of approval of GM crops in general and Bt crops in particular. The pertinent question is whether farmers are offered choice to enjoy the advantages of the new technologies in agriculture and whether 'prejudices' should be allowed to block the dissemination of promising technologies at a time when farmers are at disadvantage of unprofitable farming.

The literature survey shows a similar pattern of information and misinformation about the adoption of biotechnology around the world. As pointed out by German (German, 2007), the adoption of Bt technologies is influenced by several factors such as access or bias in pattern of sharing, assets or ability to invest, incentives such as markets, land tenures etc and poor communication amongst farmers, between farmers and research, extension and R&D institutions. Ismael (Ismael and Morse, 2001) argued that adoption of biotech crops could lead to unintended outcomes like widening socio-economic gap between the better off and the resource-poor farmers. Scandizzo and Savastano reported that besides the socioeconomic divide, other factors such as socio-cultural, technical, environmental, communication and information may also come into picture with regard to adoption decision after biotech crops are approved for introduction in agriculture (Scandizzo and Savastano, 2010).

Keeping in view these issues, the study was undertaken to analyze the dynamics of adoption and uptake pathways of Bt cotton in diverse cotton growing situations from North, Central to South India. The study aimed at measuring what changes Bt technology has brought in the farmers lives. In the past, several studies attempted to address the impact of Bt cotton at national and international levels focusing primarily on a small datasets in a particular cotton growing area and focused mainly on the economic impact and in some cases on environmental impact. These studies hardly accounted for the adoption behavior of Bt cotton growers throughout the country. None of the studies

analyzed the 'Uptake Pathway' of Bt cotton which essentially traces the spread of Bt cotton from introduction, adoption, dissemination and information sharing amongst farmers. In this investigation, it was planned to decipher the adoption process with intent to know how farmers acquired and eventually applied knowledge and practices pertaining to cultivation of Bt cotton in rainfed, semi-irrigated and irrigated areas. It is expected that the study would benefit a wide range of stakeholders in planning, policy making, regulating and deploying other biotech crops that may contribute significantly to the sustainable agriculture production system in India.

Objectives of the Study

General: The study aimed at understanding, analyzing and interpreting the adoption and uptake pathways of Bt cotton among farmers in three agro-ecological cotton growing zones under different agronomic, ecological, cultural, social and family backgrounds. The selected States are irrigated cotton area of Punjab in North zone, rainfed cotton area of Maharashtra in Central zone and semi-irrigated cotton area of Andhra Pradesh in South zone.

Specific Objectives: The study designed to look into the following parameters relating to farmers growing Bt cotton in order to arrive at the broader objectives of understanding and determining the adoption and uptake pathways of Bt cotton in the country. The specific objectives of the study are;

1) To examine and study;
   a) Socio-demographic profile: age, gender, civil status, family size, educational attainment, other sources of income and membership of organization.
   b) Farm-related profile: number of years in farming, farm size, source of capital, marketing of cotton, farm income and farming activities
2) To determine the adoption of Bt cotton in terms of
   a) Number of years engaged in planting of Bt cotton
   b) Factors considered in adoption of Bt cotton
   c) Mode of adoption of Bt cotton and
   d) Benefits accrued from adoption of Bt cotton
3) To analyze the uptake pathways of Bt cotton in terms of
   a) Sources of information
   b) Sharing of knowledge with others
   c) Information shared with others
   d) Participation in trainings, workshop, seminars etc.
   e) Organization that conducted training and workshop
   f) Interaction with those who convinced the farmers to adopt Bt cotton
   g) Support services availed by the Bt cotton farmers

h) Institutes that provided extension support
i) Support services needed by farmers
j) Constraints and problems encountered by Bt cotton farmers
k) Reasons to continue with Bt cotton

4) To assess the changes in farmer's lives brought about by the adoption of Bt cotton
5) To analyze the relationship between the farmers with respect to
   a) Socio- demographic characteristics and adoption level of Bt cotton
   b) Farmer related characteristics and adoption level of Bt cotton.

Significance of the Study

The study attempted to contribute to the following areas;

1) Role of communication in influencing the farmer's decision to adopt and share the knowledge to others. Simultaneously, the results of the study can help the extension agencies to look into the strategies of technology transfer, technology dissemination and communication.
2) The feedback of the study can guide the public sector institutions to reshape the biotechnological programs in such way that the R&D of new crops and traits are based on the priorities set by farmers. Similarly, the institutions can also avail feedback from product users such as housewives, food processors for post harvest utility, feed millers, exporters etc. for developing a particular biotech crop accordingly.
3) The study gives an insight as to who are early adopters, their profile and attitude. This will help in planning the future technology diffusion points among the farming community.
4) Results of the study help unravel the process of adoption that a farmer goes through while adopting new technology such as Bt cotton. This includes the factors that enable and facilitate a grower's adoption and uptake of new technology and the difficulties encountered in the process of the adoption.
5) The data generated from these studies can help government, academia, R&D institutions, private companies to justify the investments made in biotechnology and influence their decisions to scale up investment for further research.
6) Most importantly the findings will enlighten the public, government organizations and policy makers about the changes in the living standards of the farmers due to adoption of the technology.
7) The study can instigate researchers to expand the scope of study by furthering the sample size and broadening the base of farmers in all 10 cotton growing states in India.

Limitations of the Study

1) The study provides descriptive analysis of the patterns, dynamics and uptake pathways of Bt cotton. The scope is limited due to non availability of other biotech crops or other traits as Bt cotton is the only biotech crop commercialized in India.

2) The scope of study is limited to three cotton growing States out of nine major cotton growing States of the country due to logistic reasons. The number of districts and villages were selected based on the density of cotton areas calculated and averaged for last 10 years. Although selected districts/villages represent the best of samples, however a larger sampling size is always preferred in such types of studies. The selection of States, districts, talukas, villages and farmers were undertaken employing the random sampling selection technique and based on the recommendations of an elected representative of the village in coordination with the principal investigator of the survey familiar with the terrain, language and farmers in a particular area. The Director, Central Institute for Cotton Research (CICR), Nagpur helped in selecting the principal investigators in each surveyed State who were proficient in the area of cotton and extension.

3) One of the major limitations encountered during the survey was the non- availability of non-Bt cotton farmers as majority of farmers about 93% were growing Bt cotton for a long period. The results of the comparative economics of Bt and non-Bt cotton were based on the information provided by farmers. However, farmers could readily answer questions pertaining to Bt cotton cultivation.

“ਹੁਸ਼ਿਆਰ ਕਿਸਾਨ, ਖੁਸ਼ਹਾਲ ਕਿਸਾਨ”

The literature review suggests that the conventional agricultural technologies are inadequate to meet the formidable challenges posed by population explosions, shrinking farm land, climate change, mounting water scarcity and emergence of biotic and abiotic stresses. Some of the limitations of conventional breeding reported in many research papers include i) lack of germplasm resources resistant to some of the major pests and pathogens of crops, ii) the new plant types evolved for higher productivity are more vulnerable to pests and diseases, iii) difficulties in sourcing genes from wild relatives, iv) lack of nutritional qualities in major cereals crops, v) methodological issues of breeding new plant types based on phenotypic selection and vi) constraints of plant-environment interactions in the selection process of new plant types. Recent advances in modern biology especially biotechnology offer many advantages over traditional plant breeding techniques to overcome these challenges. Plant biotechnology offers possible solutions to previously intractable problems and made it possible to achieve difficult targets such as creating drought and salinity tolerant crops for the benefits of resource poor farmers across Asia and Africa (Serageldin, 1999). Molecular biology tools enable the scientific community to modify the genomes of the crop species to optimize its use to meet the nutritional requirements of human and animal. The applications of new tools of biotechnology will be one of the key factors to achieve the goals of development and preserve the quality of the environment. The review of literature suggests following developments in the agriculture in the near future;

1) Increase in the productivity of crops by reducing the dependency on environment damaging agrochemicals.

2) Reduce pressure on pristine land and salvage remaining uncultivated habitats

3) Develop new plant types that require fewer inputs, more efficient and tolerant to biotic and abiotic stresses.

4) Create alternative and renewable sources of energy based on biological resources.

5) Create environment-friendly raw materials for industry such as biodegradable plastics from plant starches etc and

6) Make agriculture more sustainable by reducing the amount of agrochemicals released into the environment.

Many organization including FAO, WHO, OECD and ISAAA (James 2011) pointed out that the most compelling case for biotechnology and more specifically GM crops is to contribute to i) increasing crop productivity and thus contribute to global food, feed and

fibre security, ii) lowering production costs, iii) conserving biodiversity by producing more on the same land thus saving-land for producing more food, iv) reducing environmental footprints of agriculture by efficient use of external inputs for a more sustainable agriculture and environment, v) increasing stability of production to lessen suffering during famines due to abiotic and biotic stresses, vi) improving economic, social and health benefits and alleviation of abject poverty in developing countries including India and vii) addressing the challenges associated with climatic change. In the past twenty years, crop biotechnology has made significant strides encompassing the spectacular developments in plant molecular biology and genetic engineering. A variety of traits have been introduced in plant species, which include herbicide tolerance, insect-pests resistance, viral resistance, slow-ripening in fruits, fungal and bacterial disease resistance, abiotic stress tolerance (drought, salinity, temperature, flooding etc), quality improvement (starch, protein and oil), value addition (vitamins, micro- and macro elements), synthesis of pharmaceutical and therapeutic proteins, edible vaccines, phyto-remediation and enhancing the nutrient uptake especially nitrogen fertilizers in plants.

Dr. Clive James of the International Service for the Acquistion of Agri-Biotech Applications (ISAAA) has been doing a yeoman service by releasing an annual update on the "Global Status of Commercialized Biotech/GM Crops" that benefits students, researchers, scientific community, regulators, policy makers, farmers and other stakeholders. The annual brief assists governments and other stakeholders to make an informed decision based on the available scientific evidences and experiences. ISAAA Brief 44 (James, 2012) reported that a record of 17.3 million farmers in 28 countries have planted biotech crops such as corn, cotton, canola and soybean among others on 170 million hectares of cultivated land which is more than the cultivated land area of India. Nearly 90% of farmers cultivating biotech crops are resource-poor farmers from developing countries of India, China and Philippines in Asia and other developing countries from Africa and Latin America. Biotech crops are the fastest growing crop technology in the recent history of agriculture that demonstrated a 100-fold increase from 1.7 million hectares in 1996 to 170 million hectares in 2012.

Current Status of GM Crops in India

India is the only country is the world that has a full fledge department of biotechnology to support and regulate the use of recombinant DNA research in agriculture, health and environment sector. Since mid-eighties, the efforts have been made in India to develop transgenic crops in agriculture and many drugs and vaccines have been released based on rDNA technology in the country. The Government of India has been very supportive of the efforts to set up R&D institutions, nurture human capital and develop GM crops and recombinant drugs. The Govt of India has invested liberally in biotech sector over last two decades through various departments including the Department of Biotechnology (DBT), Department of Science and Technology (DST), Council of Scientific and

Industrial Research (CSIR), Indian Council of Medical Research and Indian Council of Agricultural Research (ICAR). Many research groups developed capacity on plant transformation and embarked upon many R&D programs primarily using genes obtained from western laboratories for academic research purpose. To commensurate the domestic progress, the efforts were made to isolate useful genes from various organisms. In the past decade, many institutions have taken up intensive gene mining research as reviewed by Mayee (Mayee, 2012) and also reported in Current Science (Natesh and Bhan, 2009).

The first GM crop commercialized in India was Bt cotton in the year 2002. In 1995, Mahyco Company obtained a Coker 312 cotton variety transformed with a modified *crylAc* gene from Monsanto Co of USA. The *cry1Ac* gene was transferred to Mahyco's elite cotton hybrids by conventional breeding techniques. Bt cotton hybrids were rigorously studied and evaluated for biosafety, human and animal health, agronomic performance and environmental impact under the stringent regulations of RCGM and GEAC of the Ministry of Environment and Forests (MOEF) from 1996 to 2001. The details of studies undertaken, regulatory approval and impact of Bt cotton cultivation were documented in various reports issued between 2002 to 2012 including comprehensive reports by Dr. K.R. Kranthi, Dr. T.M. Manjunath, CICR, ISAAA and APCoAB.

Nearly 35 Indian private seed companies became sub-licensee of Mahyco Monsanto Biotech Ltd, obtained license to transfer Bt gene into their popular cotton hybrids and made them available for cultivation to cotton farmers across the country. In addition to Mon531 event expressing *cry1Ac* gene, five additional Bt cotton events were approved for commercial sale including BG-II event of Mahyco, Event-I of JK seeds, GFM Event of Nath Seeds, BNLA-601 event of ICAR and MLS-9124 of Metahelix Life sciences Refer to Table 3 for details of events approved for commercial cultivation in India.

The success of Bt cotton inspired many public and private R&D organizations to take up the work on GM technology and develop indigenous GM crops. By 2012, a dozen of GM crops have been either field tested or are under research and development including rice, mustard, chickpea, sorghum, sugarcane, and groundnut and vegetable crops such as brinjal, okra, potato and tomato. These crops have been genetically modified for various traits both by the National Agricultural Research Systems (NARS) and private companies. Field trials have also been approved for plantation of GM rubber in India. Additionally, more than 15 private R&D labs are field testing different GM crops such as maize, cotton, rice, brinjal, tomato, cabbage, okra, cauliflower and pigeon pea. The country therefore is well poised for taking huge leap forward in agriculture R&D and deployment of various crops in the future. The Bt brinjal moratorium has slowed down the R&D and field testing of GM crops. However, the opposition to GM crops is being scientifically challenged and it

is expected that India will slowly but steadily move forward to the commercialization of many GM crops in the near future (Bagla, 2012).

Social and Economic Contribution

Many peer reviewed research papers and survey conducted by public sector institutions have confirmed major economic, social and environmental benefits of Bt cotton in India and around the world. For instance, the National Center for Food and Agricultural Policy study in the US reported that six major GM crops such as soybeans, maize, cotton, papaya, squash and canola planted in the United States have produced an additional 4 billion pounds of food and fiber on the same acreage, improved annual farm income by $1.5 billion and reduced pesticide use by 46 million pounds (NCFAP, 2008). Various surveys in developing counties have documented how small and marginal farmers benefited by cultivating Bt cotton in China, South Africa and India (APCoAB, 2006; James, 2012; Qaim, 2012). A study by IIMA by Gandhi and Namboodiri reported that farmers reaped on average yield gains of approximately 31%, a significant 39% reduction in the number of insecticide sprays and increased profitability by 88% equivalent to a substantial increase of approximately US$250 per hectare (Gandhi and Namboodiri, 2006). Kouser and Qaim reported the significant reduction in the incidence of acute poisoning due to decreased use of pesticides on Bt cotton (Kouser and Qaim, 2011). The PNAS published study by Kathage and Qaim indicated that Bt cotton has contributed to a 24% increase in cotton yield per acre and a 50% gain in cotton profit among smallholders. Notably, the study reported significant increase in household consumption by 18% in Bt cotton growing areas during the 2006–2008 periods (Kathage & Qaim, 2012). The Bharat Krishak Samaj study 'Socio-Economic Impact Assessment of Bt Cotton in India' released in 2012 confirmed that the cotton production in India has risen substantially with the use of the hybrid Bt cotton seeds resulting in benefiting small farmers and helping the country to become net exporter of cotton in the world. The overall production of cotton has grown by 9.25 percent since introduction of Bt cotton in 2002-03 and farmers' income jumped up by nearly 375 percent (Farmers' Forum, 2012). Similarly, Subramanian reported larger socio-economic benefits attributed to cultivation of Bt cotton including increased rural employment and job prospects and women empowerment (Subramanian, 2010). A recent study by Qaim and Kouser published in PLOS ONE journal highlighted the role of Bt cotton in improving food security. The study reported that the calorie consumption and dietary quality among small-scale farmers have significantly improved over a 7-year period due to Bt cotton cultivation. The researchers used data from a survey of over 500 randomly selected small farm households conducted from 2002 to 2008 and found that growing of biotech cotton increased farm yields and incomes enabling these farming households to afford more and better food (Qaim and Kouser, 2013). The All India Cottonseeds Crusher's Association (AICOSCA) reported that food insecurity was reduced by 15-20 per cent due to the

cultivation of Bt cotton as an indirect consequence of better income (AICOSCA, 2013). In summary, the annual global study on the socio-economic benefits of biotech crops conducted by Brookes and Barfoot estimated that India enhanced farm income from Bt cotton by US$12.6 billion in the period 2002 to 2011 and US$3.2 billion alone in 2011 alone (Brookes and Barfoot, 2012).

In addition to the above analysis, there were twelve studies carried out between 1998 to 2010 covering the pre Bt and post Bt cotton period that studied in detail the socio-economic contribution and impact of Bt cotton cultivation in various States using multi-stage random sampling technique and farmers interviews. Some of these studies included Naik, 2001; Bennet, 2006; Dev and Rao 2007; Usha Rani and Selvaraj 2008; Padaria *et al.*, 2008; Wasnik *et al.*, 2013 and Singh *et al.*, 2013. Based on farm survey and interaction with farmers, these studies clearly demonstrated that the adoption of Bt cotton was influenced by less use of chemical pesticides, comparatively higher yield and significant additional income.

Environmental Considerations

The governments and regulatory agencies around the world ensure a rigorous and thorough evaluation of GM crops for the environmental and ecological concerns prior to their release in the environment. Harmonized risk assessment procedures are adopted by different countries while considering the environmental risk assessment (ERA) studies for the interactions between GM crops and its environment. The ERA obligates the developer of GM crops to generate safety data and information about the role of the introduced gene and the effects that it brings into the recipient plant, soil biota, non-target organisms and environment. The risk assessment procedures require answers to specific questions about unintentional effects of GM crops on non-target organisms in the environment, whether the modified crop might persist in the environment longer than usual or invade new habitats and consequences of a gene being transferred unintentionally from the modified crop to other species (Pocket K No. 4, Knowledge Center, 2012). Over the years, the ERAs of different GM crops have generated voluminous information and data on the environmental safety and considerable evidences have been gathered about how GM crops are helping to preserve the environment. In 2002, the nature biotech published a review paper 'Potential for the environmental impact of transgenic crops' indicating that the impact of free DNA of transgenic origin is likely to be negligible compared with the large amount of total free DNA. The study found no compelling scientific arguments to demonstrate that GM crops are innately different from non-GM crops (Dale, 2002).

A 2006 Swiss study 'Ecological impacts of genetically modified crops-Experiences from ten years of experimental field research and commercial cultivation' conducted by

Agroscope Reckenholz-Tänikon Research Station (ART) concluded that data available so far provides no scientific evidence that the commercial cultivation of GM crops has caused environmental harm. In relation to the commercial cultivation of Bt cotton, the study concluded that there has been a substantial reduction in quantity and in number of insecticide applications. In addition to direct environmental benefits such as fewer non-target effects and reduced pesticide inputs in water, the study reported the demonstrable health benefits due to less chemical insecticide spraying in Bt cotton for farm workers in developing countries (Sanvido *et al.*, 2006).

Another significant study 'Comparative environmental impacts of biotechnology-derived and traditional soybean, corn, and cotton crops' was released by the US based Council for Agricultural Science and Technology (CAST). The study brought together independent teams of researchers from Washington State University, the University of Illinois, Clemson University and the National Center for Food and Agricultural Policy (NCFAP) to review the scientific literature on the environmental impacts of transgenic crops. The study concluded that biotechnology-derived soybean, corn, and cotton pose no environmental concerns unique to or different from those historically associated with conventionally developed crop varieties and summarized the findings as follows;

1) Prevent soil erosion: GM soybean and cotton have led to a significant increase in the adoption of environmental friendly no-till farming practices, which conserves top soil, preserves soil moisture and reduces runoff.

2) Improve water quality: GM soybean and cotton enable farmers to use more benign herbicides that rapidly dissipate in soil and water.

3) Improve air quality: The adoption of no-till farming practices significantly reduce the release of greenhouse gas emissions and thus may help slow global warming and,

4) Increase biodiversity: Bt cotton has been documented to have a positive effect on the number and diversity of beneficial insects in U.S. and Australian cotton fields. In addition, the adoption of no-till farming practices creates additional wildlife habitat for birds and other wildlife.

The most recent comprehensive study 'GM crops: global socio-economic and environmental impacts 1996-2010' by Brookes and Barfoot released in 2012 measured various indicators of economic and environmental impact of GM crops from 1996 to 2010. One of the indicators to measure environmental impact was to demonstrate the dramatic reduction in pesticide use which varies with introduced traits and crops and other indicators are summarized as below (Brookes and Barfoot, 2012);

1) the global economic and environmental impacts of biotech crops for the first

fifteen years (1996-2010) of adoption of GM crops showed that the technology has reduced pesticide spraying by 443 million kg of active ingredient and has reduced environmental footprint associated with pesticide use by 17.9%.

2) the adoption of GM insect resistant cotton contributed the largest environmental gain reflected in the significant reduction in insecticide use that Bt cotton has allowed, in what has traditionally been an intensive user of insecticides.

3) from 1996 to 2010, the large scale adoption of GM herbicide tolerant soybean across North and South America resulted in a significant reduction in fuel use from less frequent herbicide or insecticide applications and a reduction in the energy use in soil cultivation. The study reported that the cumulative permanent reduction in fuel has been about 12,232 million kg of carbon dioxide, arising from reduced fuel use of 4,582 million liters resulting in a significant positive impact on greenhouse gas emissions from agriculture and,

4) In India, the study reported a substantial decrease in pesticides application on cotton resulting in the combined effect of the yield increases and reduced costs of production on farm income equivalent to an annual increase in production of 24%.

Biosafety and Environmental Safety Regulation

In spite of the reported benefits of GM crops, the apprehension mainly comes from an unknown risk that the new technology may bring. These concerns of biosafety have been adequately addressed in India by adopting set of internationally accepted procedures of safety and risk assessment of GM crops. The biosafety, risk assessment, agronomic evaluation, environmental impact and commercialization of GM crops involve carefully drawn guidelines, which are accepted under the 'the rules for the manufacture, use, import, export and storage of hazardous micro-organisms, genetically engineered organisms or cells in 1989' referred as EPA Rules 1989 of the Environmental Protection Act 1986 of the Ministry of Environment and Forests.

In India, the guidelines, protocols and standard operating procedures (SOPs) were evolved over a period of time coinciding with the import, safety assessment, field testing and commercialization of Bt cotton from 1995 to 2002. The system of biosafety assessment and environmental impact assessment has been developed in conformity with the internationally accepted norms and protocols. The EPA Rules 1989 established regulatory agencies such as the Institutional Biosafety Committee (IBSC), the Review Committee on Genetic Manipulation (RCGM) and the Genetic Engineering Approval Committee (GEAC) to deal with the regulations of GM crops in the country. These agencies are assigned to the Department of Biotechnology and Ministry of Environment

and Forests. A set of procedures have been laid out to regulate and comply with the requirements of R&D and commercialization of GM crops in the country. The EPA Rules 1989 separately established full fledged agencies such as the State Biotech Coordination Committee (SBCC) and District Level Committee (DLC) in collaboration with the respective State governments to undertake necessary steps for post commercial monitoring of GM crops. Over the years, it has been recognized that the effective functioning of the regulatory system requires transparency and accountability to instill public confidence in the system – a vital component for the success of GM crops in the country. With a decade of regulatory and field experiences with Bt cotton, it is well established that the existing regulatory framework is fairly robust and science based, however it failed to instill public confidence in executing its regulatory duties. Therefore, to keep pace with advances in modern biology and regulatory developments around the world, the Indian regulatory system on biosafety has to be revamped. A new bill to establish an independent Biotechnology Regulatory Authority of India (BRAI) is pending in the Parliament of India to further build up public confidence in the regulatory process in the country. In summary, the current regulatory system on GM crops has made a tremendous progress, evaluated and commercially approved Bt cotton hybrids that drove the large scale adoption of Bt cotton from 2002 to 2012 as highlighted in Table 4.

Table 4. Nation-Wide Adoption and Commercial Release of Bt Cotton Hybrids, 2002-03 to 2011-12

Year	# of Bt cotton hybrids	# of seed companies selling Bt cotton	Adoption of Bt cotton (Mha)	Total cotton area (Mha)	% Bt cotton area	% of single gene Bt cotton	% of double gene Bt cotton
2002-03	3	1	0.05	7.7	1	100	-
2003-04	3	1	0.1	7.6	1	100	-
2004-05	4	1	0.5	8.9	6	100	-
2005-06	30	3	1.3	8.9	15	100	-
2006-07	62	15	3.8	9.2	42	96	4
2007-08	131	24	6.2	9.4	66	92	8
2008-09	274	30	7.6	9.4	81	73	27
2009-10	522	35	8.4	10.3	81	43	57
2010-11	780	35	9.4	11.0	85	30	70
2011-12	884	40	10.6	12.2	88	18	82

“सावध शेतकरी सधन शेतकरी”

METHODOLOGY

The study was conducted in India as a part of the global project 'Adoption and Uptake Pathways of Biotech crops Among Farmers in India, China and the Philippines' sponsored by John Templeton Foundation and implemented globally by the International Service for the Acquisition of Agri-biotech Applications (ISAAA). The Indian Society for Cotton Improvement (ISCI) implemented the India component of the study the *"Adoption and Uptake Pathways of Biotech Cotton among Farmers in Selected Cotton Growing Villages of Maharashtra, Andhra Pradesh and Punjab in India"*. In India, the study was directed at adoption and uptake pathway of Bt cotton in three cotton growing states including Maharashtra, Andhra Pradesh and Punjab that represent three de-marketed but distinct cotton growing zones covering irrigated, semi-irrigated and rainfed conditions.

Research Design

By using the descriptive normative research design, the study was undertaken to collect multiple data points, gather narrative of farmer's experiences, analyze the pattern and dynamics of adoption and trace the uptake pathways of the adoption of Bt cotton farmers in irrigated, semi-irrigated and rainfed farming. As a part of the global project, a detailed India specific questionnaire 'Bt Cotton Survey in Punjab, Maharashtra and Andhra Pradesh States of India, Kharif Season 2012' was prepared in consultation with a group of experts in agriculture, biotechnology, economics and statistics from India, China and the Philippines in early 2012. The content of the questionnaire was translated in Punjabi, Marathi and Telugu. Similarly, Indian team was also trained to implement the innovation tree exercise to trace the uptake pathways of Bt cotton in the country. In summary, the format and structure of the study was well prepared aiming at describing the adoption and uptake patterns of Bt cotton using appropriate quantitative and qualitative tools for data collection, synthesis, interpretation and analysis.

Location of the study

The study was conducted in three major cotton growing States of India (Figure 2) with different agro-ecological situations. The survey and interviews were carried out during Kharif 2012 when the Bt cotton cultivation activities were in full swing across three States. A brief description of selected States from the point of view of cotton cultivation and agro-ecological characteristics are summarized below:

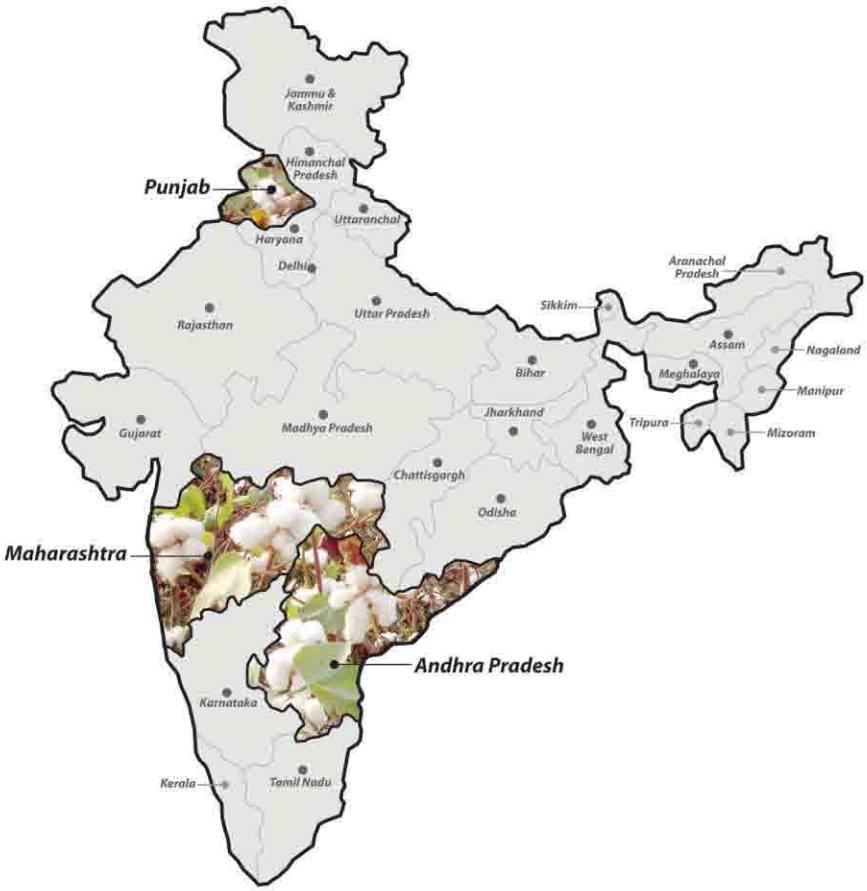
Punjab: The North Zone cotton belt constitutes three states, Punjab, Haryana and Rajasthan. Punjab was chosen as a representative of north zone because it has the largest

cotton area and truly represents the agro-ecology. It is characterized by fully irrigated and mechanized cotton cultivation except hand picking. It has sandy loam soils and the sowings are done in April-May months using canal irrigation. Punjab farmers prefer to plant short to medium duration cotton hybrids of 140-150 days maturity with the sole objective of cotton-wheat cropping system as wheat is sown by end of October or early November (Mayee *et al.*, 2010). Farmers have been using very extensive spray schedule for management of American bollworms in the past. The Northern zone has a unique problem of cotton leaf curl virus (CLCuV). Bt cotton was introduced in this zone in 2005, three years after it was commercially approved for cultivation in other areas. Punjab occupies about 0.5 to 0.55 mha equivalent to 4.8% of total cotton area and contributes nearly 5.1 % to the total cotton production.

Maharashtra: The Central Zone comprises of three States Maharashtra, Gujarat and Madhya Pradesh. Maharashtra was chosen for study mainly because of the fact that nearly 90 per cent area is rain-dependent with small farmer holdings and limited inputs capacity. From the very beginning, the State of Maharashtra has been dominant in the use of hybrid technology not only in cotton but many other dry-land crops like sorghum, pearl millet, sunflower and castor etc. The cotton cultivation is taken on vertisols, deep to light black cotton soils with high clay content. Water retention capacity of such soils is very high. Sowings are done on the onset of monsoon mostly in second-third week of June but often extended to July if sufficient rains are not available. Cotton cultivation in Maharashtra is characterized by low inputs and poor mechanization. Vidharbha region of Maharashtra - known all over the world for wrong reasons of farmer's suicide, is the dominant cotton region of the State. Maharashtra occupies nearly one third of the total cotton area of the country equivalent to approx. 4 mha but contributes only 23% to the total production pool.

Andhra Pradesh: The South Zone comprises three states including Andhra Pradesh, Tamil Nadu and Karnataka. Andhra Pradesh has largest area under cotton in this zone. After the introduction of Bt cotton, the State of Andhra Pradesh registered the highest increase in cotton area. In the last ten years, cotton area increased from 1 mha to nearly 2.1 mha, almost doubling of the cotton area. With this, Andhra Pradesh occupies the second largest cotton area representing almost 18% of the country's cotton area. However, the State contributes only 16% to the cotton production pool. Andhra Pradesh is characterized by loamy to red laterite soils and sowing is undertaken from June to July. The State falls into the semi-irrigated category with around 40% of area irrigated and remaining rainfed cotton. Farmers in the State have recently been increasing cotton mechanization mostly field operations and weeding wherein picking continues to be labor intensive.

Figure 2. Map of India Indicating Major Cotton Growing States Selected for the Survey



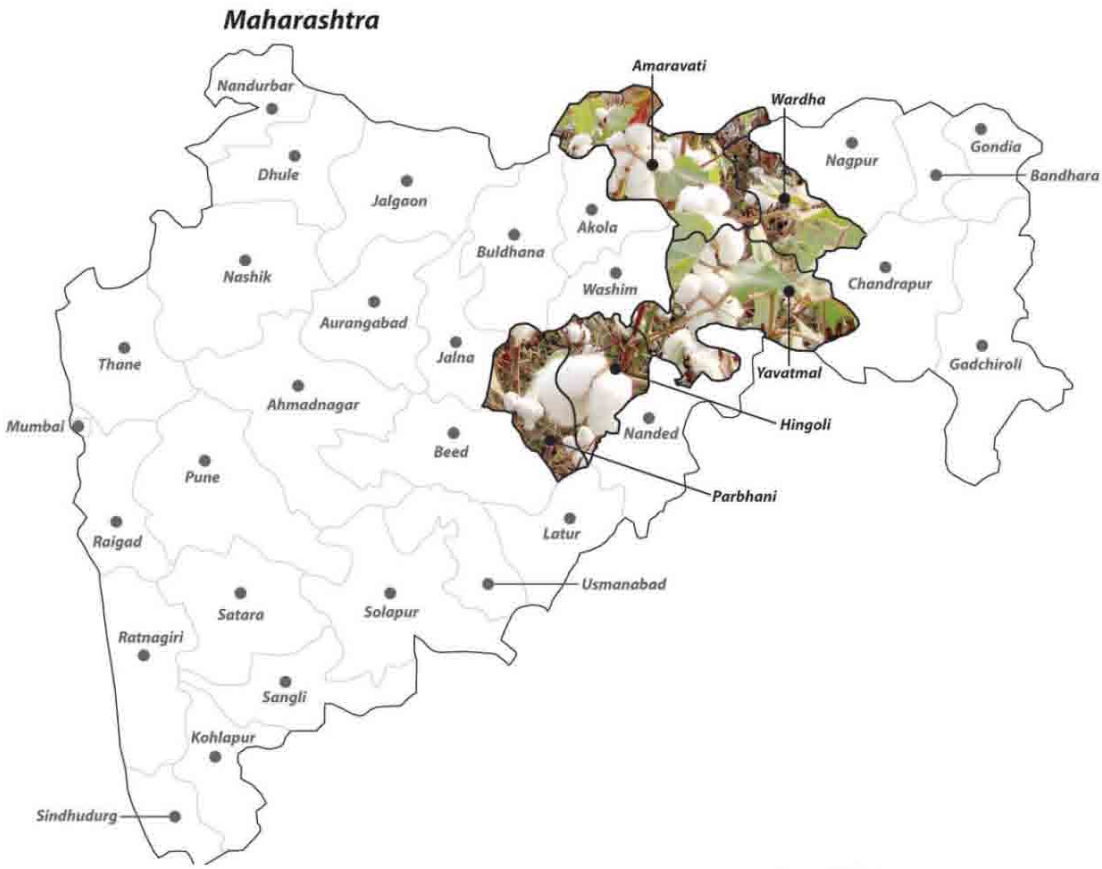
There are two distinct sources of cotton data produced separately by Department of Agriculture and Cooperation (DAC) of the Ministry of Agriculture and the Cotton Advisory Board (CAB) of the Ministry of Textile, Govt of India. Both DAC and CAB regularly publish the data on the hectrages of cotton with various advance estimates during the seasons and final hectrages of cotton after the end of the season every year. CAB usually refers to cotton hectrages data generated by the DAC. The Directorate of Cotton Developments (DOCD) of the Ministry of Agriculture reports the coverage of cotton area under Bt cotton every year. For example, DAC reported that total cotton hectrages in 2010-11 and 2011-12 were 11 and 12.2 mha respectively of which more than 7 million farmers grew Bt cotton on approx. 9 million hectares across ten cotton growing States as reported by DOCD. Both DAC and CAB regularly produce separate data on cotton production and yield with a varying degree of estimates on annual total cotton production. The difference in cotton production is due to different methodologies employed in estimating cotton production by CAB and DAC. In general, CAB estimates on cotton production are often used an accurate estimates by different market sources as compared to cotton production estimates by DAC.

The States for survey were identified on the basis of the intensive cotton growing areas with varied agro-ecological settings as reported by DAC and CAB of the Govt of India (DAC, 2012; CCI 2012). Subsequently, a multistage random sampling was followed to select the districts, blocks (in some states called talukas) and villages to avoid any preferences and prejudices in indentifying different locations for the survey. The selection of districts was based on carefull examination of secondary data pertaining to the intensity of Bt cotton cultivation as reported by DOCD. Taking into consideration the need for adequacy of representation of the area, time availability and data requirement, it was decided to select appropriate blocks/talukas at random from the selected districts. The coverage of Bt cotton in a particular district was also used as a guide for identifying the blocks/talukas. At this stage, coordinators from three states who were conversent with areas and farmers were extremely useful in selecting the blocks and the villages. Similarly, farmers were selected for interactions using a combination of the random selection techniques, the recommendation of village elected representatives and consultation with coordinators of the Survey from three States. Five districts in Maharashtra and Andhra Pradesh whereas four districts in Punjab were selected for the Survey. In each district, an appropriate number of blocks/talukas were selected – 4 blocks in each district of Maharashtra; 2-4 blocks in each district of Andhra Pradesh and 2-3 blocks in each district of Punjab. Table 5 shows a list of districts and blocks/talukas identified as a sample area for the study in three States. In summary, 20 blocks/talukas in Maharashtra, 12 in Andhra Pradesh, and 12 blocks/talukas in Punjab were chosen for the study. Subsequently, 1000 farmers each in 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 were carried out to represent uniformity in survey by selecting 10 farmers each in 10 villages each of 10 talukas from 5 districts of Maharashtra and Andhra Pradesh. In Punjab, 400 farmers were selected with 10 farmers each from 5 villages each of 2 talukas from 4 districts. Sh. Atul Sharma of Shiksha Mandal, Wardha led the survey in Maharashtra whereas Dr. Arjuna Rao of Dr. D. Rama Naidu Vigyana Jyothi Institute of Rural Development and Dr. A.K. Dhawan of the Society for Sustainable Cotton Development executed the survey in Andhra Pradesh and Punjab respectively. In summary, a total of 2400 farmers were identified for survey in three States employing a uniform method of structured interviews scheduled to gather data on socio-demographic characteristics, farm related profile, all aspects of cotton crop, farmers' assets and income, health and environmental issues, adoption and uptake pathways of Bt cotton. However, a slight variation was reported in the number of farmers and taluka surveyed due to difficulties in convincing farmers for interaction, access of villages and inconvenience in public transportation. A list of final villages and talukas surveyed in Maharashtra, Andhra Pradesh and Punjab are enumerated in Annexure 1, Annexure 2 and Annexure 3 respectively. The maps of Maharashtra, Andhra Pradesh and Punjab representing surveyed districts in respective States are shown in Figure 3, Figure 4 and Figure 5.

Table 5. List of Districts and Blocks/Talukas Identified as Sample Area for Survey

Maharashtra		Andhra Pradesh		Punjab	
Districts	**# of Villages**	**Districts**	**# of Villages**	**Districts**	**# of Villages**
Wardha		**Adilabad**		**Fazilka**	
Hinganghat	5	Bhaisa	10	Abohar	5
Arvi	5	Kubeer	10	K. Sarwan	5
Seloo	5				
Samudrapur	5				
Yeotmal		**Warangal**		**Mansa**	
Kalam	5	Sangem	10	Sardoolgash	3
Zarimazra	5	Gudur	10	Jhunil	5
Babhulgam	5			Mansa	2
Ralegaon	5				
Amravati		**A. Nagar**		**Muktsar**	
Morshi	5	Lingala	10	Lambi	4
C. Bazar	5	Telkapally	10	Muktsar	3
N. Khand	5			Malout	3
Dhamangaon	5				
Parbhani		**Guntur**		**Bhatinda**	
Parbhani	5	Prathipada	10	Sanget	5
Shalin	5	Tadikonda	10	Bhatinda	5
Pathri	5				
Manvat	5				
Hingoli		**Kurnool**			
Kalamnuri	5	Kallur	9		
Basmath	5	Koumum	6		
Audha	5	Katnool	3		
Hingoli	5	Belagal	2		
Districts:5	**Talukas:20**	**Districts:5**	**Talukas:12**	**Districts:4**	**Talukas:12**
Villages:100	**Farmers:1000**	**Villages:100**	**Farmers:1000**	**Villages:40**	**Farmers:400**

Figure 3. Map of Maharashtra Showing Districts Selected for the Survey



24

Figure 4. Map of Andhra Pradesh Showing Districts Selected for the Survey

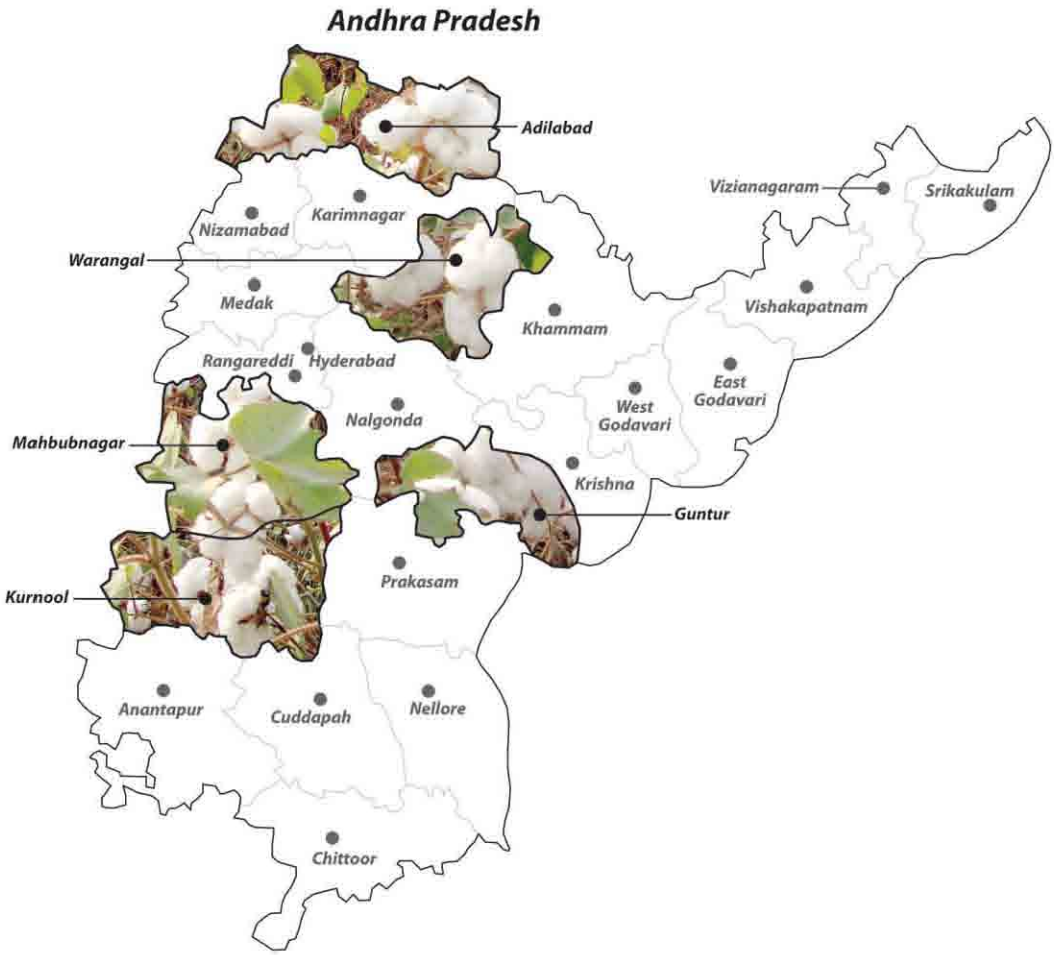
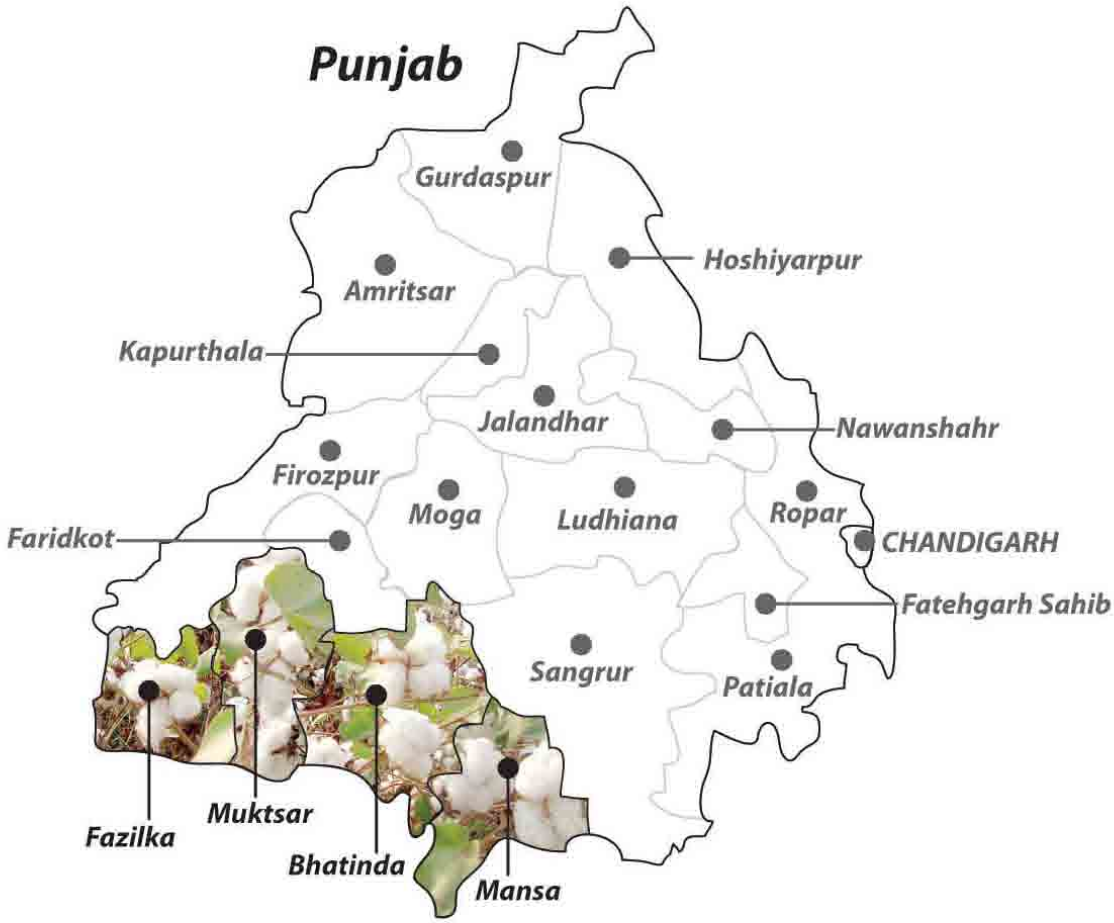


Figure 5. Map of Punjab Showing Districts Selected for the Survey

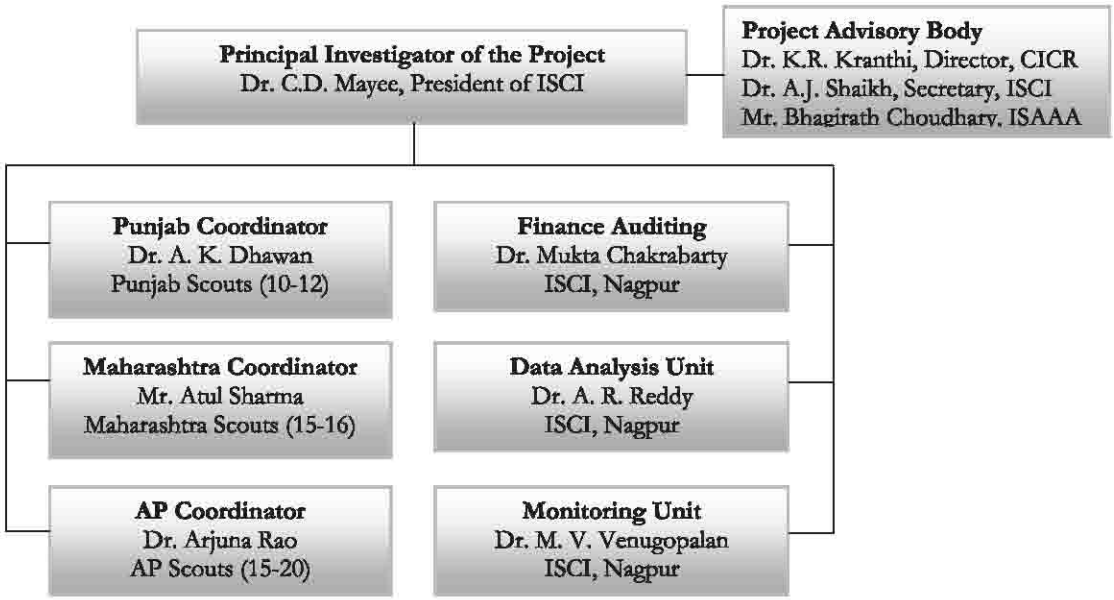


Organizational Set Up for the Survey

One of the requirements of the Templeton Project was to establish an organizational system to oversee the implementation of the study in India. To comply with that, it was decided to form a project advisory body before the commencement of the survey. The project advisory body consisted of Dr. K.R. Kranthi, Director of the Central Institute for Cotton Research (CICR), Nagpur, Dr. A.J. Sheikh, Secretary of the Indian Society for Cotton Improvement (ISCI) and former Director of the Central Institute for Research on Cotton Technology (CIRCOT) and Mr. Bhagirath Choudhary, Director of ISAAA South Asia office, New Delhi. The advisory body assisted the Principal Investigator from formation of questionnaire, performa, selection of coordinators and survey implementation to the final report. The responsibility of carrying out the field work was assigned to respective coordinators who efficiently identified local scouts and trained them, performed translation, implemented survey, collected requisite data, supervised

data recording and submitted the progress to the principal investigators. The PI also ensured timely meeting of different coordinators to share their views and opinion on the effective implementation of the survey. The PI assigned the responsibilities of respective coordinators to choose right personnel for IT and data analysis for monitoring the entire project. The advisory body of the survey was informed about the progress, implementation, analysis and report writing of the survey. Figure 6 shows the flow chart of the organizational set up for the implementation of the study.

Figure 6. Organizational Set Up for the Implementation of the Survey



Respondents and Sampling

The State coordinators were invited to meet under the guidance of Dr. Keshav Kranthi, Director of the Central Institute for Cotton Research (CICR) Nagpur in the beginning of Kharif 2012. The meeting was also attended by the members of advisory unit, audit unit, data analysis and monitoring unit. The purpose of the meeting was to finalize the questionnaire and innovation tree exercise and to familiarize the State coordinators about the implementation of the study. It was agreed to set common criterion as to how the respondents need to be chosen and what villages were to be selected for the study in respective States. The meeting was the foundation meeting that led to decisions about the final area for the survey, sample size, respondents and criteria for the selection of local scouts. Given the widespread cultivation of Bt cotton, the committee decided to select farmers who were growing Bt cotton for a minimum of one season and planted at least a

minimum of one acre cotton. The criteria helped the surveyors to interact with adequate experienced farmers who could share their experiences and learning about the adoption and uptake pathways of Bt cotton.

Taking into consideration the scope and objectives of the study, the draft questionnaire was modified to accommodate changes suggested by the State coordinators. The meeting agreed to adopt a well structured interview in the format of questionnaire and agreed on a schedule of interviews in the meeting. The survey schedule and the standard questionnaire were translated into three local languages to facilitate proper interaction between scouts and farmers. The questionnaire was translated in Marathi for Maharashtra, Telugu for Andhra Pradesh and in Punjabi for Punjab. The translated questionnaire was vetted for correctness and also pilot tested in non-sampling area to probe the usefulness of the questionnaire schedule. The meeting also adopted appropriate indications and prepared final interview schedule in the presence of coordinators for respective States.

Based on the finalization of districts, talukas/blocks and villages and number of farmers, it was decided to organize interaction with of a total 2400 farmers across three States - the largest ever survey on Bt cotton in the country. It was finalized to undertake one-on-one interview with 1000 farmers each in Maharashtra and Andhra Pradesh and 400 farmers in Punjab. In summary, the survey attempted to represent a large area of cotton in the country with the density of sample of 17.7 percent covering an area of 2.02 mha at national level which ranged from 25% in Maharashtra to 65% in Punjab for the surveyed States (Table 6).

Table 6. Area, Number of Farmers and Sample Size for Survey of Bt Cotton in India

State	Total cotton area (Mha)	% Bt cotton area	Estimated cotton farmers (Million)	Sample density	
				Area (Mha)	% of State
Maharashtra (n=1000)	4.0	96.7	2.7 (36.4%)*	1.02	25.0
Andhra Pradesh (n=1000)	2.0	97.0	1.2 (16.2%)	0.67	29.0
Punjab (n=400)	0.5	98.0	0.2 (2.7%)	0.33	65.0
India	11.4	93.0	7.6 (100%)	2.02	17.8
*Percent of total farmers					

Data Collection Method

The study employed a comprehensive survey in Kharif 2012 cotton season using a structured interview scheduled to gather data from the chosen respondents. As discussed earlier, the structure of the interview in the form of survey sheet was finalized keeping in view the uniformity while allowing slight changes locally. Each scout carried a survey sheet in local language for farmers to understand the content, respond to questions and verify information by signing each sheet. Survey data were used for describing who the Bt cotton farmers were, their social-economic and welfare status, what factors they considered in adopting the technology and uptake pathways and related issues. A copy of the standard survey performa in the form of questionnaire in attached as Annexure 4.

Farmers' Attitude and Cultivation Behavior

The term *'Cultivation Behavior'* was conceptualized to assess the attitude, awareness and knowledge of small holder farmers growing Bt cotton in the country. During the survey, a set of additional data were collected using an exfactor research design to gather information about the cultivation behavior of Bt cotton farmers. A multistage random sampling technique was followed to select the sample of this study. Buldhana and Akola districts of Maharashtra and Adilabad and Kurnool districts of Andhra Pradesh were selected at random for irrigated and rainfed Bt cotton growing situations. Two blocks from each district where sufficient number of irrigated Bt cotton growers and rainfed cotton growers were available were selected. Ten villages in each block and 25 Bt cotton growers per village were especially chosen by a separate team under the direct supervision of the Principal Investigator of the project. In total, 250 Bt cotton growers from both conditions were selected as separate respondents for this study to arrive at farmers' attitude and cultivation behavior of growing Bt cotton in respective villages. The data were analyzed to understand the farmers attitude about cultivation aspect of Bt cotton and a behavior scale was constructed on the line with "Equal Appearing Intervals (EAI)" developed by Thurstone and Chave in 1969 (Thurstone and Chave, 1969). Farmers were put on to a set of very specific questions while interacting with 250 farmers with two distinct farming situations. The questions included from where did farmer first hear about Bt cotton, from where the first Bt cotton seed was brought, who helped in buying Bt cotton seed, how well the farmer was aware of Bt cotton, from where such information was obtained, what does he/she know about the safety of Bt cotton and will he/she continue to grow Bt cotton next year etc. Similarly the respondents were classified on knowledge level aspects of Bt cotton based on the data collected in the survey of 250 farmers each from Maharashtra and Andhra Pradesh.

Innovation Tree Exercise

A two member team comprising of the Principal Investigator supported by the respective State coordinator implemented the 'Innovation Tree Exercise', which is recognized as a participatory rural appraisal (PRA) tool developed by Van Mele and Zakaslia in 2002 (Van Mele and Zakaslia, 2002). In the past, Torres *et al.* used this technique to examine the adoption and uptake pathways of biotech maize in the Philippines (Turres *et al.*, 2012). The innovation tree tool was suitably modified for examining the adoption and uptake pathways of Bt cotton in India. The exercise was designed to help people visualize and analyze the way in which an innovation is spread over time amongst the rural farming community. Although the innovation tree tool is qualitative in nature, it provided a venue for the farmers to discuss with fellow farmers and colleagues the dynamics of adoption of Bt cotton. The innovation tree exercise was conducted in two villages each of Buldhana and Akola districts of Maharashtra. The Principal Investigator of the study chose these villages because of the familiarity with the area that helped him and State coordinators in assembling required number of farmers, mobilized them, interacted with them and interviewed them for the purpose of the innovation tree exercise without any problem. Using the local extension workers, the principal investigator organized focus groups meeting with farmers in each village of Kherda of district Buldhana and Chitalwadi of district Akola of Maharashtra. In order to properly manage the exercise, twenty farmers were called on for a group discussion at Panchayat hall of each village. Farmers were asked to provide answers to a few personal questions so as to create a familiarity with them and engage them in the exercise. Each farmer was provided with piece of paper and asked to write the answers to following simple questions

a) Name of the farmer and his/her age

b) Year of cultivation of the first Bt cotton in his/her field

c) The source of first information about Bt cotton

d) Who convinced him/her to the virtues of Bt cotton seeds and,

e) To whom, which other village and relative he/she passed on the information of success and failure of Bt cotton.

The team under the guidance of the principal investigator pinned each paper strip on the board and subsequently tested the validity of their statements while connecting the dots to get to the root of Bt cotton uptake in the village.

Data Codification and Analysis

The study generated two types of datasets, first the quantitative data from the survey and second the qualitative data from "attitude, knowledge level and behavior" and the qualitative data from the Innovation Tree Exercise. The raw quantitative data from all the three States were coded into excel sheets, appropriate statistical tools were employed and analyzed for each parameter in terms of frequency of respondents. The data codification and analysis were undertaken under the supervision and help of Dr. A. R. Reddy, Senior Scientist of Economics at the Central Institute for Cotton Research (CICR) at the ISCI office. A set of data from Maharashtra and Punjab were codified and analyzed by the State Coordinator in their respective institutes. No statistical test for significance was applied due to the non probability samples used in the study. The state-wise analysis was done and compiled at respective states to show the distinctness and variations but the pooled frequencies and analysis were done at ISCI office, Nagpur. To assess the attitude and knowledge level, the quantitative data were analyzed for the frequency. However, the Innovation Tree Exercise which was primarily based on qualitative information for two villages illustrated the thematic approach and flow chart to show the patterns of adoption and uptake pathway of Bt cotton in the country.

“శ్రద్ధగల రైతు సంపన్న రైతు”

RESULTS AND DISCUSSION

Distribution of Respondents

A summary profile of the sampling areas for the Bt cotton survey is presented in Table 6 and details pertaining to each of surveyed State are presented in Annexure 1, Annexure 2 and Annexure 3. As per the proposal, the total numbers of respondents interviewed were 2400 distributed equally of 1000 each in Maharashtra and Andhra Pradesh whereas 400 respondents were from Punjab. By and large the frequency of respondents was maintained while getting responses to questions in the survey questionnaire. The respondents across States provided detailed information, however in some cases they preferred not to answer specific questions. In Maharashtra selected respondents came from 20 talukas/blocks of 5 revenue districts spread across the main cotton belt. From each taluka, 5 villages were selected and from each village 10 farmers were interviewed (Annexure 1). In summary, 1000 farmers participated in the Survey in Maharashtra which were distributed as 10 farmers each from 5 villages each of 4 talukas of 5 revenue districts.

The respondents in Andhra Pradesh distributed across 100 villages from 12 talukas of 5 revenue districts. From each village normally 10 farmers were selected. However, in some of the largely populated villages, the numbers of respondents were between 12 to15 farmers which were adjusted to other villages to maintain the sample of the Survey in Andhra Pradesh (Annexure 2). In Punjab, 400 farmers were selected from 40 villages spread across 12 blocks representing 4 main cotton growing districts (Annexure 3). The survey reasonably well captured the local, regional and zonal variability while selecting the respondents from Maharashtra, Andhra Pradesh and Punjab.

The districts selected for the study represent 25% of the cotton hectrages in Maharashtra, 29% of the cotton area in Andhra Pradesh and 65% of the area of cotton in Punjab (Table 6). Incidentally, about 54% of the cotton farmers of the country reside in these three surveyed States. Notably, Bt cotton almost saturated the cotton area in these states. Therefore, the coverage of the study amply indicated that the sampling pattern used in the study was not only exhaustive but also representative of all cotton growing situations across the country.

Socio Demographic Profile

Age of Surveyed Farmers

The age of Bt cotton growers ranged from 16 to 78 with the exception of a farmer aged 82 in Punjab. Interestingly, the mean average age of all the surveyed farmers was 42 years. At national level, a majority of the surveyed Bt cotton farmers equivalent to 53.4% were in the lower middle age group of 21 to 40 years. A large number of farmers from this group were from Punjab representing 63% whereas 53% were from Andhra Pradesh and 50% of them from Maharashtra. It was noteworthy to capture this unique trend of a majority of young farmers growing Bt cotton in Maharashtra, Andhra Pradesh and Punjab contrary to the perception that young farmers were abandoning farming. The second biggest age group representing an average of 39.3% of surveyed farmers was from 40 to 60 years age group where the percentage among three surveyed States ranged from 31 to 42% with a lowest percentage of farmers from this age group were in Punjab. The survey indicated that the young farmers who were in farming are ready to adopt new technologies and interestingly they were the ones who preferred Bt cotton cultivation. This finding of the survey in India is in contrast with the study on biotech corn cultivators in the Philippines conducted by Torres *et al.* 2012. However, the young farmers adopting Bt cotton in India is in line with the findings of Rogers in 1962 on the adoption-diffusion pattern showing young farmers preference and tendency to adopt new technologies faster than old farmers. The study also revealed that the mantle of cotton cultivation has been smoothly passed on from older generation to the younger generation. It was observed that among the respondents, usually the head of the household directed his son/daughter to respond to the survey indirectly indicating that the younger generation was involved in the decision making. In summary, Table 7 shows the socio-economic profile of cotton farmers surveyed in Maharashtra, Andhra Pradesh and Punjab.

Table 7. Socio-Economic Profile of Cotton Farmers in Maharashtra, Andhra Pradesh and Punjab

Socio - demographic profile	Maharashtra		Andhra Pradesh		Punjab		India	
	Freq (n=1000)	%	Freq (n=1000)	%	Freq (n=400)	%	Freq (n=2400)	%
Age								
< 20	10	01	20	02	09	02	39	1.6
21-40	500	50	529	53	252	63	1281	53.4
40-60	421	42	398	40	124	31	943	39.3
> 60	69	07	53	05	15	04	137	5.7
Gender								

Female	38	04	50	05	12	03	100	4.2
Marital Status								
Married	937	94	901	90	393	98	2231	93
Single	60	06	80	08	05	01	145	6
Widow/Widower	03	71	19	02	02	01	24	1
Number of Children								
None	202	20	105	11	24	06	331	13.8
1-2	610	61	513	51	224	56	1347	56
3-4	180	18	337	34	128	32	645	26.9
> 4	08	<1	45	04	24	06	77	3.3
Social Category								
General	322	32	484	48	208	52	1014	42.3
SC	76	08	64	06	44	11	184	7.7
ST	113	11	75	08	16	04	204	8.5
OBC	489	49	377	38	132	33	998	41.5
Educational Status								
Illiterate	22	02	Nil	00	08	02	30	1.3
Primary (upto 5th)	25	03	180	18	84	21	289	12
Secondary (upto 10th)	673	67	610	61	216	54	1499	62.5
Graduate	227	23	191	19	68	17	486	20.2
Post-graduate	53	05	19	02	24	06	96	4
Membership of Organization								
Farmer's association	120	12	231	23	101	25	452	18.8
Corporative	340	34	290	29	107	27	737	30.7
Women's group (SHG)	189	19	250	25	51	13	490	20.4
No membership	351	35	229	23	141	35	721	30.1
Source of Income								
Farming alone	478	48	322	32	Nil	00	800	33.3
Integrated farming	252	25	369	37	248	62	869	36.2
Business	110	11	212	21	62	16	384	16.0
Service	69	07	31	03	23	06	123	5.1
Other (not specific)	91	09	66	07	67	16	226	9.4

Gender Involvement

The data on gender clearly indicated the dominance of male farmers in cotton farming. No significant differences were observed with regard to the gender pattern in cotton cultivation in different states. Across the surveyed states, more than 95% respondents were male farmers (Table 7). The trend showed that farming is regarded as male profession requiring robust physical hard work of farm operation like ploughing, harrowing, harvesting, transport and marketing. Another significant realization is that males continued to represent the head of the family in farm transactions. Nevertheless, the survey observed an active role of women in farming particularly to support men in household matters and play an active part in farm operations including weeding, picking and cleaning etc.

Marital Status

The survey reported that majority of farmers were married across the states (Table 7). Although the farmers of age group of 20 to 40 years were dominating, the survey observed that early marriages were a common practice amongst villages across Maharashtra, Andhra Pradesh and Punjab. The status of finding more than 90% married cotton farmers was the indication of early marriage phenomena amongst young group of Bt cotton farmers. Interestingly none of the surveyed farmer even widower was keen to reveal this fact. The survey also reported the common social practice of remarriage following the demise of the spouse in most of the surveyed villages.

Number of Children

The number of children of cotton farmers ranged from none to more than 4, with an average of 1.82. Nearly 56% respondents had 1 to 2 children with more number of children in Maharashtra followed by Punjab (Table 7). This observation was in tune with the recent population survey of Govt of India indicating that the rate of growth amongst general population has come down in the last decade. The trend of 1 to 2 children correlated with those families with higher literacy amongst farming community. The study reported a great variation at district level in Maharashtra and Andhra Pradesh as number of children varied from 1 to 3. On the whole, the study reported that farmers have a smaller family size. The Indian concept of joint family did exist in Maharashtra and Andhra Pradesh but by and large the tendency to move towards nuclear families increased in the recent past as observed in the study. As a result, the survey revealed that there has been a rampant fragmentation of the land holdings resulting in an increase in the number of small holder families.

Social Category

The number of farmers belonging to the scheduled caste and scheduled tribe (SC/ST) categories who were benefited by special welfare programs run by Govt of India were fairly less (7.7 to 8.5%) as compared to other backward class (OBC) category which included a number of small communities and castes reported in the survey. At national level, farmers belonging to OBC and general category outnumbered the reserved category farmers in cotton farming (Table 7). Interestingly, it was reported that more than 50% of surveyed farmers in Maharashtra were from OBC category whereas Punjab had more than 50% from general category indicating a large variation amongst cotton farmers in different States. This variation is basically due to recent classification of some castes in Maharashtra into OBC from general category (Table 7).

Educational Status

The survey reported that about 62.5% farmers across the country were literate and had education up to 10^{th} standard or equivalent to secondary school education. Maharashtra and Andhra Pradesh reported higher literacy rate in cotton farmers than Punjab. Remarkably, the survey reported merely 1.3% illiterate respondents and 12% of farmers with primary education. Around 20% of the sampled farmers were graduates and were highly educated among the surveyed villages. Thus, the survey noted that cotton farmers across the State were literate with education level ranging from primary to post graduate education. Although, education does not appear to be a criteria for taking up cotton farming, however the survey reported farmers concern about those who were highly educated were not actively involved in farming activities. Apparently, the literacy programs and campaigns by respective States helped to remove illiteracy to a large extent as reported by respondent cotton farmers during the survey.

Membership of Organizations

The grass root level organizations form an integral part of rural communities and these often act as nerve centers for discussions and promotion of technologies. The survey noted that a majority equivalent to 79.9% of the farmers were members of some or the other organizations. However, 30.1% farmers for reasons which they did not reveal were not members of any organization. The survey recorded higher tendency of cotton farmers enrolled to support organization in Maharashtra and Punjab rather than in Andhra Pradesh. In general, Maharashtra reported a large numbers of grass root organizations playing a proactive role in providing various services to farming communities. Interestingly, the self help group (SHG) promoted by State governments were prevalent in villages where either women farmers or the wives of male farmers actively participate in the activities of these organizations. In fact, the survey recorded that out of 2400 farmers surveyed, about 490 farm women were members of the self help group. This is in

contradiction to the earlier observation that these were only 100 women farmers because of membership of the wives of male farmers to these self help groups. The critical analysis of district level data revealed that all 490 women were the owner of land and the head of the family but many of them were wives of farmers. The survey noted that the cooperatives at state level were the most functional organization for membership of the farmers. None of the farmers were the members of any national level farm organization that often claimed to represent cotton farmers at the level of Govt of India on several issues related to agricultural policies, planning and resource allocation etc.

Sources of Income

Only 30.5% farmers reported that they have other sources of income from activities such as local shops, tea stalls, dhaba, flour mills, job at cooperative mill or other part time job in local private enterprises and others reported that they derive income from occupations such as driving, carpentry etc. A majority of farmers, around 48% in Maharashtra and 32% in Andhra Pradesh stated that their principal source of income was from farming (Table 7).

The integration of farm income other than cotton like maintaining milch cattle, bee keeping, mushroom farming and other farm and non-farm activities was predominant in Punjab where none of the farmers reported sole dependency on farming along. The survey noted that farmers in Punjab generally harvest double cropping i.e. cotton followed by wheat whereas cotton followed by vegetables, pulses and oilseeds were common in Maharashtra and Andhra Pradesh. In Punjab, nearly 13.3% farmers were skilled workers and a few of them were in the business like selling of animals, marketing of produce, furniture and agri-inputs dealers. Notably, cotton farmers of Punjab were much better off than those of Maharashtra and Andhra Pradesh mainly because of additional sources of income to supplement farm income.

Farm Profile and Farm Holding

The average farm size of Bt cotton farmers was 2.1 hectares with 52.2% cotton farmers having less than 3ha and 19.5% having between 3 to 4 hectare (Table 8). The average farm size of almost 59% of surveyed farmers in Maharashtra and Punjab was nearly 2.9 hectares. About one third farmers, approx. 36% were having above 4 hectares in Punjab but less than 30% farmers in Andhra Pradesh and Maharashtra had above 4 hectares land. None of the farm indicators underscored the land holding as an attribute of the adoption of Bt cotton. Contrary, farmers irrespective of land holding in Punjab, Maharashtra and Andhra Pradesh adopted Bt cotton indicating that the technology was scale neutral in nature.

Table 8. Farm profile and Farm Holdings of Cotton Farmers

Farming profile	Maharashtra		Andhra Pradesh		Punjab		India	
	Freq (n=1000)	%	Freq (n=1000)	%	Freq (n=400)	%	Freq (n=2400)	%
Farm holding (ha)								
<1	48	05	197	23	25	06	270	12
1-3	492	49	250	30	158	40	900	40.2
3-4	226	23	140	17	71	18	437	19.5
>4	234	23	253	30	46	36	633	28.3
Years in Farming								
<5	116	12	67	08	04	01	187	8.3
6-10	101	10	143	17	45	11	289	12.9
10-20	473	47	302	36	39	10	814	36.4
>20	310	31	328	39	312	79	950	42.4
Years in cotton Farming								
<2	0	0	0	0	0	0	0	0
3-5	18	2	127	15	19	5	164	7.3
6-10	102	10	101	12	57	14	262	11.7
>10	880	88	612	73	322	81	1814	81
Availability of Irrigation								
Full	88	09	176	21	392	98	656	29.3
Partial	240	24	194	23	8	02	442	19.7
Rainfed	672	67	470	56	0	0	1142	51

Number of Years in Farming

More than two third of the respondents or 78% were farming since 10 to 25 years. On an average, Bt cotton farmers were in farming profession for more than 5 years. Only 21% were practicing farming for less than 10 years. In Punjab, Bt cotton farmers or 79% of the respondents were in farming for more than 20 years as against only 31% and 39% in Maharashtra and Andhra Pradesh respectively. The average farming experience in Maharashtra was 18, in Andhra Pradesh around 15 and in Punjab around 24 years. This clearly indicated that Bt cotton adopters were not amateur farmers but they were the ones who had wide exposure and experience in farming.

Number of Years in Cotton Cultivation

The survey data were also collected from Bt cotton farmers on the number of years in cotton farming. It was found that by and large or 81% respondent farmers were experienced in cotton cultivation for more than 10 years across the States. In Andhra Pradesh, 73% respondents were in cotton cultivation for around 10 years but the corresponding figures were 88% in Maharashtra and 81% in Punjab. The average years of cotton farming varied from 14 to 20 years in all the States indicating experience of cotton cultivation. The survey reported that farmers' experiences and their peer experiences have had an overwhelming influence in decision making on Bt cotton across the States.

Rainfed and Irrigated Cotton

The data in Table 8 confirms the statistics of Govt of India that two third of respondent farmers of Maharashtra particularly those chosen from districts of Marathwada and Vidharbha were undertaking rainfed cotton farming while Punjab farmers (98%) had full facility for irrigation. In Andhra Pradesh, 21% of the farmers had access to full irrigation whereas 23% had access to some source for providing protective irrigation to the crop.

Economic Profile

The survey found out that Bt cotton farmers were extremely careful in sourcing capital for farming and marketing cotton produce. A majority of farmers confirmed that they carefully considered various factors before adopting any new technology, which is cost effective and safe. Many farmers were of the opinion that Bt cotton was initially adopted by rich farmers who could afford to take risk before a wide spread adoption by other farmers.

Source of Capital

The cotton farmers had multiple sources of capital for farming. Farmers availed institutional capital mainly from cooperative banks which was main source of capital for 64% of cotton farmers in Maharashtra and 47% in Andhra Pradesh. On the contrary, 47% of respondent farmers borrowed money from traders and 44% availed loan from institutional banks for cotton farming. The contribution from relatives or money lenders was very less in all the surveyed states. In fact, there were sizeable number of farmers who did not respond to this question. Some farmers in Maharashtra opined that there could be many more cases of farmers taking loans from money tenders but refused to divulge exact source because of stringent law enforcement due to cases of suicides in rural Maharashtra. Many farmers did not correctly reply to the question on money

lenders. It was estimated, however, that 15% farmers in Maharashtra and 12% in Andhra Pradesh still use this route of capital for cotton farming. The traders particularly ginners and the input suppliers were also involved in offering loans either in cash or in the form of inputs such as seeds, fertilizers, pesticides and farmers in turn sell their produce through these traders. The survey also noted that many traders helped farmers to meet their social commitments (Table 9). The survey concluded that cotton farmers seldom used their own savings in farming even if they had.

Table 9. Source of Capital, Farm Income and Marketing Avenues for Cotton Farmers

Farming profile	Maharashtra		Andhra Pradesh		Punjab		India	
	Freq (n=1000)	%	Freq (n=1000)	%	Freq (n=400)	%	Freq (n=2400)	%
Source of Capital								
Bank/financial institutions	639	64	473	47	177	44	1289	57.5
Traders	142	14	146	15	189	47	477	27.3
Relatives	50	05	101	10	16	05	167	7.4
Money lenders	18	02	09	01	01	<1	28	1.3
No response	151	15	271	27	17	04	439	19.5
Marketing of Produce								
Cooperatives	218	22	90	0	00	00	308	12.8
Open mandi	52	05	342	34	167	42	561	23.4
Ginners/traders	702	70	518	52	233	58	1453	60.5
No comments	28	03	50	05	00	00	78	3.3
Farm Income Rs/ha annually (Total)								
< 50,000	318	32	229	23	16	4.0	618	25.8
50-1,00,000	212	21	259	26	228	57.0	927	38.6
1,00,000-1,50,000	204	20	163	16	145	36.0	512	20.4
>1,50,000	159	16	178	18	11	3.0	348	14.6
Not answered	107	11	171	16	00	00	278	10.6

Marketing of Cotton Produce

In Maharashtra, cotton was almost exclusively sold to the Maharashtra State Cooperative Cotton Growers Marketing Federation. However, in the recent years, cotton farmers in Maharashtra started selling cotton through various channels due to large scale cultivation

of Bt cotton that led to better quality cotton production and better realization to cotton farmers. Secondly, Bt cotton also led to a significant increase in cotton area and thus a substantial increase in cotton production resulting in selling in market at a price higher than the minimum support price offered by cooperatives. In summary, Maharashtra resorted to a multiple outlets for cotton produce in line with the cotton market/mandi system of Punjab and Andhra Pradesh. A large number of farmers reported selling of cotton produce to traders at their selling points who are either cotton ginners or involved in the cotton value chain. As much as 70% farmers in Maharashtra, 52% in Andhra Pradesh and 58% in Punjab reported selling cotton through multiple points in the market system. The cooperative federation began running a parallel purchasing through market led mandis. In Maharashtra, around 22% farmers preferred to sell cotton to cooperatives federation as they realized payment through cheques in favor of their accounts in the cooperative banks. Unlike Maharashtra, there was no concept of cooperative marketing of cotton in Punjab and a very small number of cotton farmers used cooperative federation route to sell cotton in Andhra Pradesh. Open Mandi's were very common in Punjab wherein almost 42% farmers sold their cotton produce. The survey also noted that many cotton market mandis recently upgraded to handle large quantity of cotton arrivals, quality checks and make instantaneous payments. Many experts believed that the upgradation of cotton market mandis was possible through the implementation of the Technology Mission on Cotton launched by the Govt of India.

Total Farm Income

The survey attempted to get the most critical answer for the question of average income from farming and the income from cotton alone in the surveyed States. Separate questions were also asked particularly on Bt cotton which was being cultivated for more than 5 to 6 years in most cases. Farmers across Maharashtra and Andhra Pradesh were highly reluctant to answer the questions related to assessing approximate income however, Punjab farmers were very open on this issue and answered questions more freely.

In Punjab, the attempts were made to calculate the estimate of net returns from cotton-wheat rotation, which was common in all the districts of the study. On average, 57% of the respondent farmers earned farm income between Rs. 50,000 to 1 lakh whereas farm income for 36% ranged between Rs. 1 lakh to 1.5 lakh per annum in Punjab. Only 3% of farmers earned more than Rs. 1.5 lakh per ha annually. Similarly a very few or 4% of farmers could not earn more than Rs. 50,000 per hectare per annum (Table 9). The survey reported a very different trend in farm income in Maharashtra with 32%, 21%, 20% and 16% earned farm income of less than Rs 50,000, Rs. 50,000 to 1 lakh, 1 lakh to 1.5 lakh and more than 1.5 lakh respectively. In Andhra Pradesh, 18% farmers earned more than

Rs 1.5 lakh per annum followed by 16% earning between Rs 1 lakh to 1.5 lakh, 26% earning between Rs 50,000 to 1 lakh and 23% less than Rs 50,000 per annum. On national average, the survey revealed that 38% of cotton farmers had net income of Rs. 50, 000 to 1, 00,000 per hectare per annum.

The farm income findings were based on computing the data provided by farmers on total produce, farm size, rate of produce in 2012 season and the expenses farmers incurred in farming. Unfortunately, most of the information on income and expenses were shared on the basis of memory of farmers as they seldom kept records of farm expenses and farm income. Notably, the farmers were not very serious about the net returns as long as they had money to repay their loans and meet their social commitments. The study did not report the gross income from all farm produces mainly because the data were not in order or matching with what the respondents answered. However, for cotton, a separate series of questions were aimed at getting the economics of cotton cultivation amongst the farmer across the chosen states. The farm income of Bt cotton is discussed in subsequent chapter on Bt cotton adoption.

Farm Activities Performed by Family Members

Table 10 lists nine major farm activities identified in India which were performed either by farmer himself/herself or with hired labour or by their family members. The analysis of data in Table 10 clearly showed that the activities that involved physical labour such as ploughing, harrowing, planting, fertilizer application and pesticide spraying were not done by women members of the family. Male members along with farm labour performed majority of farm operation activities. However, weeding, input application and pickings were either performed by women of the family in Maharashtra, Andhra Pradesh and to some extent in Punjab. In Punjab, women or women labour did not perform weeding and input applications. Nearly 90 per cent of the farmers reported that harvesting was done with the labour mostly women labour in Maharashtra & Andhra Pradesh but not in Punjab. However the entire marketing of the produce was done exclusively by the farmer himself. The survey found a negligible role of children in farming activity in all of the surveyed States. The survey clearly indicated that Bt cotton farmers were mostly male farmers who performed majority of farm activities related to cotton production and made crucial decisions on farm activities. In general, the women of farmer families supplemented the women laborers in picking of cotton. Farmers reported the hiring of laborers especially during land preparation, weeding, input applications and harvesting in Punjab and to some extent in other States.

Table 10. Farm Activities Performed by Farmers and Their Families

Farming activities (%)	Maharashtra			Andhra Pradesh			Punjab		
	1	2	3	1	2	3	1	2	3
Preparation Land	80	20	0	84	16	00	82	18	00
Buying of seed	78	03	19	85	01	15	92	00	08
Planting	85	10	05	82	09	09	82	18	00
Weeding	12	80	08	08	82	10	30	70	00
Fertilizer application	15	80	05	12	82	06	20	80	00
Irrigation	35	55	10	30	60	10	18	75	05
Pesticide application	05	95	00	08	92	00	10	90	00
Harvesting	03	90	07	05	92	03	01	98	01
Marketing	90	0	10	92	00	08	92	00	80
1=By self; 2= With hired labor; 3= Family members									

Adoption of Bt Cotton: Events and Hybrids Planted

In 2002, only 3 Bt cotton hybrids of Mahyco were approved for commercial cultivation in the Central and Southern zone of the country. Subsequently an additional Bt cotton hybrid developed by Rasi Seeds was released for commercial plantation in 2004. By 2005, all the 9 cotton growing states of the country including Northern zone were permitted cultivation of Bt cotton. Over the years a large number of Bt cotton hybrids have been approved for planting belonging to 40 private seed companies between 2002 to 2012.

In the early years, Bt cotton hybrids were popular initially by their numbers like Rasi-2, MECH-12, MECH-152 and Ankur-161 etc. The cotton farmers reported that they usually remembered either the name of company or the number of Bt cotton hybrids. During the survey, cotton farmers informed that there was only BG-I type of Bt cotton hybrids, which were sold by many seed companies in the initial years. Later, farmers recounted activities by dealers, retailers and private seed companies relating to the introduction of a new type of cotton called BG-II popularized by MMB in 2006 onwards. In 2012, the year of survey, on average 77.8% of surveyed farmers were planting BG-II Bt cotton hybrids followed by 10.8 % of BG-I, 1.2% of Event-1 and GFM event based hybrids and approx. 10.4% Bt cotton hybrids were unidentifiable. Maharashtra, Andhra Pradesh and Punjab exhibited similar trend on the adoption of different types of Bt cotton (Table 11).

Table 11. Classification of Bt Cotton Events Used by Cotton Farmers

Farming profile	Maharashtra		Andhra Pradesh		Punjab		India	
	Freq (n=1000)	%	Freq (n=1000)	%	Freq (n=400)	%	Freq (n=2400)	%
BG-I (MMB)	123	12	113	11	23	06	259	10.8
BG-II (MMB)	760	76	777	78	328	82	1865	77.8
Event-1 (JK Seeds)	20	02	01	00	00	00	20	0.8
GFM (Nath Seeds)	08	01	00	00	00	00	08	0.4
MLS-9124	00	00	00	00	00	00	00	00
Unidentifiable	89	09	110	11	49	12	248	10.4
BNLA-601 : Bt cotton event promoted by CICR has been discontinued								

The survey reported the availability of large number of Bt cotton hybrids across the surveyed villages and observed a massive marketing campaign to promote different Bt cotton hybrids belonging to different companies. However, 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 Bt cotton hybrids with a very 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 of Bt cotton hybrids in the field. Punjab farmers showed a high degree of changes in preference about 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 (Table 12).

Table 12. Dominant Bt Cotton Hybrids of Different Seed Companies in Three States

Name of Company	Maharashtra	Andhra Pradesh	Punjab
Mahyco Seeds	Dr. Brent/MRC7351	Dr. Brent	Nikki
Ankur Seeds	Jai-3028	Jai-3028	Jai-3028
Nuziveedu Seeds	Mallika	Mallika	Mallika

Shriram Bioseeds	No presence	Not seen	6488, 6588
Ajit Seeds	Ajit-155	No presence	No presence
Rasi Seeds	Rasi-530	Rasi-530	-
Kaveri Seeds	Jadu, Jackpot	Jadu, Jackpot	No presence

Table 12 shows the preferences of different Bt cotton hybrids in Maharashtra, Andhra Pradesh and Punjab. Farmers reported planting of Bt cotton hybrids known as per the denomination either recalled brand name or name of the company marketing Bt cotton hybrids such as Dr. Brent, Bunny, Mallika, Jai, Ajit, Rasi, JK and Nath seeds. In summary, a majority of farmers were planting BG-II hybrids produced and marketed by different seed companies. The survey revealed the dominance of BG-II hybrids by 78% followed by 11% BG-I event based Bt cotton hybrids both introduced by MMB. The adoption of Bt hybrids containing other events were negligible. Nearly 10% of the farmers could neither identify event or the company that marketed them.

Farmers were dependent on what the seed companies offered and dealers supplied to them. However, several states have started regulating the supply of seed packets in each district to avoid clamor for any one or few brands of Bt cotton hybrid which often created black market and disturbed law and order situations due to non-availability of preferred Bt cotton hybrids. Interestingly, in many cases, cotton farmers could correctly recall name of Bt cotton hybrids because of the familiarities of these names either with God/Goddess such as Brahma, Mahesh, Laxmi and Vishnu or other attractive names such as Gold, Jadu and Jackpot. The seed companies strategically branded their Bt cotton hybrids to improve their brand retention among farmers. In many cases, many cotton farmers recognized the brands of seeds without recognizing the name of their suppliers. A list of popular names of brands and their respective companies are highlighted in Table 12. Notably, cotton farmers recalled the names of established seed companies which have been in existence for long time and have been involved in the seed business of cotton, other field crops and vegetables such as Mahyco, Rasi, Ankur, Monsanto, Bayer, Nuziveedu, Ajit, Bioseeds and Kaveri to name a few. This finding of the survey is in conformity with the data published by many organizations including the Biospectrum magazine that annually produces the rating of Bt cotton hybrid seed companies (Biospectrum-ABLE survey, 2012).

Number of Years into Planting Bt Cotton

The data collected on the experience of farmers planting Bt cotton indicated that at national level, an average experience with the cultivation of Bt cotton was 6.5 years (Table 13). Nearly 42% of respondent farmers were planting Bt hybrids for more than 3

years but less than 5 years, while 50% farmers were planting Bt hybrids for more than 6 years. In the early years, the growth of Bt adoption was slow due to limited production and sale of Bt cotton hybrids to limited area. Therefore, the survey revealed that only 4 to 11% (national average of 8%) farmers planted Bt cotton consistently for more than a decade from 2002 to 2012. In Punjab, Bt cotton was released for planting in 2005. However, 16 farmers out of 400 surveyed cotton farmers reported planting of Bt cotton for over a decade confirming the planting of Bt cotton seeds prior to official release in the Northern zone.

Table 13. Number of Years of Planting Bt Cotton

Years of planting	Maharashtra		Andhra Pradesh		Punjab		India	
	Freq (n=890)	%	Freq (n=750)	%	Freq (n=400)	%	Freq (n=2040)	%
> 2	2	>1	3	>1	8	02	13	>1
3-5	401	45	308	41	145	36	854	41.9
6-10	418	47	360	48	231	58	1009	49.5
>10	69	08	79	11	16	04	164	8.0

Factors Considered in the Adoption of Bt Cotton

Table 14 summarizesthe data for agronomic, economical and social factors that cotton farmers considered crucial for the adoption of Bt cotton in the respective States. In the questionnaire, cotton farmers were given multiple choices to select the answers. Interestingly, the frequency of respondents varied for each factor on agronomic, economic and social parameters.

Notably, the most important factor that cotton farmers considered as critical for the adoption of Bt cotton was agronomic followed by economic considerations. Freedom from repeated chemical sprays and its subsequent link to successful management of bollworm ranked top. Freedom from the dreaded pest bollworms was clearly predominant factor in the minds of farmers. Interestingly, cotton farmer recounted their experiences of the frequent failures of cotton crops and vividly recalled the difficult period of living in the 'Spray or Pray' regime before the introduction of Bt cotton. The agronomic consideration, freedom from spray coupled with successful management of bollworm and reduced requirement of chemical sprays were some of priority wise considerations in accepting Bt cotton by cotton farmers across the surveyed States. The possibility of a subsequent crop and quality of seed cotton produced in the first few cotton flush were other dominant factors in Maharashtra and Andhra Pradesh. The farmer had less

relevance of second crop in Punjab as the irrigated area was already under double cropping system (cotton -wheat).

Table 14. Agronomic, Economic and Social Factors for Adoption of Bt Cotton by Farmers

Category	Maharashtra		Andhra Pradesh		Punjab		India	
	Freq (n=1000)	%	Freq (n=1000)	%	Freq (n=400)	%	Freq (n=2400)	%
Agronomic								
Success in bollworm management	820	82	721	72	362	90	1903	79.2
Freedom from bollworm spray	891	89	780	78	398	99	2069	86.3
Reduced spray	732	73	797	80	390	98	1919	80.0
Early, good quality cotton harvest	624	62	592	59	176	34	1392	58.0
Second crop possible easily	788	79	711	71	85	21	1584	66.0
Economic								
High yield	254	25	525	52	388	97	1167	48.6
Higher income and better profit margin	377	38	418	42	370	93	1165	48.5
Cost of seed	209	21	147	15	97	24	447	19.0
Reduced labor and easy picking	238	24	159	16	50	13	445	19.0
Social/other								
Impressed by demo	326	45	181	22	130	32	637	32.6
Friend/relative influenced	73	10	174	21	17	04	264	13.5
Witnessed the success of others	240	33	346	42	70	17	656	33.6
Status symbol of growing Bt cotton	361	50	90	11	05	01	456	23.3
*Based on multiple responses								

Amongst economic consideration, a large number of respondents considered a significant reduction in chemical sprays on cotton resulting in high income and better profit margin

as an important factor in adopting Bt cotton in Punjab. On the contrary, less than 40% farmers from Maharashtra and less than 40% farmers from Andhra Pradesh attributed income and profit margin as a major consideration. Ironically, cotton farmers across three States recognized the cost of seeds as a lowest consideration in accepting Bt cotton and surprisingly farmers in general ignored to accept it as an important factor. However, the authors of the study were puzzled to note the controversy associated with the cost of Bt cotton seeds at the national level. The issue of reduced spray and better management of bollworms coupled with higher yield and better profit margin were the factors cotton farmers considered while adopting Bt cotton at the national level.

The study reported that the adoption of Bt cotton was predominantly influenced by agronomic and economic considerations. Importantly, the study also recognized that there was also a social angle to the adoption process. In Maharashtra, the survey reported that the cultivation of Bt cotton cultivation was also seen as a status symbol in the farming community. The majority of cotton farmers or 50% of them considered growing Bt cotton as a status symbol in the society which was weighing much higher than other factors such as demonstration and success of fellow farmers considered important by 33-45% respondent farmers. In Andhra Pradesh, the status symbol factor was nearly absent among surveyed farmers whereas the success obtained by others due to the adoption of Bt cotton influenced their decision as reported by 42% cotton farmers. Similarly, the social status as a factor was absent in Punjab wherein 32% of cotton farmers considered the demonstrations carried out by private seed companies on their research farms a motivational factor to adopt Bt cotton. In essence, the survey revealed these subtle differences in the adoption behaviors of Bt cotton farmers show how much the agriculture is intertwined to the social fabric of the rural community across the surveyed States.

The discussions with farmer groups by the authors in the three States during the survey revealed the fact that the farmers remembered years of bollworm outbreak such as 1978, 1982 and the cycles of 3 to 4 years of outbreaks of bollworm causing huge financial losses due to the epizootics nature of the insect-pests bollworm on cotton crop. In fact a series of studies carried out by several organizations pointed out to the fact that the farmers suicides in Andhra Pradesh started in 1982 due to utter failure of cotton crop as insect-pests bollworms developed resistance to chemical pyrethroids and repeated sprays resulted in resurgence of whiteflies on cotton (Kranthi, 2012). These cases of crop failures during late seventies and early eighties in Andhra Pradesh have been properly documented. In summary, it was not surprising that the agronomic factor of successful control of bollworm and freedom from sprays were the dominant factors in the minds of cotton farmers who opted for cultivation of Bt cotton in the respective States.

Mode of Adoption of Bt Cotton

For understanding the mode of adoption, the questionnaire was designed in such a way as to seek answers to three important questions on the mode of adoption, 1) full package adoption referred to adoption of the recommended package of practices provided either by the company or by SAUs/KVKs; 2) partial adoption referred to adoption of only a few practices and 3) modification of package of practices in which farmers modified the recommended package of practice based on their own experience. Table 15 shows the mode of adoption of Bt cotton by farmers across three States. The data indicates that farmers seldom adopted the entire package of practice recommended for Bt cotton cultivation presumably because the conditions under which these practices were developed were different from those under which farmers operated. The majority of the farmers or 60 to 80% in three States and on average 69.2% at all India level modified the practices to suit their local conditions and requirements. Notably, cotton farmers tweaked the package of practices to suit cotton cultivation in their respective areas such as changes in the seed rate, spacing, irrigation schedule, fertilizer dose and time of pesticide application. It was observed that farmers normally followed the practices of land preparation, time of sowing, picking and weeding as per the recommendations.

The variations in adoption of the practices were also evident from one farmer to another. No two farmers used the similar spacing, fertilizer and pesticide application etc. None of the Bt cotton farmers used scouting as suggested for the effective pest management in three States. In Punjab, the seed rate varied from 1.5 to 2 packets per acre while in Maharashtra and Andhra Pradesh it was 1.2 to 1.5 packets per acre. The spacing varied from place to place with a wide range of adjustments including 2x4, 3x4, 4x5, 3x5 feet and at some places it was observed 3x6 feet. The time of sowing ranged from dry sowing in the mid June to mid July in Maharashtra & Andhra Pradesh while in Punjab farmers planted cotton in the last week of April to mid May.

Table 15. Mode of Adoption of Bt Cotton by Farmers

Category	Maharashtra		Andhra Pradesh		Punjab		India	
	Freq (n=1000)	%	Freq (n=1000)	%	Freq (n=400)	%	Freq (n=2400)	%
Full package adoption	21	02	79	08	00	00	100	4.2
Partial adoption	122	12	221	22	19	05	362	15.1
Modification by self	744	75	96	60	321	80	1661	69.2

No replies	113	11	104	10	60	15	277	11.5
Major modifications: Seed rate, spacing, soil testing, irrigation, fertilizer dosages and pesticide application, no refuge and changes in time of sowing **No modifications:** weed management, land preparation, picking								

None of the cotton farmers in rainfed and irrigated areas planted refuge as per the recommendation of the Govt of India. The interactions with Bt cotton farmers during the survey confirmed that more than 90% farmers declined to use refuge of non-Bt cotton for planting in Bt cotton field. Moreover, a majority of 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. Interestingly, those farmers who received pigeonpea seeds as refuge preferred to plant strips of pigeonpea in Bt cotton field particularly in Maharashtra. Many famers also complained about low quality of non-Bt cotton refuge seeds and therefore avoided planting refuge fearing it would attract insect-pests and would not get desirable cotton yield. It is important to note that refuge is supplied as a separate packet of non-Bt counterpart of 120 gm along with the packet of Bt cotton seeds.

Benefits from Adoption of Bt Cotton

The most obvious benefits of Bt cotton adoption were the freedom from pesticide sprays and better control of bollworms in cotton fields. A majority of farmers surveyed across different villages in Maharashtra and Andhra Pradesh opined that Bt cotton enabled farmers to raise a second crop such pulses, vegetables and oilseeds. Raising a subsequent crop was one of key triggers for cotton farmers to adopt Bt cotton in Maharashtra and Andhra Pradesh. In contrast, farmers in Punjab did not consider this as an important factor as cotton-wheat system was established prior to the arrival of Bt cotton in Punjab. Around 98% in Punjab and 85% in Andhra Pradesh considered higher income as an important benefit in adoption of Bt cotton which was not considered so important by 42% of farmers in Maharashtra. The reason for this discrepancy could be due to the fact that only 24% of the farmers in Maharashtra considered higher yield as major benefits from Bt cotton unlike 79% in Andhra Pradesh and 100% farmers in Punjab. Only a small minority or 7.8% farmers at all India level could not perceive any tangible benefit from adoption of the technology however the reason for their continuation with Bt cotton was not immediately made available to the survey team (Table 16).

Table 16. Benefits from Adoption of Bt Cotton

Category	Maharashtra		Andhra Pradesh		Punjab		India	
	Freq (n=1000)	%	Freq (n=1000)	%	Freq (n=400)	%	Freq (n=2400)	%
Bollworm control	991	99	992	99	400	100	2383	99.3
Reduced spray	777	78	817	82	392	98	1986	82.8
High yield	241	24	794	79	398	100	1433	59.7
Both bollworm and high yield	403	40	892	89	370	93	1665	69.4
Higher income	424	42	851	85	390	98	1665	69.4
Labor saving	83	08	87	09	55	14	225	9.4
No major gains	59	06	99	11	30	07	188	7.8
*Multiple responses								

Credible Sources of Information for Bt Cotton

Data presented in Table 17 clearly indicates that 30 to 52% of the respondent farmers derived primary information for Bt cotton cultivation from input retailers, dealers and seed companies that enthusiastically promoted Bt cotton hybrids across the surveyed villages. At national level, the aggregate figure was 40% who primarily relied on private sources for credible information on Bt cotton cultivation. Unlike Andhra Pradesh and Maharashtra, 55% of respondent farmers considered the progressive farmers as the main source of the information on Bt cotton in Punjab. The role of public sector extension system including SAUs, KVKs and agriculture departments was minimal and around 10 to 11.5% respondent farmers referred to them at all India level. The role of public sector extension agencies was more perceptible in Andhra Pradesh than other two States. It is noteworthy to report that the respondent farmers for unexplained reasons had found a dismal role of mass media in the promotion of Bt cotton technology in all three States. This obviously means that the mass media in rural India did not consider the content of Bt cotton either relevant or appealing to them as Bt cotton was a positive subject of discussion amongst cotton farmers.

Table 17. Credible Sources of Information Obtained by Farmers on Bt Cotton

Source	Maharashtra		Andhra Pradesh		Punjab		India	
	Freq (n=1000)	%	Freq (n=1000)	%	Freq (n=400)	%	Freq (n=2400)	%
Progressive farmer of village	199	20	322	32	220	55	741	30.9
Input dealers/seed companies	524	52	299	30	135	34	958	40.0
Agri officer (ext)	97	10	146	15	33	08	276	11.5
SAUs/KVKs	55	06	154	15	29	07	238	9.9
Relatives/friends	79	08	59	06	15	04	153	6.4
Media (TV/paper /magazine)	46	04	20	02	08	02	74	3.3

Sharing of the Knowledge by Bt Cotton Farmers

Once Bt cotton was adopted by a select group of farmers, the diffusion of the technology depended upon the pace of knowledge sharing among the stakeholders. Data presented in Table 18 shows that the nature of knowledge sharing was similar across the surveyed States. At all India level, the knowledge on Bt cotton was commonly shared among fellow farmers (49%) followed by local traders and inputs retailers (58%). The survey noted a very low interaction of Bt cotton farmers with the staffs of the public sector extension system varying from SAUs (10.9%) to extension functionaries (11.3%) - often a more formal system which made it a less preferred route for Bt cotton farmers on knowledge sharing.

Table 18. Knowledge Sharing Amongst Bt Cotton Farmers in India

Category	Maharashtra		Andhra Pradesh		Punjab		India	
	Freq (n=1000)	%	Freq (n=1000)	%	Freq (n=400)	%	Freq (n=2400)	%
Fellow farmer	453	45	502	50	221	55	1176	49.0
Trader/dealer	605	60	555	55	232	58	1392	58.0
SAUs/KVKs	102	10	82	08	77	19	261	10.9
Agri officer (ext)	49	05	133	13	89	22	271	11.3
Media	112	11	140	14	34	08	286	11.9
No replies	79	08	119	12	09	02	207	8.6
*Multiple responses								

Nature of Information Shared by Bt Cotton Farmers

The survey noted that cotton farmers frequently shared information regarding the performance of Bt cotton hybrids, occurrence and management of pests and diseases in Bt cotton, input management strategies and input cost and market price related issues (Table 19). While performance of Bt cotton hybrids, inputs cost and market price and management of pests & diseases were the most important information shared in Maharashtra and Andhra Pradesh, cotton farmers in Punjab were more open to sharing information on input management of Bt cotton. Importantly, it was told that much of the information shared during a particular season was utilized by cotton farmers while selecting appropriate cultivars and managing the crop in the subsequent crop season.

Table 19. What Information/Knowledge Shared by Bt Cotton Farmers to Others

Information	Maharashtra		Andhra Pradesh		Punjab		India	
	Freq (n=1000)	%	Freq (n=1000)	%	Freq (n=400)	%	Freq (n=2400)	%
Hybrid cultivar	822	82	779	78	229	57	1830	76.3
Pests/diseases	805	80	849	85	254	63	1908	79.5
Fertilizer/ irrigation /inputs	710	71	6116	62	281	70	1607	67.0
Benefits	429	43	567	57	248	62	1244	51.8
Problems of seed price/ cost	824	82	709	71	131	35	1564	65.2
*Multiple responses								

Participation in Capacity Building Activities

It is well recognized that formal and informal trainings, workshops, farm visits, field days, farm exhibitions and demonstrations are some of formal external sources through which farmers improve their knowledge, information and skills. In progressive State of Punjab, 87% of Bt cotton farmers reported attending trainings and workshops, visited demonstration plots to learn more about Bt cotton technology (Table 20). On the contrary, only 14% of the farmers in Andhra Pradesh and 24% farmers in Maharashtra participated in capacity building activities to improve their understanding about Bt cotton. The survey reported that about 70% cotton farmers were keen to attend capacity building activities such as trainings and workshops on new crop technologies across the country. Notably, the seed companies and their dealers, retailers and suppliers of farm

input were the main organizers of these training programs in both Maharashtra and Andhra Pradesh. The role of the State Agricultural Universities (SAUs), KVKs and government extension system was slow in imparting and spreading knowledge and awareness about Bt cotton. However it was reported that the public sector extension system has been gradually picking up on the capacity building activities realizing the massive spread of Bt cotton across the surveyed villages. Interestingly, the survey noted that both State government (12%) and agricultural universities (20%) and progressive farmers' organizations were proactive in spreading knowledge about Bt cotton in the State of Punjab. It was also reported to survey team that during the initial years up to 2005, the seed companies and input dealers organized more than 80% of the training programs to encourage farmers to switch over to Bt cotton hybrids. During the subsequent year, the public sector extension system realized the true value of Bt technology through independent field experiments and commenced propagating the benefits of Bt technology to cotton farmers (Table 20).

Table 20. Participation in Capacity Building Activities on Bt Cotton Technology

Capacity building activities	Maharashtra		Andhra Pradesh		Punjab		India	
	Freq (n=800)	%	Freq (n=550)	%	Freq (n=320)	%	Freq (n=1670)	%
Yes/No								
Participated in some event	191	24	86	14	260	87	437	25.7
Not at all participated	609	76	514	86	40	13	1163	68.4
Organized by								
SAUs/KVKs	144	18	32	05	62	20	238	14.0
Govt depts	15	02	24	04	38	12	77	4.5
Seed companies	337	42	192	32	71	25	600	35.3
Input dealers	204	25	180	30	52	18	436	25.6
Others (including progressive farmer)	100	13	172	29	77	25	349	20.5
Showed interest in capacity building	728	91	276	46	186	62	1190	70.0

*Nearly 80% training before 2005 was provided by seed companies & dealers but subsequently SAUs/KVKs and govt departments also initiated capacity building activities on wide adoption of Bt cotton by farmers.

Services Received and Expected in Future for Bt Cotton

Table 21 summarizes the data in respect of farm services availed by Bt cotton growers, major service providers and the services expected in the future. The survey gathered that the majority of the respondent cotton farmers (44%) received no support for farm services such as finance, inputs and technical know-how across the surveyed States. Interestingly, cotton farmers in Punjab did not receive adequate support in this respect. However, a small section of cotton farmers in Maharashtra and Andhra Pradesh received financial support as compared to minimal support services received by cotton farmers in Punjab. Similarly, the survey noted that crop input services such as fertilizers and pesticides were availed by 21% farmers in Maharashtra, 16% in Andhra Pradesh and 5% of cotton farmers in Punjab.

Table 21. Services Received and Expected in Future for Bt Cotton

Services received	Maharashtra		Andhra Pradesh		Punjab		India	
	Freq (n=800)	%	Freq (n=550)	%	Freq (n=320)	%	Freq (n=1670)	%
Financial	121	15	54	10	0	00	175	10.5
Inputs	168	21	163	30	16	05	347	208
Technical	176	22	138	25	90	28	404	24.2
No support	335	42	195	35	198	62	728	43.6
Major Service Providers								
Seed companies	242	30	177	32	45	14	464	27.8
Dealer / distributors	416	52	302	55	145	45	863	51.7
Extension system	30	04	16	03	52	13	98	5.9
SAUs/ KVKs	112	14	55	10	78	22	245	14.7
Services Expected								
Quality inputs	177	22	122	22	78	25	377	22.6
Availability of capital	255	32	218	40	99	31	572	34.3
Technical info	246	31	154	28	115	36	515	30.8
Mechanization	122	15	56	10	28	08	206	12.5

The major service providers were the dealers and distributors of the private seed companies. In fact, the private agencies were more forthcoming in organizing input supply than the government agencies. The local dealers and retailers of farm inputs supplies were the interface between cotton farmers and private seed companies for continuously providing inputs support and requisite know-how for the proper management of Bt cotton crop. In comparison, the public sector extension system such as SAUs and KVKs were also engaged in providing support services at a scale lower than those of private sector. Cotton farmers received major technical support from local extension system with issues related to selection of hybrids and management of pests and diseases.

In response to the questions related to what support farmers needed for Bt technology, it was interesting to note that by and large 35% cotton farmers preferred to seek access to capital as one of the most sought after farm services (Table 21). In general, farmers demanded the farm support services which were grouped into various categories such as seeds and inputs, capital, technical selection of hybrid, planting pattern, drip irrigation and insect-pest control and machinery. In Maharashtra, nearly 31 to 32% cotton farmers opted for capital and technical support as the most sought after farm services in Bt cotton. However, as large as 40% respondent farmers in Andhra Pradesh preferred financial services for purchase of seed and inputs followed by technical services for adopting new technologies by 28% cotton farmers. On the contrary, a large percentage of cotton farmers (36%) in Punjab preferred receiving technical support as compared to financial services by only 31% respondent farmers. The finding of the survey is in line with the established fact that farmers in Punjab are very receptive to the adoption of new technologies, which was evident from the days of green revolution and believe that technical support is key for farm prosperity.

Cost of Cultivation of Bt Cotton

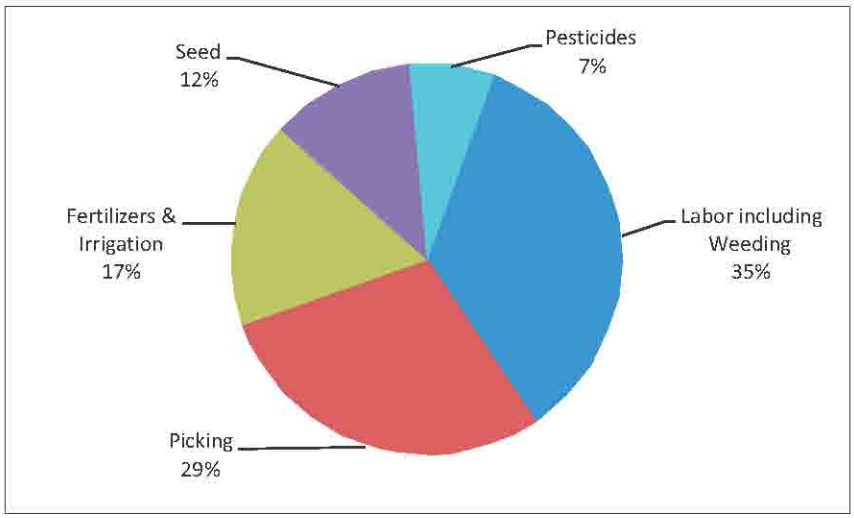
Table 22 shows various components of cost of cultivation of Bt cotton across rainfed and irrigated conditions. The survey reported that Bt cotton reduced and changed the composition of the cost of cultivation of cotton across three States. In the post-Bt cotton period, the total cost of production ranged between Rs. 35,500 to 36,500 per hectare. Interestingly the variation in inputs cost was observed marginal among States contrary to the perception that the cost of cultivation of irrigated cotton is higher than of rainfed cotton. The survey noted that on average, Bt cotton farmers spent around 64% of total inputs cost on labour including farm operation, weeding and picking as shown in Table 22 and Figure 7. Fertilizers and irrigation accounts for 17% of total inputs 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 that has reduced significantly and ranged from 5.9% in rainfed area to 8.3% in irrigated area, which was reported to be the lowest of all inputs cost post Bt cotton cultivation (Figure 7). The investment in 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 (Table 22). The cost of cultivation reported by the respondents is in line with the recent observations made by CICR. Cotton farmers across rainfed and irrigated areas complained about the timely unavailability and ever increasing cost of labors during the cotton season. For example, cotton farmers reported that picking cost of cotton increased significantly ranging from Rs 6 to Rs 10 per kg seed cotton corresponding to increase in cotton yield owing to adoption of Bt cotton.

Table 22. Cost of Cultivation of Bt Cotton

Cost of cultivation	Cost (Rs/ha)		
	MH (%)	AP(%)	PB(%)
Seed	3633 (9.9)	4180 (11.9)	5383 (15.2)
Fertilizers & irrigation	6090 (16.7)	6200 (17.6)	5468 (15.5)
Pesticides	2168 (5.9)	2736 (7.8)	2946 (8.3)
Labor	16071 (44.0)	10848 (30.8)	10172 (28.7)
Picking	8558 (23.4)	11250 (31.9)	11473 (32.4)
Total	36520 (100)	35214 (100)	35442 (100)
*Based on 729 respondents in Maharashtra, 602 in Andhra Pradesh and 398 in Punjab. Percentage cost of total is given in parenthesis.			

Figure 7. Average Distribution of Cost of Cultivation of Bt Cotton in Three States



Economics of Bt Cotton Cultivation

Table 23 summarizes the economics of Bt cotton cultivation based on the information provided by 1729 respondents from Maharashtra, Andhra Pradesh and Punjab. The surveyed farmers reported a substantial increase in net income of Bt cotton farmers corresponding to non-Bt cotton days. However, farmers also 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 last couple of years giving higher return to Bt cotton farmers.

The overall economics of Bt cotton cultivation was favourable to cotton farmers across three States. In 2011 Kharif season, the survey reported an average net income of Rs. 41,837 per hectare at national level which was reported to be highest in Punjab at Rs. 53,139 per hectare followed by Rs 39,786 in Andhra Pradesh and Rs. 32,885 per hectare in Maharashtra. Ironically, Maharashtra reported highest cost of cultivation whereas the reported yield was highest in Punjab and Andhra Pradesh (Table 23).

Table 23. Economics of Bt Cotton Cultivation

Particulars	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)	32,885	39,786	53,139	41,837
*Based on 729 respondents in Maharashtra, 602 in Andhra Pradesh and 398 in Punjab				
** Average cotton price Rs.40 to 42 per kg				

Willingness of Farmers to Continue Bt Cotton Cultivation

Table 24 shows cotton farmers' willingness to continue and discontinue the cultivation of Bt cotton across three States. The question posed to cotton farmers was to gather farmers insights on his/her willingness to continue or discontinue planting of Bt cotton after a decade of experience of cultivating Bt cotton since it was approved for commercial planting in 2002. In response to the question, the survey reported that 97% of respondent farmers in Punjab expressed their desire to continue with Bt cotton cultivation. Similarly, a little over 3/4th respondent farmers in Maharashtra and Andhra Pradesh showed willingness to continue with Bt cotton technology. Yield gains and freedom from

bollworm damage appeared to be the overwhelming reasons for their desire to continue with Bt cotton hybrids in respective States. The non-availability of good quality hybrid seeds of non-Bt cotton could be one of the reasons for their continuance as expressed by some farmers. In Maharashtra, a few cotton farmers expressed their desire to have straight cotton varieties with Bt instead of hybrids with Bt technology.

Table 24. Willingness of Farmers to Continue Cultivation of Bt cotton

Status	Maharashtra		Andhra Pradesh		Punjab		India	
	Freq (n=1000)	%	Freq (n=1000)	%	Freq (n=400)	%	Freq (n=2400)	%
Will continue	693	69	760	76	386	97	1839	76.6
Not continue	287	29	114	11	14	03	415	17.3
Unsure	20	02	126	13	00	00	146	6.8

Avenues for Utilization of Extra Income from Bt Cotton

While increased income from Bt cotton cultivation was a foregone conclusion, it was worthwhile to investigate how the additional farm income from Bt cotton was utilized across the States. Table 25 indicates the farmers in Maharashtra and Andhra Pradesh rated repayment of loan (21 to 28%) as the main avenue for utilizing extra funds earned from Bt cotton. The further consultations revealed prior indebtness was the main reason for repayments. Notably, farmers in Punjab reported spending extra income on purchase of household amenities and also on purchase of farm equipments and vehicles. Many farmers reported spending of additional income on house construction and renovation in Maharashtra and Andhra Pradesh. Similarly, farmers utilized extra income for social commitment such as education of children and marriage of daughters in the surveyed States.

Table 25. Extra Income Utilization by Bt Cotton Farmers

Items of Investment	Maharashtra		Andhra Pradesh		Punjab		India	
	Freq (n=1000)	%	Freq (n=1000)	%	Freq (n=400)	%	Freq (n=2400)	%
House construction/renovation	129	13	154	15	101	25	384	16.0
Purchase TV/AC/Washing machine, house hold items	160	16	152	15	79	20	391	16.3
Tractor / Farm Implements	121	12	126	13	83	21	330	13.8
Car / Two wheeler	73	07	98	10	97	24	268	11.2
Purchase of New land	17	02	48	05	04	01	69	2.9
Social commitments like marriage and education of children	20	02	47	05	20	05	87	3.6
Repayment of loan	280	28	214	21	00	00	494	20.6
No investments made	200	20	161	16	16	04	377	15.7

Constraints in the Adoption of Bt Cotton

Table 26 lists numbers of constraints encountered by farmers while adopting Bt cotton for cultivation in three States. The respondents were asked to prioritize the constraints faced with continuation of Bt cotton cultivation. Prior to adoption of Bt cotton in 2002, bollworm management was the major constraint as compared to Bt cotton era (Table 26). The surveyed farmers identified three major problems in Maharashtra which included the absence of proper irrigation facilities so as to maximize the yield potential from Bt hybrids (88%), high fluctuation in cotton market prices (78%) and high cost of Bt hybrid seeds. In Andhra Pradesh, farmers indentified the high cost of labor (69%) as the most critical constraint in addition to high seed cost and irrigation facilities. In addition to seed cost (70%) and labor wages (60%), the resurgence of pests and diseases (59%) were reported as major constraints in Punjab. Recent studies indicated that the number sprays to control sucking insect pests in cotton increased during early stage. The volatility in cotton market prices continued to remain a major issue in all three States, which rose from a low of Rs. 3,500 in 2009 to an all time high of 6,000 in 2011 before plummeting to around Rs. 4,000 per quintal in 2012-13. In summary, the constraints expressed by farmers were also reflected in the views expressed in the independent reports.

Table 26. Constraints in the Adoption of Bt Cotton

Constraints	Maharashtra		Andhra Pradesh		Punjab		India	
	Freq (n=1000)	%	Freq (n=1000)	%	Freq (n=400)	%	Freq (n=2400)	%
High seed cost	720	72	629	63	279	70	908	37.9
Lack of quality seed	522	52	502	50	150	38	1174	48.9
Inadequate knowledge	343	34	353	35	89	22	785	32.7
Irrigation facilities	880	88	555	55	90	23	1525	63.5
Pests/diseases	434	43	320	32	237	59	991	41.3
High cost of labor	555	55	692	69	244	60	1491	62.1
Price fluctuation	781	78	304	30	87	22	1172	48.8
Market issues	99	10	52	05	08	02	159	6.6
Lack of Govt support	752	75	140	14	127	32	1019	42.5
*Multiple responses								

Awareness About Other Biotech/GM Crops

Bt cotton is the only GM crop released on a commercial scale for the benefits of Indian farmers, however, there are several other GM crops that are under R&D pipeline and some of them are at an advance stage of contained and confined field trials. The most promising trait that has been extensively tested in India over the years is the herbicide tolerant trait in cotton that has shown promising results in effectively managing weeds. Table 27 shows the awareness among farmers about other biotech crops either field tested or under R&D pipeline. Among the technologies in the offing, farmers were most aware about herbicide tolerant BG-II RRF cotton and Bt brinjal. Notably, on the national level around 31% farmers were aware about the development and field testing of BG-II RRF cotton. A very high percentage of farmers or 61% in Punjab were informed and expressed willingness to adopt BG-II RRF cotton. However, few farmers in three States were aware about other technologies including Bt/HT maize, golden rice and Bt rice. At all India level, around 28% farmers were aware of Bt brinjal as well. In general farmers in Punjab were more informed about new technologies as compared to Maharashtra and Andhra Pradesh.

Table 27: Awareness About Other Biotech Crops and Traits

Biotech crops	Maharashtra		Andhra Pradesh		Punjab		India	
	Freq (n=1000)	%	Freq (n=1000)	%	Freq (n=400)	%	Freq (n=2400)	%
BG-II RRF cotton	201	20	304	30	242	61	747	31.1
Bt/HT maize	84	08	114	11	113	29	311	13.0
Bt rice	22	02	169	17	39	10	229	9.4
Bt brinjal	111	11	218	22	339	85	668	27.8
Golden rice	10	01	24	02	38	10	72	3.0
*Multiple responses								

Future Biotech Traits/Crops

Farmers were convinced about the potential of biotechnology in making available crops with economically important traits. Table 28 shows farmers' interest in specific traits in different crops. The survey sought farmers' priorities on different traits in cotton that should be developed in addition to Bt trait in cotton. It was not surprising to note that an overwhelming majority of farmers were in favor of traits confirming pest resistance preferably sucking pest, disease tolerance and weedicide resistance to control weeds. The pest and disease resistance (81%) followed by weed management (71%) were the most preferred traits in cotton by farmers across different States. Additionally, farmers of Maharashtra and Andhra Pradesh sought traits for drought resistance as majority of the farmers cultivate cotton under rainfed conditions. Importantly, farmers across the States (34%) preferred trait to improve fertilizer use efficiency for reduced fertilizer dose application.

Table 28. Farmers Interest in Specific Traits in Future Biotech Crops

Biotech crops	Maharashtra		Andhra Pradesh		Punjab		India	
	Freq (n=350)	%	Freq (n=400)	%	Freq (n=400)	%	Freq (n=1150)	%
Pest/disease resistance	279	80	316	79	340	85	935	81.3
Weed management	186	53	265	66	368	92	819	71.2
Drought tolerance	297	85	281	70	71	18	649	56.4
Quality crops	20	06	37	09	91	23	148	12.9
Reduced fertilizer	112	32	144	36	137	34	393	34.2

Cultivation Behavior of Cotton Farmers

As detailed in the methodology chapter, a multistage random sampling design was used to select samples for *'Cultivation Behavior'* study. Two districts in Maharashtra (Buldhana and Akola) and two in Andhra Pradesh (Kurnool and Adilabad) were selected for this purpose. The data generated from personal interviews from 250 farmers was subjected to attitude analysis and categorized into favorable and unfavorable attitude of the surveyed farmers (Table 29).

Based on the responses from Maharashtra and Andhra Pradesh, it was found that 80% respondent farmers had a favorable attitude towards Bt cotton cultivation with around 79% of farmers favoring the technology in Maharashtra and 82% in Andhra Pradesh. Farmers across the two States viewed the cultivation of Bt Cotton as a sustainable solution for cotton farming. They felt that Bt cotton was compatible with the existing farming system. Farmers refuted NGO's claims on death of animals, soil toxicity effect, environment pollution, biodiversity loss and extra nutritional dose etc. The opinions of cotton farmers surveyed in two States concurred that Bt cotton and new technologies would pave the way for opportunities of controlling pests and enhanced yield. However, a small percentage of farmers differed and demanded prudence in handling Bt cotton technology particularly in rainfed agriculture. These farmers expressed certain reservations about lack of suitable hybrids for rainfed situation, development of resistance due to non planting of refuge and increasing cost of seed.

Table 29. Measuring Attitude of Farmers Towards Bt Cotton

Production System	Total farmers Interviewed	Attitude	Number of Farmers	% Farmers
Area				
Irrigated	125	F	113	90.4
		UNF	12	09.6
Rainfed	125	F	84	67.2
		UNF	41	32.8
Total (MH)	250	F	197	78.8
		UNF	53	21.2
Area 2				
Irrigated	125	F	105	84.0
		UNF	20	16.0
Rainfed	125	F	99	79.2
		UNF	26	20.8
Total (AP)	250	F	204	81.6
		UNF	46	18.4
Total Response (Area I+II)	500	F	401	80.2
		UNF	99	19.8

"An Alert Farmer is An Affluent Farmer"

28

29

INNOVATION TREE EXERCISE

Uptake Pathways of Bt Cotton

An established method, the 'Innovation Tree' helped to visualize and analyze the way in which new innovation such as Bt cotton spread across the country over a short period between and among the farming community in small and large groups. Using the focus group discussion (FGD) technique, the survey team probed the factors that influenced the adoption, diffusion and modification of the innovation when it entered into a large scale application.

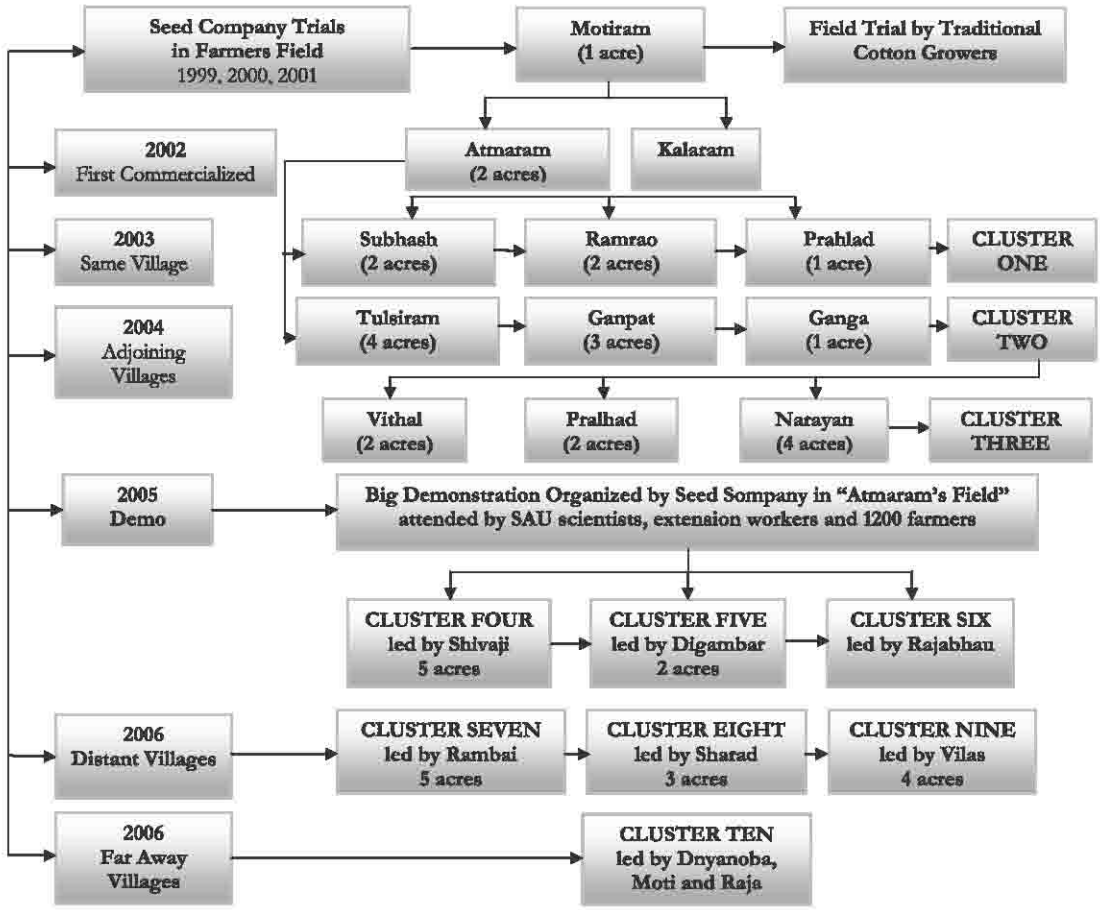
In the present study, the innovation tree exercise was conducted under the direct supervision of the principal investigator (PI) with the help of two team members from the villages where the exercise was performed. The team faced several difficulties in conducting the exercise in two villages in spite of help from Sarpanch – an elected representative of the village. It was difficult to gather the requisite number of farmers together for the exercise. Subsequently, the innovation tree exercise was conducted in the villages adjoining the ancestral home of the principal investigator Dr. Mayee, which helped the team to meet, gather and interact with cotton farmers for the innovation tree exercise.

Innovation Tree Exercise: Buldhana District Cluster Formation

Figure 8 depicts the thread of information that connected different dots before forming a large cluster of farmers planting Bt cotton in Buldhana district of Maharashtra. Farmer Motiram Navle of village S. Kherda, Buldhana district of Maharashtra is the man who dared to experiment the first plot of Bt cotton in his village or probably in the whole area before anyone dreamed of emancipation from the curse of cotton bollworm, an insect-pest that used to cause havoc in cotton field across his village. Figure 8 shows a diagrammatic presentation of the adoption and uptake pathways of Bt cotton in this area. Farmer Motiram Navale planted Bt cotton seeds that grew in tall and healthy plants and blossomed the life of thousands of cotton farmers across the Buldhana district of Maharashtra. The innovation tree exercise in this village deciphered the pathway of Bt cotton that resulted in the formation of Bt cotton cluster around Mr Navale's field. This is the first of its kind study that attributes the successful spread of Bt cotton to cluster formation across the country. A detailed description of the flow of information listed in chronological order resulting in the formation of Bt cotton cluster in Buldhana district of Maharashtra;

1) Farmer Motiram Navle grew Bt cotton trials on his farm on behalf of Mahyco in 2001 in his village S. Kherda, Buldhana district of Maharashtra. His village is located in the periphery of 70km from Jalna, the headquarter of Mahyco seeds. In 2002, farmer Navle planted commercial Bt cotton on 1 acre of his land after a satisfactory field testing for the company in 2001.
2) His son Atmaram was convinced and grew Bt cotton on 2 acres in 2003 but his other son Kalaram did not take up cultivation.
3) In 2004, farmers Subhash, Ramrao and Prahlad learnt of Bt cotton and decided to cultivate Bt cotton in a nearby village. This became cluster 1.
4) Farmer Atmaram's success induced farmers Tulsiram, Ganpat and Ganga to grow Bt cotton on 1 acre each in 2004 in same village S. Kherda. This became cluster 2.
5) Inspired by the success of Atmaram, a new cluster in another nearby village formed with 3 additional farmers planting Bt cotton. This became Cluster 3.
6) At this juncture, other vigilant farmers could count the 9+1 farmers growing Bt cotton in 3 villages within a periphery of 10 km. In 2005, a large scale demonstration of Bt cotton was organized by the seed company which was attended by farmers, Govt extension personnel, SAUs and KVKs. The demonstration underscored the legitimacy of Bt cotton and therefore the adoption became wide spread in nearby areas by 2005.
7) Clusters 4 to 6 were large clusters with lead famers in all three villages (nearly 15-20 farmers chose to grow Bt cotton in 2005).
8) In 2006, the new clusters in the Block were evident with additional 25 to 50 cotton farmers in different villages.
9) Additionally, farmers in all clusters continued to cultivate and expand area under Bt cotton year after year thus increased total Bt cotton area in respective clusters.
10) By 2006, a large number of farmers and fields across several villages were growing Bt cotton resulting in the formation of a district wise cluster of Bt cotton in Buldhana district of Maharashtra.

Figure 8. Uptake Pathway of Bt Cotton Among Farmers of Buldhana District, Maharashtra



The detailed cluster formation is based on group interactions with 20 farmers who participated in the innovation tree exercise. Nearly 18 farmers shared their experiences and expressed their views and thus the uptake pathway of Bt cotton was constructed as depicted in Figure 8. The first generation Bt cotton adopter is represented by Mr. Atmaram, a risk taking farmer who cultivated Bt cotton during the first year of its commercialization in 2002. However, he participated along with his father Mr Motiram in the open field trials of Bt cotton in the previous years and experienced benefits of Bt cotton from an 0.25 acres of experimental plot by harvesting nearly 4 quintal of seed cotton which he used to get from one acre in the past.

Figure 8 shows the flow of uptake pathways of Bt cotton starting with farmer Atmaram but the adoption was slow in the first 2-3 years as majority of farmers were careful and sometimes skeptical about cotton and Bt technology. At that stage, farmers around his village were observant and vigilant in making any decision to grow Bt cotton in haste prior to obtaining a first-hand experience of 'seeing is believing' from the field of risk

taking farmers. In 2005, a massive demonstration of Bt cotton was held and participated by government officials that generated immense interest of farmers in Bt cotton resulting in an unparalleled beginning of the adoption of Bt cotton in and around his village. The flow of information about Bt technology spread among farmers of neighboring villages as well. Farmer Atmaram shared his jubilation of welcoming his relatives from other villages to his Bt cotton farm. This exercise reinforced general hypothesis that technology adoption is driven by risk-taking farmers and followed by risk-averse farmers. In summary, the demonstrations (seeing is believing) in farmers' field and experiences (doing is knowing) of risk taking farmers were two vital components of a nation-wide strategy for the adoption and uptake pathways of Bt cotton in the country.

Innovation Tree Exercise: Akola District Village Hub Model

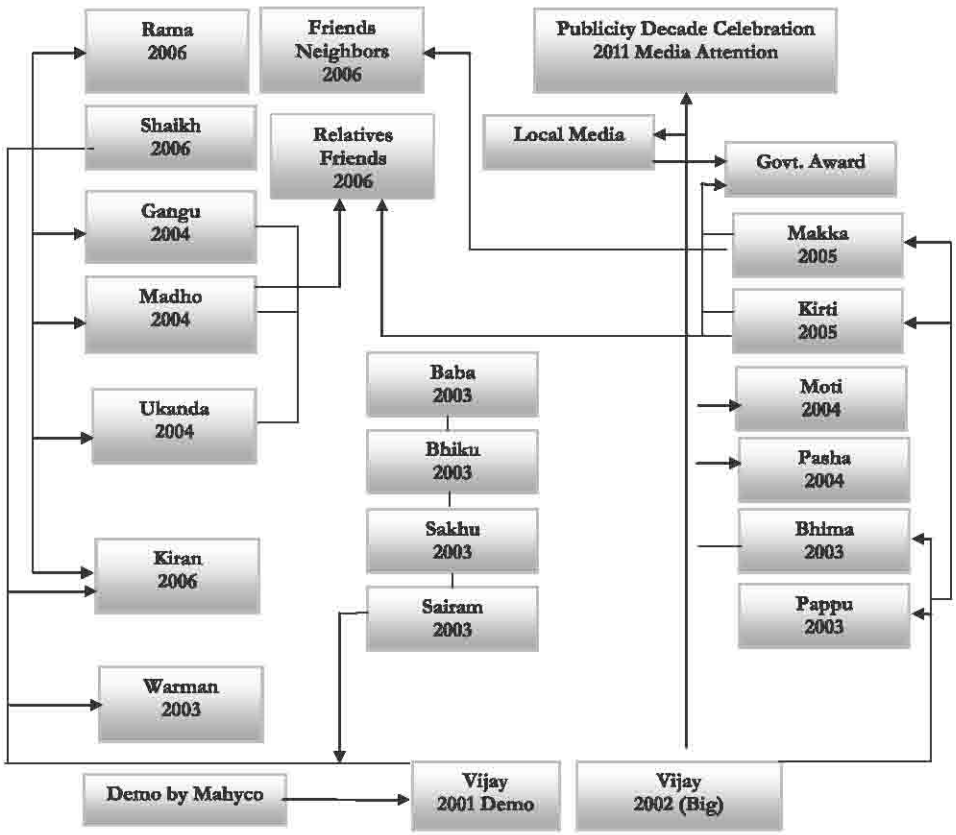
The second exercise of the innovation tree technique was conducted in Chitalwadi village of Akola district of Maharashtra. Mr. Vijay Atmaram Ingle, a progressive farmer from Chitalwadi village helped in tracing the flow of Bt cotton by implementing innovation tree exercise in his village. Mr. Vijay Ingle was invited to present his success story of Bt cotton in the "International Conference on Adoption and Uptake Pathways of Biotech Crops in China, India and the Philippines" organized by John Templeton Foundation, ISAAA and NAST from 2-3 April 2013 in Manila, the Philippines.

Like Atmaram, farmer Vijay Ingle of Chitalwadi village of Akola conducted first field trial cum demonstration of Bt cotton of Mahyco in 2001. He was the first to plant commercial Bt cotton in 2 acre of plot in the first year of commercialization of Bt cotton in 2002. Figure 9 shows the dissemination of Bt cotton which made his village the first Bt cotton hub although a slight detour from the concept of cluster was noticed as compared to Buldhana district. In 2011-12, around 125 farmers representing the majority of farmers of Chitalwadi village grew Bt cotton hybrids of different seed companies (Figure 9). The formation of 'village hub' concept of Bt cotton in Chitalwadi village is described as follows;

1) In 2001, farmer Vijay Atmaram Ingle, a risk taking farmer conducted field trial cum demonstration of Bt cotton in his village Chitalwadi against the wishes and advise of his family, relatives and fellow farmers.
2) Convinced of the results of Bt cotton trial, he was the first in his village to buy Bt cotton seeds in 2002 when Bt cotton was allowed for commercial planting.
3) In 2003, Bt cotton technology spread to all sides of the Chitalwadi village. Vijay's friends who regard him a progressive and risk taking farmer were the first to listen to his advise and planted Bt cotton. Farmer Pappu and Bhima planted Bt cotton on the East side while farmers Baba, Bhiku, Sakhu and Sairam to the West and farmer Waman in the South of the village.

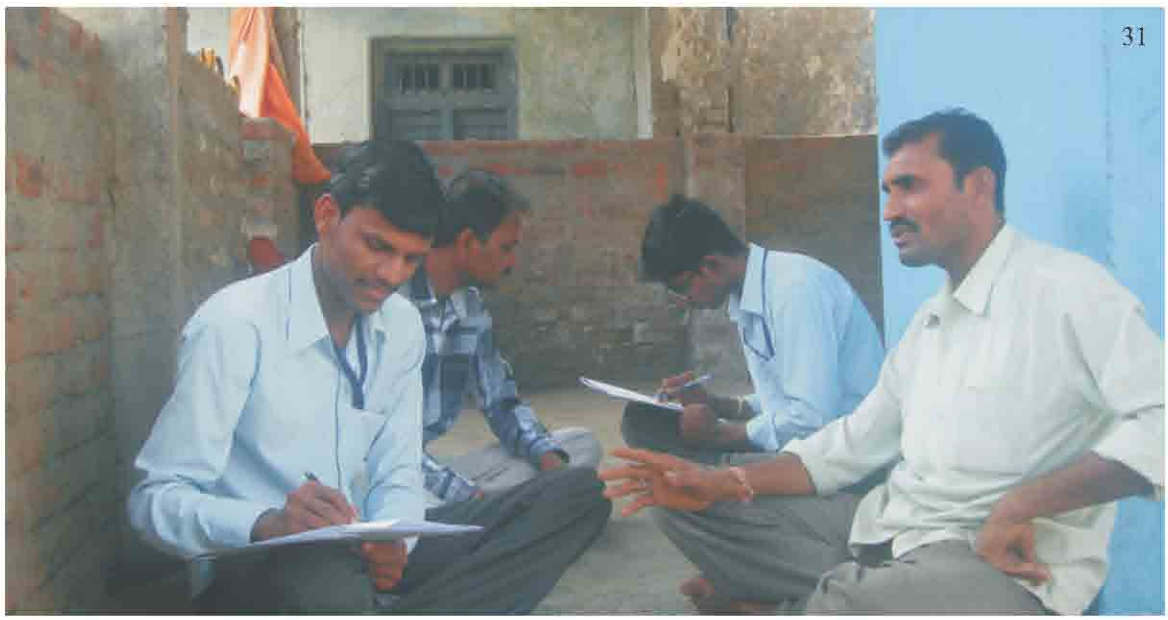
4) Subsequently, additional 5 farmers with more than 5-10 acres of land planted Bt cotton which furthered the dissemination of Bt cotton in the village.
5) By 2005, a few more farmers took up cultivation of Bt cotton in the village and by 2006 several of them adopted the technology in Chitalwadi village.
6) Additionally, local media who projected Vijay Atmaram Ingle as the architect of Bt cotton stirred the rapid adoption of Bt cotton technology in his village. Farmer Vijay was recognized and awarded by government for producing highest yield of cotton in the early years of adoption of Bt cotton in his village. These events helped faster dissemination of Bt cotton in his village. Interestingly, farmer Vijay Ingle organized a large demonstration celebrating 10th "Bt Cotton Birthday" in his village which was attended not only by local farmers but large number of government officials, media and companies supplying seeds and irrigation equipments. Farmer Vijay Ingle demonstrated to fellow farmers the power of technology by harvesting the highest yield of 25 quintal per acre with the help of Bt cotton hybrids and drip irrigation, a new and evolving method of irrigation in his village. Figure 9 shows an outline of the formation of "Village hub" of Bt cotton adoption and a chain of uptake pathways.

Figure 9. Uptake Pathway of Bt Cotton Among Farmers of Akola District, Maharashtra



“सर्तक किसान समृद्ध किसान”

30



31

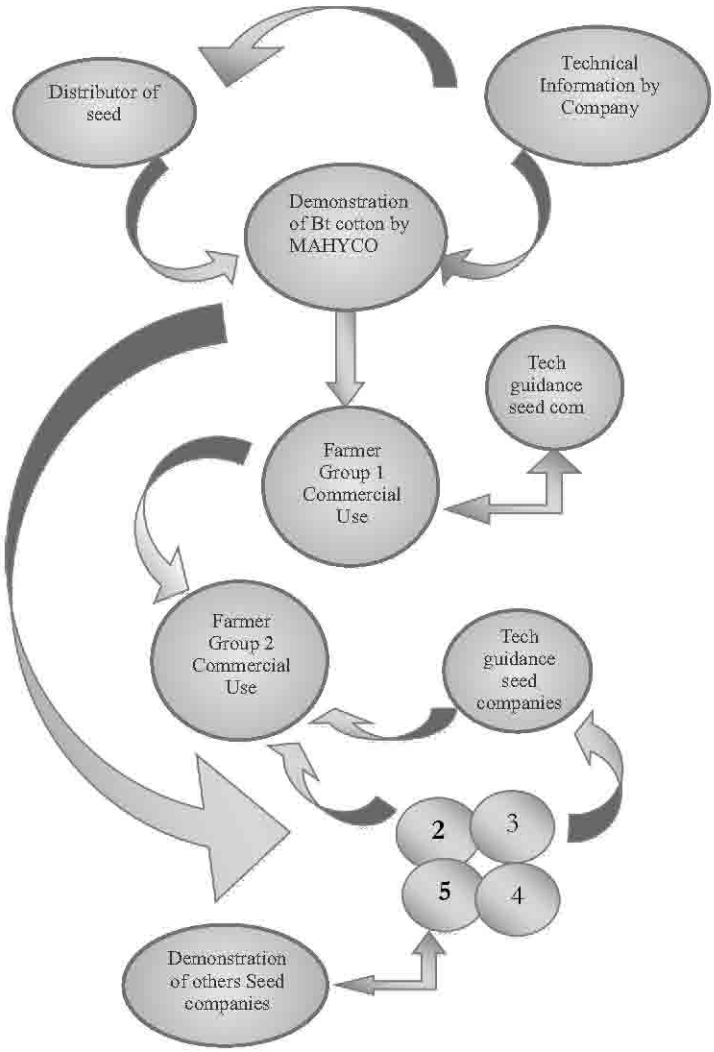
ANALYSIS OF RESULTS

Innovation Tree Exercise

The innovation tree exercise in Buldhana and Akola districts of Maharashtra demonstrates the involvement and influence of various actors and factors in the adoption and uptake pathways of Bt cotton cultivation in the country. Two distinct models emerged from the exercise reinforce the age old practice of field demonstration as the most effective tool of technology dissemination in agriculture in the country. The role of progressive and risk taking farmers along with the institutional support, in this case the private seed company Mahyco, which was known to the farmers in the region as a pioneering seed company producing hybrid seeds of cotton, sorghum, pearl millet and vegetables played a critical role in field level demonstrations and dissemination of Bt technology in both districts. Notably, the country-wide dissemination of Bt cotton supported by the private sector seed companies was the first massive exercise of technology deployment in the first decade of twenty first century after the success of green revolution technologies in wheat and rice, which were primarily supported by public funded institutions in late seventies. The exercise also revealed the connection of farmers with the reputation and trust of Mahcyo and attributed confidence in Dr. B.R. Barwale who championed many breakthroughs in agriculture in the past in the State. Mahyco was instrumental in conducting the open field trials and demonstrations of Bt cotton hybrids MECH-161, MECH-184 and MECH-12 in all cotton growing districts of Buldhana, Akola, Amravati, Yeotmal, Wardha, Jalna, Parbhani, Jalgaon, Aurangabad and Nanded across the state of Maharashtra. Additionally, the district of Buldhana is adjoining district to Jalna and Mahyco's seed production program was well spread and known in this area to the farmers. Additionally, the role of the network of dealers, distributors and retailers of companies who were locally popular in villages played an important role in mobilizing farmers to the demonstrations to Bt cotton fields and effectively popularized the usefulness of Bt technology in simple languages to local farmers. Farmers also attributed Bt cotton adoption to a series of trainings and workshops organized in local languages explaining the features of Bt technology in different areas. By 2003, many progressive and risk taking farmers participated in the capacity building programs and demonstrations and others learnt from the experiences of progressive farmers. Figure 10 shows the diagrammatic representation of adoption and uptake pattern designed to represent the findings of the innovation tree exercise conducted in Buldhana and Akola districts of Maharashtra as explained in the previous chapter. By 2007-08, Bt cotton technology spread wider mainly because of the availability new hybrids from many other popular seed companies. The classic example is the involvement of other seed companies such as Rasi Seeds, Ankur Seeds and Nuziveedu Seeds, which undertook large scale demonstrations of Bt cotton and disseminated information through a

large scale network of technical personnel, distributors, dealers and retailers which helped in spreading the information about Bt cotton technology to a wider section of rural India.

Figure 10. Uptake Patterns of the Adoption of Bt Cotton Among Farmers



The different characteristics of the adoption and uptake pathways of Bt cotton are summarized as follows;

1) **The private seed companies triggered the initial push that hastened the adoption of Bt cotton technology in the early years. Subsequently, Bt cotton technology was** effectively disseminated by progress of Bt cotton growing farmers amongst the farmers in the country-side.
2) **The involvement and endorsement of local government officials, SAUs and KVKs representative to Bt cotton raised credibility of the technology by 2005 onward that spiked the adoption on large scale areas across different villages.**

3) The risk taking and progressive farmers who often involved in the Front Line Demonstration of public sector technologies, have played a key role in organizing demonstrations, field days and mobilizing fellow farmers and dissemination of Bt technology through local media.
4) The cooperatives and traders particularly cotton ginners provided the needed capital for Bt cotton cultivation in the early years and were considered another group of players in dissemination of Bt cotton technology.
5) By and large, farmers fully adopted Bt cotton technology by 2006-07, however, the cultivation practices of raising Bt cotton crop were greatly influenced by local staff, retailers and distributors of private seed companies. Meanwhile, private seed companies drove a massive demonstration and marketing campaign to popularize their respective brands that indirectly helped in the dissemination of Bt cotton technology.

The analysis of various factors that influenced the adoption and uptake pathways of Bt cotton are summarized as follows:

1) Assurance of successful management of bollworm
2) Freedom from chemical sprays
3) Assurance of high yield
4) Reduced cost of production
5) Choice of different Bt cotton hybrids
6) Early harvesting and higher return
7) Possibilities of successive crops
8) Competition with fellow farmers to enhance yield and,
9) Assured market support price and often higher market price for cotton

Similarly, the innovation tree exercise listed many reasons for late adopters of Bt cotton technology who exercised prudence in decision making on cultivating Bt cotton until 2006;

1) Late adopters thought that Bt cotton seeds were expensive and introduced mostly for large scale farmers.
2) Many late adopters were skeptical of Bt cotton because of the influence of the older generation people in decision making in farming.
3) Lack of access to right information about the way in which Bt cotton controls bollworms
4) Fear of losses of Bt cotton due to failure of monsoon rains and
5) Limited availability of initial capital to purchase Bt cotton seeds

Welfare Benefits of Bt Cotton

One-on-one interaction with Bt cotton farmers during the innovation tree exercise and the survey across three States confirmed that Bt cotton technology had a large scale impact on welfare of cotton farmers and their families. Farmers narrated various welfare stories that go beyond the established facts limiting the impact of this particular innovation to economic benefits. Farmer Vijay Ingle explained his life changing story of Bt cotton cultivation that enabled him to send his children, a son and daughter for higher education, particularly admitted his son for graduate course in agricultural biotechnology. His two storey building constructed after he commenced cultivation of Bt cotton is regarded as a milestone of Bt cotton in the Chitalwadi village. Based on his experience and views expressed by others farmers, the study grouped the welfare benefits of Bt cotton under following sub-heads;

Renovation and Construction of Family House

Many Bt cotton farmers shared their stories of either renovating mud house or building pucca house in the recent years. The first and foremost investment made by majority of Bt cotton farmers were to build brick or cement house on his/her land. Some progressive farmers like Vijay Ingle constructed big house and others small either in their villages or on farms.

Acquisition of Appliances and Properties

Some farmers reported the purchase of additional land while big farmers purchased property in their respective village or nearby town. Only those big farmers who grew Bt cotton on 15 to 20 acres regularly reported purchase of properties when they earned significant return due to high market prices of cotton during the Bt cotton period. Some farmers purchased additional land and raised their holding from a few acres to more than 10 acres per family in last ten years. Many farmers reported purchase of household appliances such as mobile, TV with cables, refrigerators, two wheelers and kitchen appliances. A large number of farmers reported purchase of farm implements such as tractors, cultivators and rotavators. All the respondent farmers surveyed during the study possessed mobile for themselves and for family members.

Education of Children

There has been a massive awareness about the need for enrollment of children for primary, secondary and higher education among all the surveyed farmers. A majority of farmers expressed the greatest satisfaction of enrolling and sending their children to the best

school and grown up children to best colleges. Many farmers proudly reported sending their children to private schools as well. Farmer Vijay Ingle expressed jubilation of sending his daughter and son for higher education. He shared his satisfaction of being a proud father as he himself could not obtain higher degree because of unaffordable education which he felt compensated by the education of his children.

Restoring Social Functions

The surveyed farmers reported an average increased profit margin ranging from Rs. 28,000 to 35,000 per hectare that helped them in making a modest contribution to social activities at village levels. Farmers across villages reported that there has been a restoration of social activities in respective villages. Farmers also reported their active participation in these functions that they often avoided due to lack of monetary contribution in organization of social functions. Some of the farmers also reported that the technology has helped them in facilitating family functions and wedding of their daughters. Others proudly indicated timely repayment of loan and fulfilling other commitments with friends and relatives.

Revitalizing Cotton Farming

A majority of farmers were of the opinion that cotton farming was at a verge of collapse and cotton growers were indebted with loan and frequent failure of cotton crop due to bollworms. The chemical spray became a norm of cotton cultivation. The effectiveness of chemical sprays to control insect-pests was becoming a day dream for many farmers. The introduction of Bt cotton technology salvaged not only cotton crop but also the life of cotton growers across the surveyed villages. Many farmers expressed that their fear of bollworms was over and Bt technology gave them the peace of mind and immunity to cotton against dreaded bollworms. For surveyed farmers, it was unbelievable to know that cotton can be grown with one or two sprays or sometimes without spraying to control bollworm. Additionally, farmers enthusiastically shared their freedom from the nuisances and headache of frequent spraying. In summary, farmers reported that the age old practice and pleasure of cultivating cotton was restored and Bt technology revitalized the cultivation of cotton which registered a large increase in area under cotton in the recent years.

“सावध शेतकरी सधन शेतकरी”

CONCLUSION

The study on the "Adoption and Uptake Pathways of Biotech Cotton among Farmers in Selected Cotton Growing Villages of Maharashtra, Andhra Pradesh and Punjab in India" was one of largest and most comprehensive survey undertaken on Bt cotton in rainfed and irrigated cotton areas of the country. The survey covered 2,400 farmers across three agro-ecologically distinct States focusing on rainfed areas of Maharashtra, semi-irrigated areas of Andhra Pradesh and fully irrigated cotton area of Punjab. Notably, the survey revealed some striking findings, confirmed some interesting facts and validated some hypothesis on the adoption and uptake of Bt cotton technology that was commercialized for cultivation for the first time in the country in 2002. The socio-demographic characters indicated that Bt cotton farmers by and large are young farmers, fall in the middle age group and inherited land from their parents. A majority of cotton farmers preferred to grow Bt cotton technology because of its dual functions of reducing the cost of production and increasing yield and farm income. Bt cotton farmers raised the necessary financial capital from the cooperative bank and traders predominantly cotton ginners. The innovation tree exercise confirmed evolution of two types of adoption and uptake pathways and were characterized as "Clusters" and "Village hub" system. Notably, the adoption and uptake pathways of Bt cotton were triggered by "seeing is believing" of field demonstration and facilitated by the peers and kinship systems. Two dominant factors influenced the decision of adoption were; first, the freedom from the dreaded pest bollworm and relief from the 'pray or spray' regime and second, increased cotton production resulting in higher farm income.

It is noteworthy to recognize the unparalleled progress on the adoption and uptake leading to 93% coverage of Bt cotton within a period of ten years. This is a milestone achievement in the modern history of Indian agriculture. The survey probed the factors that influenced the adoption, diffusion and modification of the innovation when it entered into a large scale application. It was evident from the data that the adoption and uptake pathways of Bt cotton were sustained by multiple players who performed different roles in the process including risk taking and progressive farmers, technical personnel of private seed companies and network of retailers, dealers and distributors of private seed companies. The demonstration by private seed companies in the fields of progressive farmers and mobilization of farmers to these demonstrations were the most convincing and appealing methods that triggered a large scale adoption of Bt cotton in the villages. Additionally, seed companies conducted large demonstrations, field days hosted by progressive farmers. The financial support services extended by cotton ginners and cooperative banks further encouraged farmers to take up cultivation of Bt cotton and therefore, these groups were classified as secondary actors in the chain of technology

deployment. The tertiary groups included officials from public sector extension system including extension departments, SAUs and KVKs that induced farmers' trust and confidence in Bt cotton technology. The survey noted that the credibility of Bt technology dissemination could have achieved vigorously had there been an active partnership between private seed companies and well established public sector extension system. In summary, the experience and learning of the survey suggests that the government of India should create a suitable public private partnership platform between private seed companies and extension system for a smooth and quick adoption and uptake of new GM technologies in the future. It is noteworthy to mention that farmers across the State particularly in Punjab vehemently spoke in favor of Bt technology and underscored the need and desire for the application of similar breakthrough technologies in other crops including cereals, oilseeds and vegetables. Additionally, farmers also prioritized the delivery of other important characters in different crops including abiotic stresses such as drought, fertilizers, salinity and quality characters and biotic stress such as efficient weed control, sucking pest and virus resistant characters. The authors, State coordinators, scouts, advisory team and administration unit of the survey along with thousands of farmers who directly and indirectly participated in the survey strongly believe that this exercise, its observations and findings and recommendations specific to different stakeholders will be a useful guide for the planners, policy makers, regulators and scientists for considering the successful releases of other biotech crops for commercial cultivation in the country.

34

REFERENCES

APcoAB. 2006. Bt cotton in India: A Status Report. Asia-Pacific Consortium on Agri. Biotechnology, New Delhi.

AICOSCA. 2011. 51st Annual Report and Account 2010-11, All India Cotton Seed Crushers Association, Mumbai, 2011.

AICOSCA. 2013. AICOSCA News letter, June 2013 p. 15-16.

Bagla P. 2012. Negative reports on GM crops shakes Government's food agenda. Science. 337:789

Barwale Badrinarayan. 2008. My Journey with seeds and the development of the Indian Seed Industry, An Autobiography, Barwale Foundation.

Biospectrum ABLE Survey. 2012.Biospectrum Top 20 Survey. Industry Insights. (June 2012)

Brookes G and Barfoot P. 2012. Global Impact of Biotech Crops: Environmental Effects, 1996-2010, GM Crops 3: 2 April-June 2012, p 1-9

CCI. 2012. Current Cotton Scenario – Domestic Cotton Situation, Cotton Corporation of India, 2012.

Mayee, C.D. *et al.* 2002. Transgenic Bt Cotton, CICR Technical Bulletin No. 22, Central Institute for Cotton Research, Nagpur.

DAC. 2012. Agricultural Statistics at a Glance – 2012. Directorate of Economics & Statistics, Ministry of Agriculture. Govt of India.

Dale *et al.* 2002. Potential for the environmental impact of transgenic crops. Nature Biotechnology 20:567-574.

Farmer's Forum. 2012. Bt, indeed, the better cotton, survey on the socio-economic impact assessment of Bt cotton in India. 12(4):8-13, Bharat Krishak Samaj. July-August 2012

Gandhi, V.P. and Namboodri N.V. 2006. The adoption and economics of Bt cotton in India: Preliminary results from a study, Indian Institute of Management, Ahmedabad working paper no. 2006-09-04, pp. 1-27. (September 2006).

German L. 2007. Technology Uptake and Upscaling: Approach Matters. TUUSI Inception Workshop. Feb 7-9, 2007.

Ismael, Y. R. Bennet and S. Morse. 2001. Biotechnology in Africa: The Adoption and Impact of Bt cotton in the Makhathini Flats, Republic of South Africa. A paper presented in Africa Bio-Conf for Sub Saharan Africa on Sep 26-27, 2001, Johannesberg, SA.

James, Clive. 2011. Global Status of commercialize Biotech / GM Crop: 2011 ISAAA Brief 43; Ithaca, NY.

James, Clive. 2012. Global Status of commercialize Biotech / GM Crop: 2012 ISAAA Brief 44; Ithaca, NY.

Kathage, J.K. & Qaim, M. 2012. Economic impacts and impact dynamics of Bt (Bacillus thuringiensis) cotton in India, Proc. Natl. Acad. Sci. USA (2 July 2012).

Kouser, S. and M. Qaim. 2011. Impact of Bt cotton Pesticide Poisoning in Small holder Agriculture- a panel data, Ecological Economics; 70 (11):2105-2113

Knowledge Centre. 2012. Pocket K4 GM Crops and Environment.

Kranthi, K. R. 2012. Bt cotton Q & A. ISCI, Mumbai

Manjunath, T. M. 2011. Q &A on Bt cotton in India. Answers to more than 85 questions. Second Edition. Association of Biotechnology Led Enterprises. Agricultural group, Bengalour

Natesh S and MK Bhan. 2009. Biotechnology sector in India: strengths, limitations, remedies and outlook,Current Science, Vol, No. 2, PP. 157-169, 25 July 2009.

Mayee C. D. 2009. Bt cotton in India: Current status and impact on textile industry. Proceedings of National Academy of Sciences (PNAS) Vol. 79 No. 3 pp. 195-211.

Mayee C. D. 2012. Bt cotton success and the progress of GM crops in India. Journal of Biosafety; 4 (2):13-19.

Mayee C. D. 2013. Indian Success Storey with Bt cotton: New Hope, New Life for Cotton Farmers and Economy. Paper presented in 8th Genetic Engineering Congress, held in Tehran, July 6-10, 2013.

NCFAP. 2008. Quantification of the Impacts on US Agriculture of Biotechnology-Derived Crops Planted in 2006, National Center for Food and Agricultural Policy, Feb 2008

Padaria *et al.* 2008. Farmer Participatory Assesment of Bt Cotton and its Socio economic Implications. Indian Journal of Ext. Education. 44:25-31

Qaim M., Kouser S., 2013. Genetically Modified Crops and Food Security. PLoS ONE 8(6): e64879.

Sanvido, O., Stark, M., Romeis, J. and Bigler, F. 2006. Ecological Impacts of Genetically Modified Crops: Experiences from Ten Years of Experimental Field Research and Commercial Cultivation. Zurich, Switzerland: Agroscope Reckenholz-Ta¨nikon Research Station ART

Scandizzo, P. L. and S. Savastino. 2010. The Adoption and diffusion of GM crops in United States: A Real option approach. AgBioForum, 13(2).

Serageldin, I. 1999. Biotechnology and Food security in the 21st century. Science 285: 387-389.

Singh *et al.* 2013. Adoption of Bt cotton Technologies and Constraints faced by Cotton Growers in Haryana. Journal of Cotton Research and Development 27(1): 149-151

Subramaniam, A. 2010. GM crop and gender issues. Nature Biotechnology, 28 (5): 404-406

Thurestone, L. L. and E. J. Chave. 1969. The Measurement of Attitude. Uni Chicago Press, Chicago.

Torres *et al.*, 2012. Adoption and uptake pathways of Biotechnology crops: The case of Biotech Farmers in Selected Provinces of Luzon. College of Development Communication, ISAAA, SEASia Center, and SEAMEO Southeast Asian Regional Centre for Graduate Study and Research in Agriculture (SEARCA): Los Banos, Laguna, Philippines.

Usha Rani, S. and G. Selvaraj 2008. An Empirical Analysis on Cultivation Behaviour of Bt Cotton Growers. Journal of Agri. Ext. Management, 9(1): 79-88

Usha Rani, S. and G. Selvaraj 2009. Empirical Analysis of Adoption and Impact of Bt cotton cultivation in cotton Production System of Tamil Nadu, India. Agricutural Situation in India. Vol LXVI (a): 545-552

Usha Rani, S. and G. Selvaraj. 2010a. Performance of Bt cotton- Evaluation of Farmers Experiences with Empirical Evidences. Journal of Ext. Education, 22(2): 4431-4436.

Usha Rani, S. and G. Selvaraj. 2010 b. Impact of Bt cotton Technology on cotton Farming and cotton farmers- An Empirical Analysis. Jornal of Ext. Education 22(3):4472-4479

Van Mele, P. and A. K. M. Zakaria. 2002. The Innovative Tree: A New PRA Tool to Reveal the Innovation Adoption and Discussion Process. PLA Notes.

Annexure 1. List of Villages Selected As Sample Area for the Survey in Maharashtra

District	Taluka	Village	Frequency N=1000	Percentage (%)
Amravati	Chandur (rail way)	Dhanora	10	1
		Ekpala	10	1
		Mandawa	10	1
		Palaskhed	10	1
		Rajura	10	1
	Dhamangaon	Bhatkuli	10	1
		Borgaon (dhande)	10	1
		Nimboli	10	1
		Talani	10	1
		Vitala	10	1
	Nandgaon khandeshwar	Fubgaon	10	1
		Javara (m)	10	1
		Khandala	10	1
		Wai	10	1
		Yenas	10	1
	Warud	Dhaga	10	1
		Ekalvihir	10	1
		Ekdara	10	1
		Jamathi	10	1
		Shendurjanaghat	10	1
Hingoli	Aundh	Aasola	10	1
		Chodhi(s)	10	1
		Kathoda(t)	10	1
		Umara	10	1
		Walki	10	1
	Hingoli	Bhirada	10	1
		Lasina	10	1
		Maldhamni	10	1
		Malhiwara	10	1
		Parsoda	10	1
	Kalamnoori	Bolda	10	1
		Harwadi	10	1
		Sawangi(b)	10	1
		Sodegaon	10	1
		Warnga	10	1
	Vasmat	Aaral	10	1

		Balegaon	10	1
		Chikhali	10	1
		Ekrukha	10	1
		Telgaon	10	1
Parbhani	Manvat	Bondarwadi	10	1
		Rudhi	10	1
		Sawali	10	1
		Sawargaon	10	1
		Tadborgaon	10	1
	Parbhani	Allapur	10	1
		Bharaswada	10	1
		Endewadi	10	1
		Pokharni	10	1
		Rahati	10	1
	Pathari	Hadgaon	10	1
		Kherda	10	1
		Rampuri	10	1
		Saroda	10	1
		Wadi	10	1
	Seloo	Dansala	10	1
		Devalgaon	10	1
		Kumdi	10	1
		Mhalsapur	10	1
		Nipani(t)	10	1
Wardha	Arvi	Kachnur	10	1
		Pachod	10	1
		Parsodi	10	1
		Rohana	10	1
		Virul	10	1
	Higanghat	Kangaon	10	1
		Khangaon	10	1
		Kosurla	10	1
		Mozari	10	1
		Varud	10	1
	Samudrapur	Arwi	10	1
		Khursapar	10	1
		Pimpalgaon	10	1
		Shivanfal	10	1
		Undirgaon	10	1
	Seloo	Junona	10	1
		Khairi(k)	10	1
		Nanbardi	10	1

		Sindi (rail way)	10	1
		Wahitpur	10	1
Yavatmal	Babhulgaon	Ashti	10	1
		Loni	10	1
		Nandura	10	1
		Pimpri	10	1
		Weni	10	1
	Kalamb	Donoda	10	1
		Khutala	10	1
		Narasapur	10	1
		Pimpalgaon	10	1
		Shankarpur	10	1
	Ralegaon	Chikana	10	1
		Menghapur	10	1
		Raved	10	1
		Sangama	10	1
		Sawangi	10	1
	Zarijamni	Ganeshpur	10	1
		Matharjun	10	1
		Mulgavhan	10	1
		Shiradhoki	10	1
		Tembhi	10	1
Total # of Farmers Selected in Maharashtra			**1000**	**100**

Annexure 2. List of Villages Selected As Sample Area for the Survey in Andhra Pradesh

District	Taluka	Village	Frequency N=1000	Percentage (%)
Adilabad	Bhainsa	Degaon	10	1
		Gundegaon	10	1
		Linga	10	1
		Kumbi	10	1
		Siddur	10	1
		Takli	10	1
		Walegaon	10	1
		Elegaon	10	1
		Mategaon	10	1
		Mirzapur	10	1
	Kubeer	Kubeer	10	1
		Rajura	10	1
		Belgaonthanda	10	1
		Belgaon	10	1
		Jamgaon	10	1
		Siripelly thanda no. 1	10	1
		Siripelly thanda no. 2	10	1
		Pardi(k)	10	1
		Darkubeer	10	1
		Ka rsa	10	1
Warangal	Sangem	Guturpally	12	1.2
		Kapulakanaparthy	12	1.2
		Ashalapally	12	1.2
		Katrapally	12	1.2
		Gavicharla	12	1.2
		Teegarajupally	12	1.2
		Gadepally	12	1.2
	Gudur	Bollikunta	10	1
		Gundenga	10	1
		Madhanapuram	10	1
		Ayodhyapuram	10	1
		Ponugodu	10	1
		Gudur	10	1
		Bhupathipeta	12	1.2
		Vengampeta	10	1
		Sithanagaram	12	1.2
		Dhamaravancha	10	1

		Maccharla	12	1.2
Mehaboob	Lingala	Surapoor	10	1
		Rampur	10	1
		Madapoor	10	1
		Magdumpur	10	1
		Vallabapoor	10	1
		Ba ka ram	10	1
		Komati kunta	10	1
		Lingala	10	1
		Jinugapally	10	1
		Kothakuntapally	10	1
	Tellkapally	Peddur	10	1
		Aler	10	1
		Golagundam	10	1
		Laknaram	15	1.5
		Raipakula	10	1
		Boppally	10	1
		Jangayonipally	10	1
		Kammareddypally	15	1.5
		Nellikuduru	10	1
Kurnool	Kallur	Remaduru	10	1
		Nayakal	10	1
		Ulsala	10	1
		Bollavaram	10	1
		Gokulapadu	10	1
		Pandipadu	10	1
		Lakshmipuram	10	1
		Parla	10	1
	Kodumuru	Polakurthi	10	1
		Varkuru	10	1
		Venkatagiri	10	1
		Kallapari	10	1
		Baindodhi	10	1
		Laddagiri	10	1
	Kurnool	Salkapuram	10	1
		R.kuntalpadu	10	1
		Markapuram	10	1
	Belgal	Krishnadoddi	15	1.5

		Golladoddi	15	1.5
Guntur	Prathipedu	Gottipadu	10	1
		Kondepadu	10	1
		Koyavaaripalem	10	1
		Mallayapalem	10	1
		Nimmagaddavaripal	10	1
		Prathipedu	10	1
		Raavipaativaripalem	10	1
		Thikkireddipalem	10	1
		Yanamadala	10	1
	Tadikonda	Dhamarapalli	10	1
		Garikapadu	10	1
		Gorlavaripalem	10	1
		Pamulapadu	8	0.8
		Panidharam	8	0.8
		Pedaparimi	10	1
		Pamulapadu	10	1
		Panidharam	0.8	0.8
		Pedaparimi	08	0.8
		Ponekallu	10	1
		Ravella	10	1
		Tadikonda	8	0.8
Total # of Farmers Selected in Andhra Pradesh			**1000**	**100**

Annexure 3. List of Villages Selected As Sample Area for the Survey in Punjab

District	Block	Villages	Frequency N=1000	Percentage (%)
Fazilka	Abohar	1. Dharang Wala	10	1
		2. Tazajtti	10	1
		3. Murad Wala	10	1
		4. Kundal	10	1
		5. Bahav Wala	10	1
	Khuian Sarwar	6. Kikkar Khera	10	1
		7. Alamgarh	10	1
		8. Koyal Khera	10	1
		9. Bakainwala	10	1
		10. Haripura	10	1
Mansa	Sardoolgarh	1. Jhanduke	10	1
		2. Tibbikhurd	10	1
		3. Fattamaluka	10	1
	Jhunir	4. Khiali Chehlanwali	10	1
		5. Korwala	10	1
		6. Jhunir	10	1
		7. Rama Nandi	10	1
		8. Dasaundia	10	1
	Mansa	9. Dulowal	10	1
		10. Kot Dharmu	10	1
Muktsar	Lambi	1. Bodiwala	10	1
		2. Sikh Wala	10	1
		3. Saina Khera	10	1
		4. Fattoi Khera	10	1
	Muktsar	5. Roorhian Wali	10	1
		6. Chaknanu Wala	10	1
		7. Lakhmirae Wala	10	1
	Malout	8. Lakkar Wala	10	1
		9. Bhulerian	10	1
		10. Shergarh	10	1
Bathinda	Sanget	1.Bhagwangarh	10	1
		2.Jassibagwali	10	1
		3.Gheri Butter	10	1
		4.Guru Sar Sainawala	10	1
		5. Pathrala	10	1
	Bathinda	6. Bahosivia	10	1
		7.Deon	10	1
		8.Kili Nihal Singh wala	10	1
		9.Naruana	10	1
		10.Balade Wala	10	1
Total # of Farmers Selected in Punjab			**400**	**100**

Annexure 4. Questionnaire for the Survey in Maharashtra, Andhra Pradesh and Punjab

Interview Schedule No. _____

Adoption and Uptake Pathways of
GM/Bt Cotton among farmers in selected cotton growing villages in Maharashtra, Andhra Pradesh and Punjab in India, 2012

Name of Farmer: _____

State & District: _____

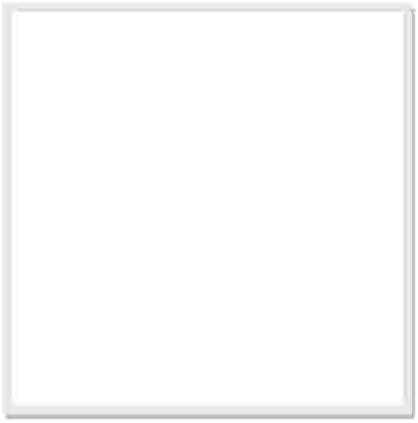
Taluka & Village: _____

Telephone/cellular phone no.: _____

Date Accomplished: _____

Interviewer: _____

Farmer's Photo in field/community or with family



I. SOCIO-DEMOGRAPHIC CHARACTERISTICS

1. Age	
2. Gender	Male/ Female
3. Demographic Information 3.1 Status 3.2 Number of children* (Age) 3.3 No of family members living in house: M/F 3.4 No of members engaged in farming: M/F *Mentioned only living with family	 Single/Married/Widow/Widower/Separated Male Female
4. Caste/category	SC/ST/OBC/GEN/other
5. Highest educational attainment	

6. Total yearly income from farming (Rs)

<20,000	20,000 to 50,000	50,000 to 80,000	>80,000	Specify

7. Other sources of income aside from farming- Amount (Rs/annum)

Allied agriculture (specify)	Business (specify)	Service	Other (specify)

8. Name and type of social organizations/ cooperatives affiliated with

Farmer's Organization	Cooperative	Women's Organization	Youth Organization	Others (Please specify)

II. FARM-RELATED PROFILE

9. Number of years farming/agriculture	
10. Irrigation 10.1 Status of irrigation 10.2 Source of irrigation	 • Fully irrigated/Partially irrigated/Rainfed • Tubewell/Canal/others

11. Land Holdings

Total Area (acres)	Leased in	Leased out	Total area cultivated	Total cotton area

III. COTTON CROP

A. Input Cost

12. Seed

Cultivar					Total
Area (acres)					
Quantity					
Cost (Rs/Pack)					

13. Fertilizer

Fertilizer	DAP	Urea	SSP	MOP		N:P:K 13:0:45				Total
Quantity										
Cost										

14. Pesticides

Pesticides	Imidacloprid 17.8 SL	Triazophos 36 EC	Acephate 75 SP				Total
Quantity							
Cost							

15. Irrigation

Water source	Canal	Tube well	Total irrigations	Comment on water use (Quality)
Number				
Cost				

Specify use of drip irrigation if any: cost/acre)

B. Labour Cost

16. Weeding

Weeding	Tractor	Manual	Total	Comment
Number				
Cost				

17. Pesticide applications

Number of sprays	Jassid	Whitefly	Other specify	Comment

Cost (Rs)				

18. Fertilizer/Thinning/Irrigation etc

a. Cost (Rs)

19. Picking

Picking*	First picking	Second picking	Third picking	Total
Seed cotton				
Cost of picking				
Gross income				

*Specify where the picking is done by farmers themselves only- no hired labour

*Percent contribution of farmer home labour

20. Miscellaneous

Name of pest/weed*	Insecticide/weedicide	Quantity used/acre

* Mention details of weedicides used if any

21. Computation of expenses and income in the last cropping season (cotton)

Expenses/income	Amount (in Rs.)	
A. GROSS INCOME		
B. EXPENSES (a + b)		
a. Labor	Last year	Before Bt cotton cultivation
Sowing operation Weeding Irrigating Spraying Picking Marketing Others (specify)		

b. Farm inputs		
Seeds Fertilizer Pesticide Weedicide Irrigation Others (specify)		
A – B = NET INCOME		

Note: Compare income before and after Bt cotton adoption

IV. ADOPTION OF BIOTECH CROPS

22. Information about Bt cotton

22.1 Year

22.2 Purpose

Bollworm control	High yields	Both	Others (specify)

23. First source of information on Bt cotton?

24. What steps initiated for adoption?

Looked for seeds	
Sought additional information	
Observed farms planted with Bt cotton	
Others (Specify)	

25. Adoption of cotton hybrid and Bt cotton hybrid

Year	
Number of years planting cotton hybrid and its name	
Number of years planting Bt cotton	
Area planted with Bt cotton vs total cotton	
Selection of Bt cotton hybrid and its name	
What was the reason for your immediate/delayed adoption?	

26. What encouraged you to plant Bt cotton?

Better yield and income	
Lesser expenses	
Success of other farmers	
Resistance to pest	

Resistance from drought	
Good product quality	
Others, specify	

27. Type of Bt cotton used for planting and why

BG I	BG II	Event1 (JK)	GFM (Fusion Bt)	Comment

28. Source of capital (% share)

- Own money/savings
- Loan
    - Bank/institution
    - Private individual
    - Others (specify)
- Total loan

29. Access to facilities used in Bt cotton production

Facility	Owned	Rented
Tractor		
Irrigation		
Seed drill		
Others Specify		

30. Cotton farming activities performed by family members

ACTIVITY	FAMILY MEMBER				
	Male	Female	Children		Others/hired labour (specify)
			Female	Male	
Land preparation					
Sowing					
Irrigating					
Weeding					
Fertilizer application					
Pesticide spraying					
Picking					
Marketing of produce					
Other specify					

31. Where do you market/sell your produce?

Mandi	Trader	Ginner	Cooperative	Others (specify)

32. Does Bt cotton fetch you higher/lower process in than the Minimum Support Price (MSP)?

33. For what purposes did you use your income from Bt cotton last cropping season?

34. Are you aware of the recommended steps in Bt cotton production?

Aware	Not aware

35. Do you follow the sowing of refugia? If not what do you do with non-Bt cotton seeds?

36. Was there any instance that you stopped planting Bt cotton?

36.1. Yes

Why?

36.2. What year did you stop planting?

When did you resume planting?

36.3. None

Why?

37. Where do you get information about Bt cotton?

University/Govt Extension worker (specify)	KVK (Krishi Vigyan Kendra) workers	Agro-input dealers	Seed industry personnel	News paper/brochure/magazine (specify)	TV/radio program (specify)	Others (specify)

38. Have you attended any training on Bt cotton production?

Yes	Not yet

39. Who conducted the training?

40. If not yet, are you interested in training?

- Yes (on what topic should the training be?)
- No (why not)

41. With whom do you share your knowledge about Bt cotton? Why

42. What support services (financial, infrastructural, technical, etc) have you requested/asked and received regarding Bt cotton production?

Service/Support Received (financial, infrastructural, technical, etc)	Who provided the service/support (Person, organization/institution)

43. What other services/support do you need with regards to Bt cotton farming? For what purpose?

Service/support	Purpose

44. What problems have you encountered in Bt cotton production? How do you want it to be solved?

1	Seed	
2	Fertilizer	
3	Pesticide	
4	Picking	
5	Labour	
6	Marketing	
7	Pest management	
8	Soil health	
9	Any other	

46. Are you aware of other Bt crops under development/field testing, if yes

Bt crop	**Awareness**		**Likely to adopt**		
BG-II RRF Cotton	Yes	Not yet	Yes	Maybe	No
Bt/HT Maize					
Bt Brinjal					
Bt Rice					
Golden Rice					
Other Bt crops					

47. What characteristics do you want to develop in crops?

Pest resistant	Virus resistant (Leaf curl virus)	Sucking pest resistant	Drought tolerant	Others (specify)

V.HEALTH AND ENVIRONMENTAL ISSUES

48. Decline in toxicity due to pesticide if yes what %
49. Any death/hospitalization after adoption of Bt cotton
50. Any health problems with cultivation of Bt cotton
51. Reduction in pesticide pollution: Yes/No
52. Effect on local environment and return of birds/other animals due less pesticides usages:

VI.ESTIMATED ANNUAL INCOME (YEAR)

A. Crop(s)	Area (acres)	Yield (quintal)	Gross income (Rs)	Cost of cultivation (Rs)	Net income (Rs)	Other income	Total
Cotton							
Rice- Coarse							
Rice - Basmati							
Wheat							
Other							
B. Other source of income (as at sr No. 7)							
Total Annual Income (Rs/year)							

VII. ASSETS PROFILE (After introduction of Bt cotton)

Assets	**Item**	**Year of Buying**	**Item**	**Year of Buying**
	Car		Gas Connection	
	Tractor/Farm Equipments		TV	
	Mobile		AC	
	Motorcycle/cycle		Washing Machine	
	Insurance		Others	

House: Kachha/Pucca

Amount spent on renovation after introduction of Bt cotton

Year	Amount	Remarks

Any loan amount paid/ reduction in loan amount after Bt cotton introduction:

Amount spent on marriages:

Land purchased/ freed from mortgage:

VIII. GENERAL INFORMATION

Bt cotton was adopted due to	• Protection against bollworms • Higher yield • Less use of pesticides
Yield of seed cotton (kg/acre)	• 2005 • 2006 • 2007 • 2008

	• 2009 • 2010 • 2011
Yield of Bt cotton are	• Increasing • Decreasing • Consistent • Fluctuating
If declining are due to	• Lack of good hybrids • Quality seed • Delayed sowing • Irrigation facilities • Pests • Lack of technical knowledge
Sucking insect-pest increase: Yes? No- if yes due to	• Bt cotton • New hybrid • Reduction in insecticide use • Climate • Any other
Soil Health	• Declining- Yes/No • When soil testing was done : • Applied any micronutrient: Iron/Zinc/Manganese/Any other • Quality of water used:
Are non-Bt cotton hybrids /varieties available for cultivation? If yes will you grow traditional cotton hybrid/variety? If not why?	
Have you ever tested soil, if yes what improvement it requires?	