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Returns and Economics of Bt Cotton vis-à-vis Traditional Cotton Varieties in the State of Maharashtra in India

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Chapter 1

Introduction and Objectives of the Study

1.1 Introduction

There have been major advances in biotechnology in the recent years and this has made it possible to directly identify genes, isolate them, know their functions, and transfer them from one organism to another. These developments have spanned the entire biological sciences, and now many applications have emerged, including emergence of transgenic crops, aimed at increasing agricultural productivity, improving resistance to diseases and pests, and improving the quality of the output. Since the introduction of transgenic crops in 1996, there has been a substantial increase in their area. The main transgenic crops include soybean, maize, cotton and canola. The world market for transgenic plants was estimated to be $ 8 billion in 2005 and is projected to be around $25 billion by year 2010 (James, 1999). The number of countries growing transgenic crops commercially had increased from just 3 in the early years to 13 by 1999. The global area under transgenic crops increased more that 25 fold from 1.7 million hectare in 1996 to 68 million hectare in 2003 (James, 2003). By the year 2005, which marked the 10^{th} anniversary of commercialization of transgenic/ genetically modified (GM)/ biotech crops, the global area was

estimated to be around 90 million hectares. This came from 21 countries, 11 developing and 10 industrialized countries (ISAA Brief, 2006).

The Monsanto Company developed Bt Cotton (*Bacillus thuringiensis* Cotton) and it is now one of the most widely grown transgenic crops and is grown in many countries, including United States, China, India, Australia, Argentina, South Africa and Indonesia. The cultivation of Bt cotton has risen rapidly in the world from 0.8 million hectares in 1996 to about 6 million hectares in 2003 and touched about 8 million hectares by 2005. Many countries have reported positive experience with Bt cotton. Bt cotton has spread very rapidly in China. It is reported that there is great demand for it from the farmers who find that it reduces the cost of pesticide as well as the exposure to pesticides. In China, the public sector has played an important role in providing this technology to the farmers (Pray, EC, et al, 2002).

After considerable hesitation, in 2002, the Government of India allowed the production of three genetically modified Bt cotton hybrids for three years from April 2002 to March 2005. This followed the controversial unauthorized release and cultivation of Bt cotton in some areas in the previous year. The impact assessment commissioned by Mahyco Monsanto Biotech claims sizable benefits for Bt adopters (AC Nelson, 2004), but anti-biotechnology activist have declared the technology a complete failure (Shiva and Jafri, 2003). Strong views both for and against Bt technology have surfaced.

1.2 Voices for and against Bt cotton

Many voices have been raised for and against Bt cotton in India since the mid-2000's.

Advantages of Bt Cotton have been reported to be:

1. Reduction in the use of insecticides by almost 50 percent.
2. Reduction in the use of insecticides and hence reduction in the harmful effect on the environment, including soil, water, atmosphere and life.
3. The quality of cotton fibre is at par with that of non-Bt cotton.
4. Better yield per unit of input use.
5. Reduction in the use of insecticides favours building up of population of beneficial insect pests.
6. Lesser residue of pesticides in the fibre produced which reduces the chances of harmful effects such as allergic reactions and so on.

The criticisms and fears that have been voiced against Bt Cotton include:

1. The gene may spread and its impact in the eco-system is not known
2. The Bt Cotton seed will be very expensive compared to Non-Bt seeds for the farmers and some companies may have a monopoly in seed multiplication and sales
3. Even on Bt cotton the farmers may require to use insecticides same as that of non-Bt cotton
4. The Bt cotton seed cake produced will cause harm to the animals and Bt may enter in the human food chain
5. Farmers will have to purchase Bt cotton seeds every year
6. Transgenic crop varieties will lead to the destruction of the native crop of the country. (Varieties as used in this study includes varieties and hybrids.)

7. Insects will soon develop resistance to Bt Cotton and hence the control of boll worm will become even more difficulty in the near future

In view of these diverse views and considering the importance of cotton in Indian agriculture it was considered worthwhile to undertake a systematic study examining the returns and other significant aspects of Bt cotton as opposed to non-Bt cotton.

This study examines the returns and economics of Bt cotton in the state of Maharashtra, as a part of a coordinated research project undertaken to examine the returns and economics of Bt cotton vis-à-vis traditional cotton varieties across important cotton growing states of Gujarat, Maharashtra, Andhra Pradesh and Tamil Nadu. It has been undertaken at the request and support of Ministry of Agriculture, Government of India. The project has been conducted in collaboration with the Agro-Economic Research Centres (AERCs) located in the different states, under the overall coordination of the Centre for Management in Agriculture (CMA), Indian Institute of Management, Ahmedabad (IIMA). The study on Maharastra, has been undertaken directly by CMA-IIMA.

1.3 Objectives of the Study

The following objectives were taken up for examination:

1 To examine the advantages and disadvantages of Bt cotton as a pest-resistant variety in rain-fed as well as irrigated conditions
2 To assess the cost of cultivation of Bt cotton as compared to other cotton varieties grown by farmers
3 To assess the net returns to Bt cotton as compared to other cotton varieties grown by farmers

4 To find out about any other impacts perceived by the farmers such as on the pest population/incidence, impact on other crops, impact on environment etc.

5 To comment on the usefulness of the technology and ways if any to improve its performance.

Chapter 2

Development of Bt Cotton and Cotton Cultivation in India

2.1 Bt Cotton: Genesis

The Bt cotton contains a foreign gene obtained from a bacteria called *Bacillus thuringiensis,* which is an aerobic bacterium characterized by its ability to produce crystalline inclusions during sporulation. This bacteria is a natural enemy of the boll worm, a major insect pest of cotton. This bacteria was first discovered by Japanese bacteriologist in 1901 and subsequently in 1915, a German scientist isolated the crystal toxin in Thuringen region of Germany. B.thuringiensis has been registered as a microbial pest control agent in 1961 under federal Insecticide and Rodenticide Act in the US. In India Bt formulations have been registered under pesticides Act 1968. With the advance of biotechnology, a method has been developed to introduce the bacterial gene responsible for the production of this toxin into the cotton plant, leading to the development of Bt cotton by Monsanto. This is the Cry1Ac gene which encodes for an insecticidal protein, Cry1Ac, derived from the common soil microbe *Bacillus thuringiensis*. This then protects the plants from bollworms, a major pest of cotton. The worms feeding on the Bt cotton plant becomes lethargic and sleepy causing less damage and are then eliminated.

2.2 Adoption of Bt Cotton in the World

The chronological progress of field trials and the adoption of Bt cotton across countries is shown in Table 2.1.The Commercial cultivation of Bt cotton has been taken up by United States of America, Australia and Mexico since 1996 and by China and South Africa with a lag of one year. Countries such as India, Indonesia and Colombia have taken up its commercial cultivation since 2002. The area under Bt cotton, including Bt with herbicides tolerance, has increased from merely 0.8 million hectare during 1996 to almost 6 million hectares by the year 2003 (Table 2.2, Figure 2.1).

Table 2.1: Year of Adoption of Bt Cotton in the World

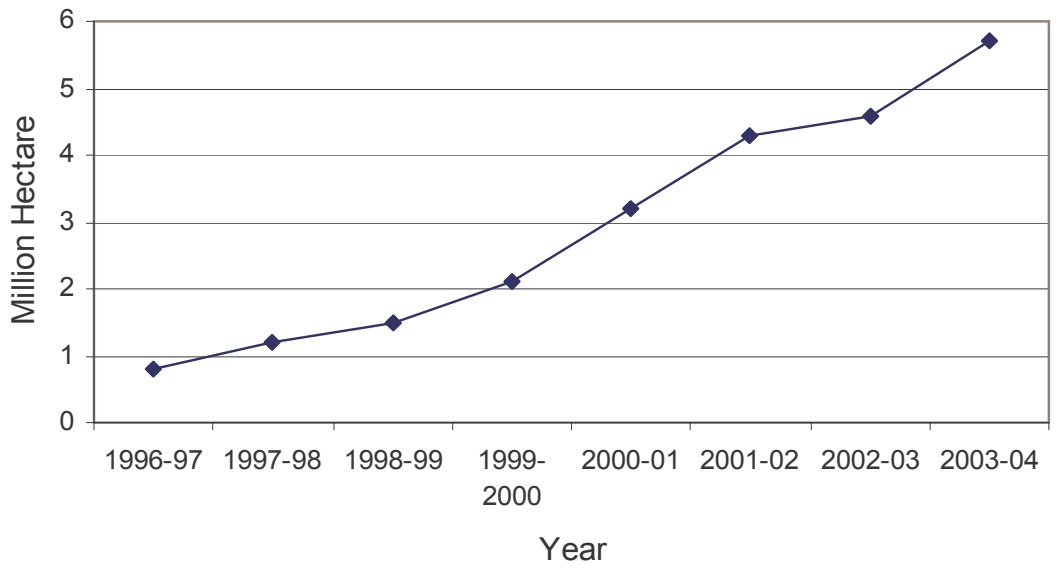
Country	1996	1997	1998	1999	2000	2001	2002	2003
USA	√	√	√	√	√	√	√	√
Australia	√	√	√	√	√	√	√	√
China		√	√	√	√	√	√	√
India							√	√
Indonesia							√	√
Mexico	√	√	√	√	√	√	√	√
Argentina			√	√	√	√	√	√
Colombia							√	√
South Africa		√	√	√	√	√	√	√

Source James C (2003)

Table 2.2: Global Adoption of Bt Cotton (Million Hectares)			
Year	Bt Cotton	Bt and HT Cotton	Total Area
1996	0.8	0.0	0.8
1997	1.1	0.1	1.2
1998	1.4	0.1	1.5
1999	1.3	0.8	2.1
2000	1.5	1.7	3.2
2001	1.9	2.4	4.3
2002	2.4	2.2	4.6
2003	3.1	2.6	5.7

Source: James C (2003), Preview: Global Status of Commercial Transgenic Crops: 2003, ISAAA Brief No.30, Ithaca, New York
HT is herbicides tolerant

Figure 2.1: Global Adoption of Bt/Ht Cotton



The potential advantages of Bt cotton envisaged include agronomic, economic and environmental. The major agronomic attributes of Bt cotton are improved pest control and yield advantage compared to conventional cotton

varieties. The major economic benefits envisaged are reduced pesticide cost and effective yield superiority over non Bt cotton varieties. Major environmental benefits include reduction in number of insecticides spray, less insecticides in aquifers and soil, less exposure to pesticides by human and animals, increase in the population of beneficial insects. These issues are examined below based on various studies conducted in India and elsewhere in the world.

2.3 Impact on Insecticides Use

A major agronomic attribute of Bt cotton over the conventional cotton is indicated to be its resistance to bollworm complex. Since the use of pesticides against bollworms is very high in the conventional cotton varieties, with the use of Bt cotton, the use of pesticides such as monocrotophos and synthetic pyrethroids gets reduced to a great extent. Data from many countries based on field trials has indicated that Bt cotton reduces the need of pesticides from seven to two or three sprays (James, 2002). Survey of Bt cotton in China during 1999 to 2001 period showed that on an average the incidence of insecticides poisoning for farmers using Bt cotton was up to four times less than for farmers using conventional varieties (Pray, et al). Growers in the US reduced insecticides use by 1.9 million pounds of active ingredient per year in 2001 (Gianessi, et al). In China the insecticides application was reduced by 67 per cent (Pray and Wang, 2002). This also helped reduce the adverse environmental impact.

The field level observations from various parts of India were mixed on this aspect. Many studies have found that there is significant reduction in the use of pesticides on Bt cotton as compared to non-Bt cotton (e.g. Sharma, 2002). A

study carried out in four states of India during the first season of Bt cotton adoption in India shows that the Bt technology leads to significant pesticide use reduction (Naik et al, 2005). Around 70 per cent of the farmers in Andhra Pradesh exposed to Bt Cotton have responded favorably to its commercial release because of its resistant to pests. A statement of Director General of Indian Council of Agricultural Research (quoted in Indian Express, 2003) says that about 65 per cent of the insecticide used in cotton production is to tackle the menace of bollworm and if the genetically modified (GM) varieties are resistant to the pest, their cultivation must be encouraged.

On the other hand, Shai and Rahman, (2003) observed that since Bt cotton does not offer protection against pink boll worm, it was necessary to spray pesticides to almost the same extent as in non-Bt cotton. Some indicate that the Bt cotton is susceptible to the bollworm and the yield is below par. A study (K. Venkateshwarlu, 2002) conducted in 11 villages of Warangal district in AP, indicates that non-Bt cotton produced 30 per cent more and there is only a marginal difference in the pesticides use. The farmers sprayed pesticides 4-6 times in Bt, and 5-7 times on non-Bt cotton. Bt farmer had to pay Rs.1150 more per hectare towards the purchase of seed. Besides, the labour charges are stated to be about Rs.150 more per hectare for picking Bt cotton. The price of Bt cotton was reported to be 10 per cent less in the local market (Business Line, 2002). The study indicated that Bt Cotton has failed on many counts and the claims made by the company were wrong. It neither improved yield through better plant protection or reduced the pesticide usage and the returns were less

since the pods were small, seeds were more, lint and the staple length were less (K. Venkateshwarlu, 2002).

In some cases, it was reported that the new pests and diseases emerged, and Bt cotton failed to prevent even the boll worm attack. The economics that was worked out by the Indian Council of Agricultural Research (ICAR), Genetic Engineering Approval Committee and Monsanto-Mahyco to promote this technology are questioned. Bt cotton was afflicted with the 'leaf curl virus' in the northern states of India. In Maharashtra, the Bt cotton crop in Vidarbha has been badly affected by the root-rot disease. In Gujarat heavy infestation of bollworm on the Bt cotton was reported in the districts of Bhavanagar, Surendranagar and Rajkot. Some reports indicated that initially Bt Cotton showed resistance to boll worms but as soon as the formation of bolls started, the worms started attacking them (RFSTE, 2002). Thus, the literature indicates that the opinions are diverse in the context the reduction in pesticide use and the resistance of Bt cotton to pests, and it needs further study.

2.4 Impact on Cost of Production and Yield

It was generally believed that significant decline in the use of pesticides would reduce the total cost of cultivation. But some it may not be so mainly due to relatively high cost of seed compared to non Bt cotton (Iyengar and Lalita, 2002). Since the need for yield increasing inputs for Bt cotton is relatively high, the total cost of cultivation for Bt cotton is found to be relatively high not only in India but also elsewhere in the world (Financial Express, 2003). However, a study in China for the years 1999 to 2001 showed that though the cost of seed

was greater for Bt cotton, this was offset by a much greater reduction in pesticides use and a reduction in labour because there is reduction in the time of spraying pesticides (Pray, 2002). The positive impact of Bt cotton on yield was reported from various parts of the world (Chaturvedi, 2002; Pray et al, 2001). Significant yield gains by Bt cotton were reported from Maharashtra, Karnataka and Andhra Pradesh in India during the year 2002 (Gopal Naik). The net benefit of Bt cotton over non-Bt cotton was found to be around Rs. 7000 per acre mainly due to increase in yield (Thomas, 2002; www.kisanwatch.org). The gross margin for Bt cotton was substantially higher in case of Bt cotton in Maharashtra, Karnataka and Tamil Nadu (Gopal Naik, 2005). The net benefit from Bt cotton was reported to be higher in US, China, and South Africa (Pray et al, Dong et al, 2004). Thus majority of the studies mentioned here are by and large of the opinion that Bt cotton do have effective yield superiority compared to non-Bt cotton.

2.5 Environmental Impacts

Significant decrease in the number of insecticides sprays for the control of the bollworms should reduce environmental hazards due to high toxicity of the insecticides. Lesser farmer exposure to insecticides would also reduce health hazards. Similarly reduction in the use of insecticides will reduce the risks to mammals, birds, bees, fish and other organisms (USEPA, 2001). No systematic study has reported any direct adverse impact of Bt cotton on the environment.

2.6 Cotton Cultivation in India

This section gives a brief account of cotton cultivation in India and the level and pattern of adoption of Bt cotton by farmers in different parts of the country. Though India ranks first in area cultivated under cotton in the world, it occupies only the third position in production and has a very low ranking in productivity. Nearly 65 per cent cotton cultivation in the country is under rain-fed conditions and hence subject to heavy vagaries of monsoon rains. Continuous presence of cotton in the subcontinent makes it easy for pest, diseases and other biotic stress agents to survive, multiply and cause frequent epidemics (Mayee, 2002). The cotton fiber accounts for almost 73 per cent of the total raw material mix of the textile industry. The research programs undertaken by Cotton Institutes, Agricultural Universities and ICAR over the past decades have led to significant improvements in terms of quality and quantity of cotton. The country is by and large able to meet the demand of different quality cottons through a wide range of hybrids and varieties developed in the system (Cotton: A March Towards New Millennium, 2001).

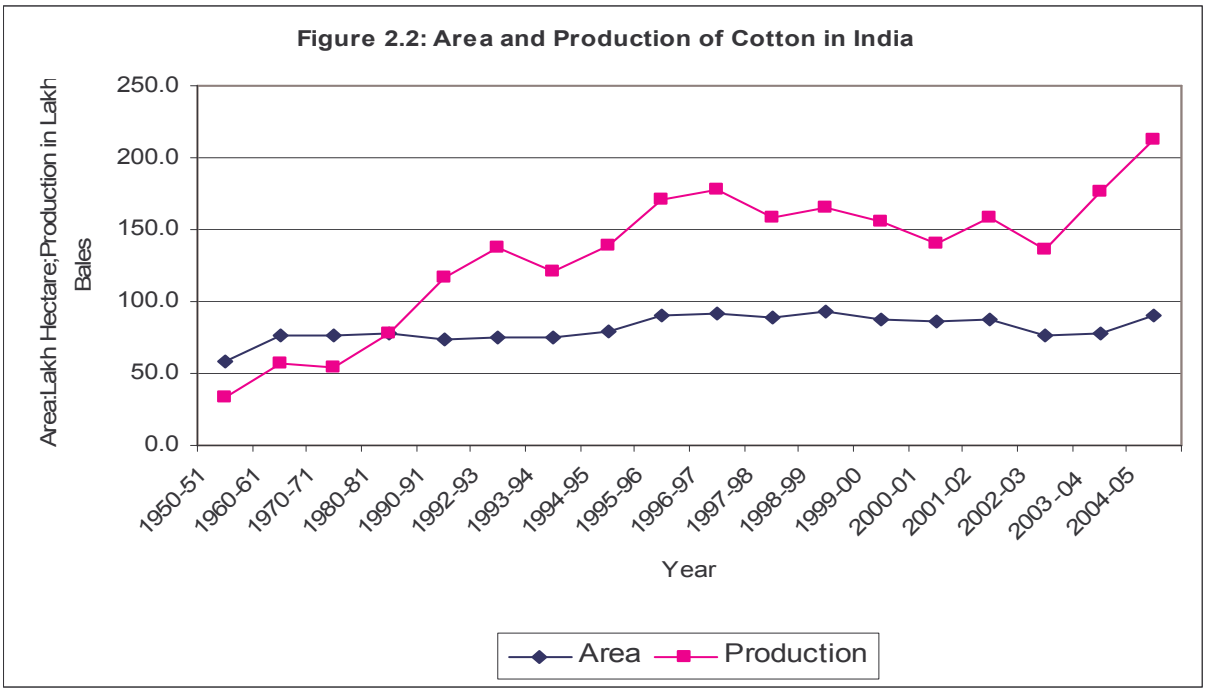
The cotton crop is highly susceptible to insect pests. About 166 different species of insects and pests are reported to attack cotton at various stages of its growth. Among these, the cotton bollworm, whitefly, jassids, pink bollworm and spotted bollworm have been causing substantial economic damage to cotton crops all over the country. It is roughly estimated that the pests and diseases cause more than 50 percent damage to cotton crop in India compared to 24.5 percent world over. About 96,000 metric tons of technical grade pesticides are

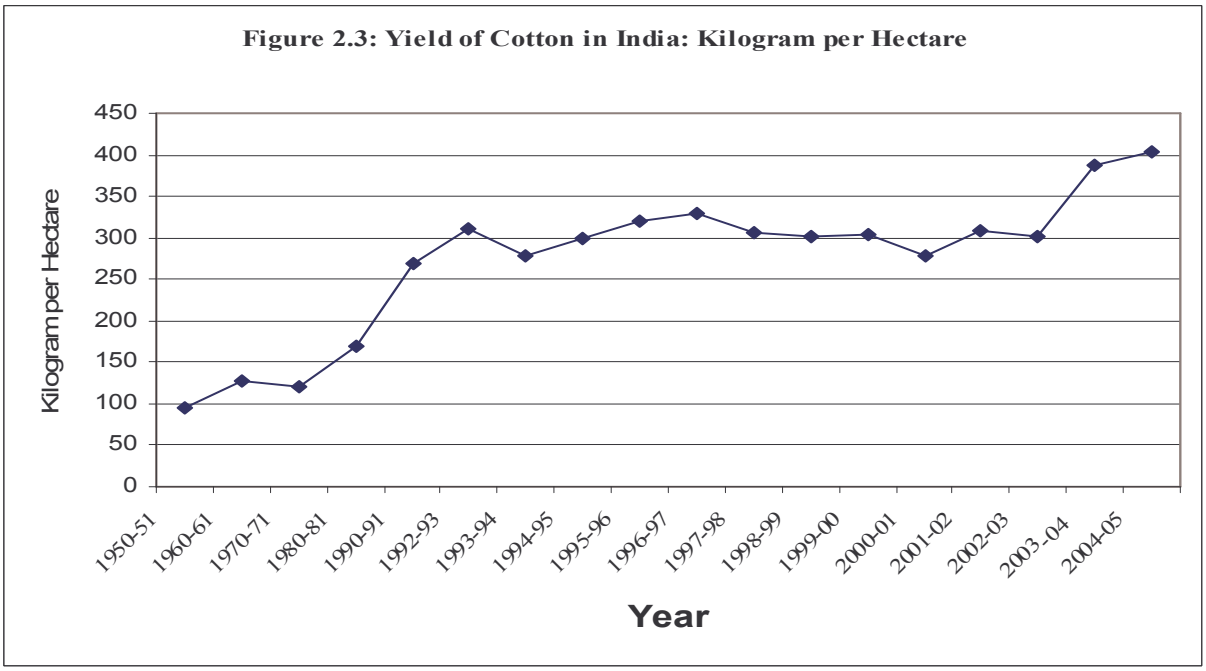
currently produced in the country of which 54 percent are consumed on cotton. It is estimated that India loses about Euro 300 million per year to the boll worm, besides the annual cost of pesticides application on cotton is over Euro 350 million (Bio-scop.org, 2004).

India ranks third in the world after China and US in terms of the production of cotton. Area under cotton in is about 9 million hectares and which is about 10 percent of the total cultivated area in the country. Large variation in area under cotton could be observed and this could be primarily attributed to the vagaries of rainfall as the area under irrigated cotton is very limited. The estimated production of cotton during 2004-05 is the record production in the history of cotton cultivation in the country at 21.3 million bales of 170 kilogram each. The cotton yield in the country is not only one of the lowest in the world, it has been either stagnating or on the decline until early 2000. The cotton yield had shown an upward trend till the 1990s and since then it was stagnant at around 300 Kg/hectare till 2002 (Table 2.3 and Figure 2.2 and 2.3). There is an upward trend in cotton yield since 2002. The growth in cotton yield from 1990-91 to 2000-01

Table 2.3: Area, Production and Yield of Cotton in India			
Year	Area (Lakh Hectares)	Production (Lint) (Lakh Bales of 170 Kgs.)	Yield (Kg./Hectare)
1950-51	58.8	32.8	95
1960-61	76.1	56.8	127
1970-71	76.1	53.5	120
1980-81	78.2	78.0	170
1990-91	73.9	117.0	269
1991-92	74.0	119.1	273
1992-93	75.4	138.0	311
1993-94	74.4	121.5	278
1994-95	78.6	138.5	300
1995-96	90.6	170.7	320
1996-97	91.7	177.9	330
1997-98	88.3	158.0	307
1998-99	92.9	165.0	302
1999-00	87.3	156.0	304
2000-01	85.8	140.0	278
2001-02	87.3	158.0	308
2002-03	76.7	136.0	302
2003-04	77.9	177.0	387
2004-05 (P)	89.7	213.0	404
Annual Growth Rate (%)			
1990-91 to 2000-01	2.35	2.73	0.40
1990-91 to 2004-05	0.77	2.47	1.70

is merely 0.4 percent per annum and the same between 1990-91 to 2004-05 is more than four times at 1.7 percent per annum. Cotton yield in the country reached a peak in the year 2004-05.





2.7 Adoption of Bt Cotton in India

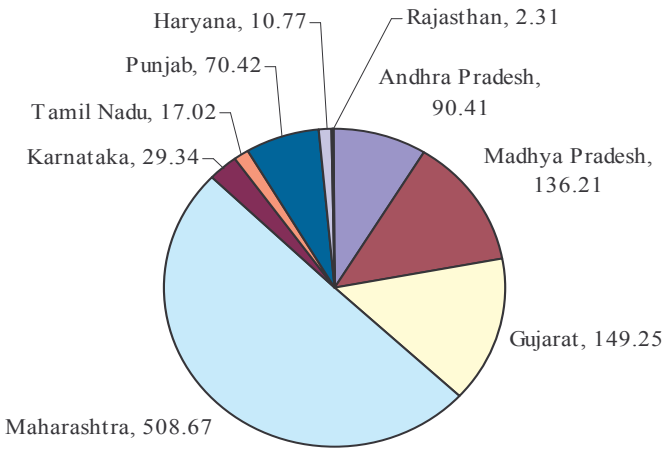
In March 2002 the Genetic Engineering Approval Committee (GEAC), the regulatory authority for transgenic crops in India, approved the commercial

cultivation of Bt cotton varieties Bt Mech 12, Bt Mech 162 and Bt Mech 184. These varieties were developed by Monsanto in collaboration with its Indian partner the Maharashtra Hybrids Seeds Company (MAHYCO) for commercial cultivation in central and southern India. The GEAC approved large scale field trials and seed production of 12 more varieties of Bt hybrids in 2005. While MAHYCO is Monsanto's partner in India, Rasi Seeds and Ankur Seeds are sub-licensees of Monsanto. Ankur Seeds has been given the green signal to conduct large scale field trials and seed production of Ankur 651 Bt and Ankur 2354 Bt in North India, and Ankur 651 Bt and Ankur 09 Bt in Central India. In 2005, RCH 2 Bt became the fourth transgenic cotton crop to be approved for commercial cultivation in the country.

Gujarat and Maharastra were the early adopters of Bt cotton in the country that commenced in 2002 followed by Andhra Pradesh and Karnataka (Table 2.4 and Figure 2.4). According to available statistics (which may be underestimates and not including unofficial use), the area under Bt cotton in India today is about 1 million hectare, or about 11 percent of the total area under cotton in the country. As of 2005, the share of area under Bt cotton to total area under cotton was over 27 percent in Madhya Pradesh, about18 percent in Maharashtra.

Table 2.4: Growth in Area under Bt Cotton in India : 000 ha						
State	2003	2004	2005	Area under Bt cotton as percent of total area under Cotton		
				2003	2004	2005
Andhra Pradesh	5.46	71.22	90.41	0.65	6.07	9.30
Madhya Pradesh	13.35	86.12	136.21	2.26	14.95	21.45
Gujarat	41.68	125.92	149.25	2.53	6.61	7.19
Maharashtra	21.85	161.47	508.67	0.79	5.42	17.61
Karnataka	3.04	34.30	29.34	0.97	6.70	8.08
Tamil Nadu	7.69	11.99	17.02	7.46	8.45	11.34
Punjab	Neg*.	Neg.	70.42	Neg.	Neg.	12.14
Haryana	Neg.	Neg.	10.77	Neg.	Neg.	1.80
Rajasthan	Neg.	Neg.	2.31	Neg.	Neg.	0.51
Total	93.08	491.02	1014.40	1.22	5.50	11.51
* Negligible or Nil						

Figure 2.4: Area under Bt Cotton in Major Cotton Growing States as of 2005: Area in 000 ha



Chapter 3

Cotton Cultivation in Maharashtra

This chapter examines the status and performance of cotton in the state of Maharastra, as well as in the districts sampled for the study. It then presents the sampling design and profile.

3.1 Cotton Cultivation in Maharashtra

Cotton is traditionally one of the important crops in Maharastra. Area under cotton is about 3 million hectares in the state and it accounts for about 30 percent of the cotton area in the country. The area was about 2.5 million hectares until 1994-95, and since it has expanded to about 3 million hectares. Even though the share in area is high, the share in the production is low due to the relatively low yield levels. Further, a declining trend in the 90's, with a particularly sharp declining trend in the yields. However, a change is evident in the early 2000s with an upturn in the production and yield growth rates when these years are included.

Cotton experiences wide fluctuation in Maharashtra due to vagaries of weather as it is mainly cultivated under rain-fed conditions. The cotton production in the state shows very low levels of production during 1970-71, 1991-92, 1997-98 mainly because of crop failures due to the poor rainfall or early withdrawal of monsoon. The yield levels in all these years were very low; see Table 3.1 and Figures 3.1 to 3.3.

Table 3.1 : Area, Production and Yield of Cotton in Maharashtra			
Year	Area (000 ha)	Production (Lint) (000 Bales)	Yield (Kg/Ha)
1960-61	2500	2843	114
1965-66	2716	1787	66
1970-71	2750	824	30
1975-76	2307	1326	58
1980-81	2550	2081	82
1985-86	2709	3372	125
1990-91	2721	3188	117
1991-92	2759	1965	71
1992-93	2574	3214	125
1993-94	2481	4465	180
1994-95	2760	4463	162
1995-96	3078	4781	155
1996-97	3085	3143	102
1997-98	3139	1753	56
1998-99	3199	2619	82
1999-2000	3254	3099	95
2000-01	3077	3064	100
2001-02	3105	4572	147
2002-03	2800	4424	158
2003-04	2766	3100	112
2004-05	3049	5200	171
Annual Growth Rate (%)			
1990-91 to 2000-01	2.31	-1.09	-3.29
1990-91 to 2004-05	0.93	2.05	1.12

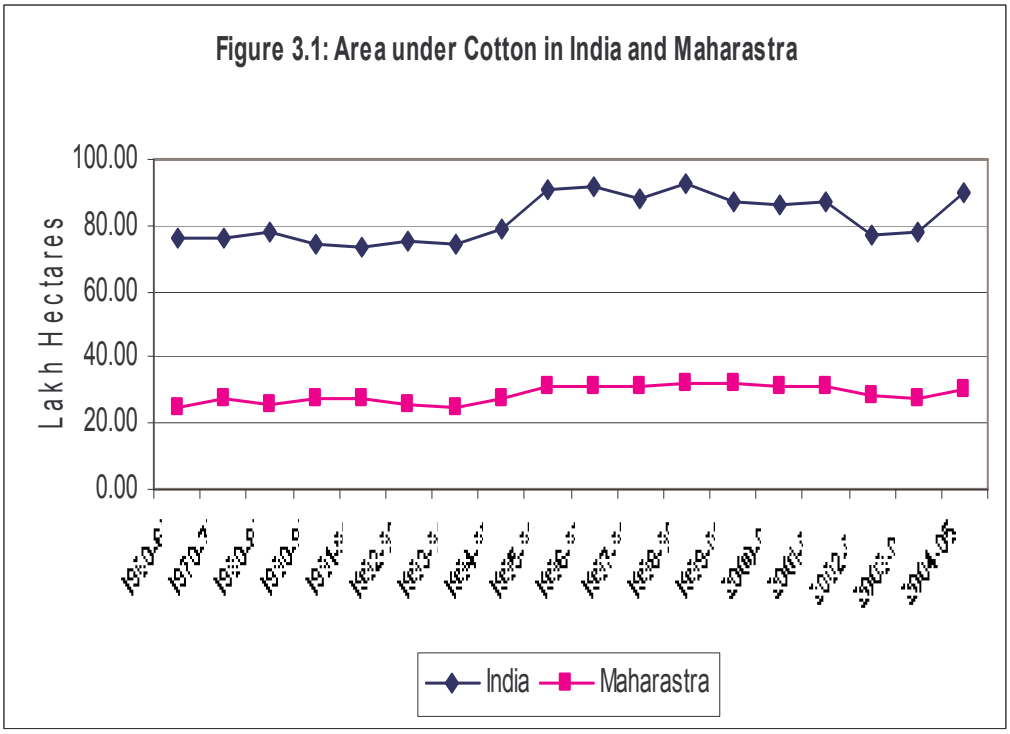


Figure 3.1: Area under Cotton in India and Maharastra
Lakh Hectares
100.00
80.00
60.00
40.00
20.00
0.00
India
Maharastra

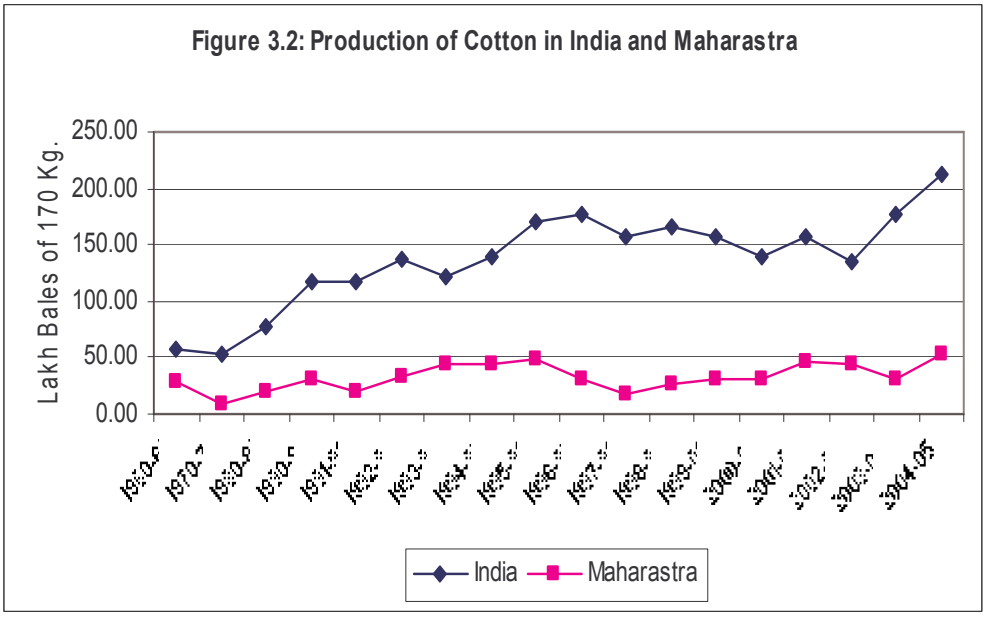
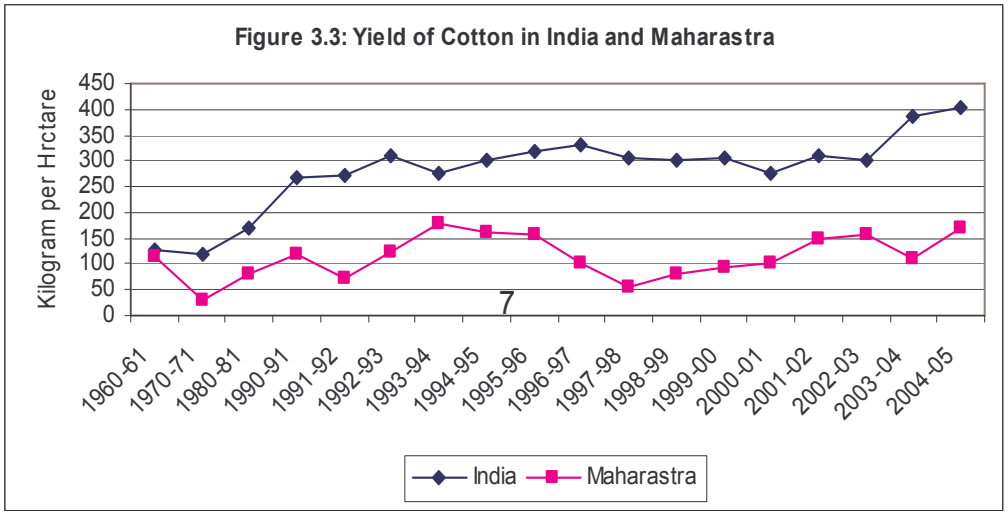


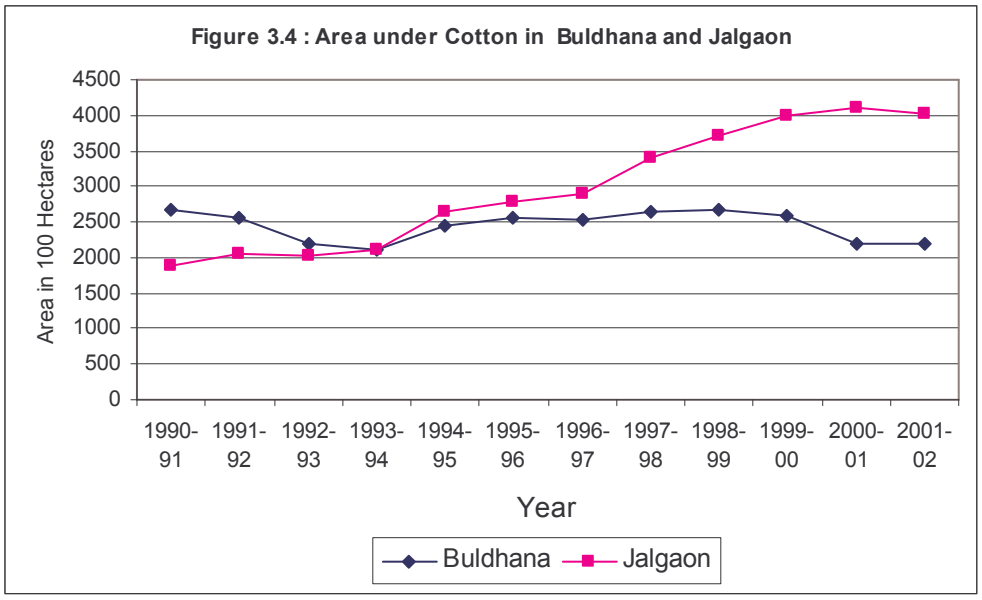
Figure 3.2: Production of Cotton in India and Maharastra
Lakh Bales of 170 Kg.
250.00
200.00
150.00
100.00
50.00
0.00
India
Maharastra



3.2 Cotton Cultivation in the Selected Districts

The districts sampled for this study, Buldhana and Jalgaon, belong to two different agro-climatic regions of Maharashtra, and are important cotton growing districts in state. Jalgaon has greater irrigation availability for cotton whereas the cotton cultivation in Buldhana is predominantly rain-fed. Due to this, the yields are relatively low in Buldhana compared to Jalgaon. While area under cotton shows a decrease in Buldhana, it shows an increase in Jalgaon (Table 3.2 and Figures 3.4 and 3.5). As elsewhere in the state of Maharashtra, both production and yield of cotton in these districts shows large fluctuations, and hardly any trend is evident until 2001-02.

Table 3.2 : Area, Production and Yield of Cotton in sample districts						
	Area in '00 Hectare		Production '00 Bales		Yield in Kg/ha	
	Buldhana	Jalgaon	Buldhana	Jalgaon	Buldhana	Jalgaon
1990-91	2667	1893	1699	1909	108	171
1991-92	2571	2040	717	1116	47	93
1992-93	2186	2034	1256	2340	98	196
1993-94	2112	2098	2075	2542	167	206
1994-95	2436	2633	2122	3454	148	223
1995-96	2547	2779	1861	3143	124	192
1996-97	2524	2899	2425	4475	163	262
1997-98	2655	3404	1199	3706	77	185
1998-99	2658	3719	2025	4895	130	224
1999-00	2580	3991	2635	5620	174	239
2000-01	2198	4115	892	2811	69	116
2001-02	2201	4030	1978	5049	153	213



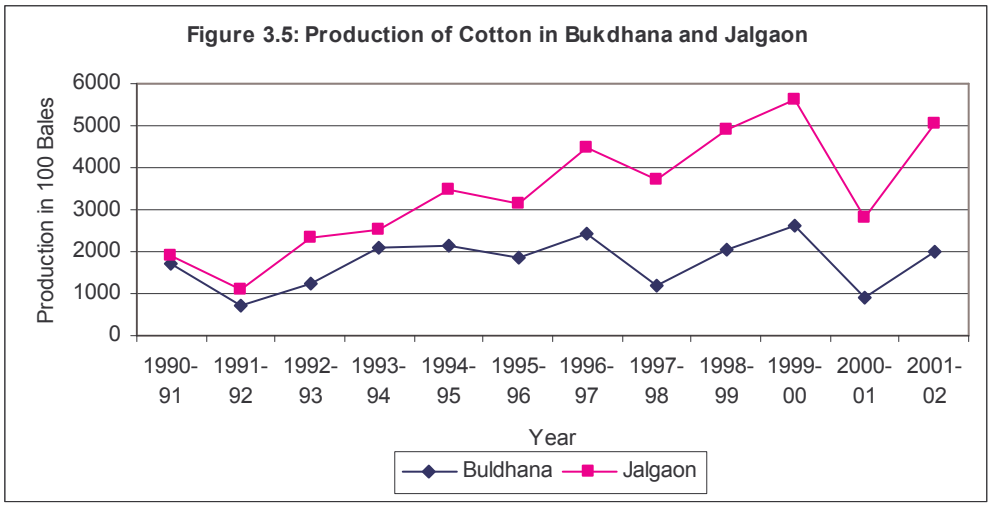


Figure 3.5: Production of Cotton in Bukdhana and Jalgaon
Production in 100 Bales
6000
5000
4000
3000
2000
1000
0
1990-91
1991-92
1992-93
1993-94
1994-95
1995-96
1996-97
1997-98
1998-99
1999-00
2000-01
2001-02
Year
Buldhana
Jalgaon

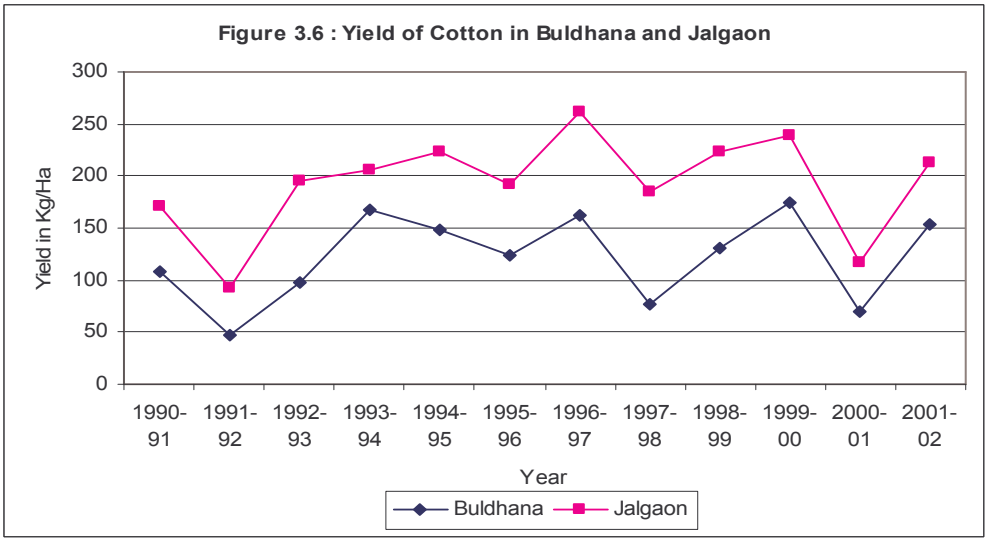


Figure 3.6 : Yield of Cotton in Buldhana and Jalgaon
Yield in Kg/Ha
300
250
200
150
100
50
0
1990-91
1991-92
1992-93
1993-94
1994-95
1995-96
1996-97
1997-98
1998-99
1999-00
2000-01
2001-02
Year
Buldhana
Jalgaon

Chapter 4

Sampling and the Profile of Bt and Non-Bt Sample Farm Households

4.1 Introduction

This chapter presents the profile of the sample households on features such as age, education, experience in cotton farming, farm size, irrigation status, sources of irrigation, cropping pattern, access to cotton markets and towns, and their distribution across Bt and non-Bt farmer households. It also explores the relationship of these factors to the adoption of Bt Cotton.

4.2 Sampling Design and Profile

A sample survey of farmers was undertaken in two sample districts of the state of Maharashtra. Broadly, a stratified random sampling process was followed. A major consideration for the selection of the districts was sampling of different agro-climatic regions, and as indicated, the two districts belonged to two different agricultural regions of the state. The selection the districts was done on the basis of information provided by the District Agricultural Office on the cultivation of cotton varieties, particularly Bt and non-Bt cotton. Given the objectives of the study, a major consideration was the presence of Bt cotton in the districts as per the records of Commissionerate of Agriculture, Government of Maharashtra, and the District Agricultural Offices. After selecting the districts, three Talukas were selected in each district again considering the agro-ecologic diversity and the presence of Bt cotton. From each taluka one village was

selected at random. Farmers growing Bt and Non-Bt cotton and across small, medium and large farm were selected through a stratified random sampling process considering representation, as far as possible, of different farm sizes, and irrigated and unirrigated conditions. In this way, a total of 12 villages and 154 farmers were covered across 2 districts and 6 talukas. The names of selected talukas, villages and the number of farmer households selected under different categories are given in the Table 3.3 below. Data were collected for the agricultural year 2004-05. The data indicated that among the Bt farmers, about 82 percent took up Bt cultivation for the first time in 2003-04 and the rest during 2004-05, i.e. the survey year.

Table 3.3 : Selection of Sample Farmer Households

S. No	District	Taluka	Village	Number of Farmer Households					
Bt Cotton									
				I	UI	Total	Small	Medium	Large
1	Jalgaon	Jalgaon	Nasirabad	8	8	16	0	5	11
2	Jalgaon	Bhusaval	Sakhegaon	2	7	9	2	2	5
3	Jalgaon	Jamner	Gharkheda	8	2	10	0	2	8
4	Buldhana	Jalgaon	Sungaon	9	4	13	2	2	9
5	Bildhana	Motala	Advihir	8	9	17	1	6	10
6	Buldhana	Bhuldhana	Tharatkhed	13	7	20	12	6	2
Total				48	37	85	17	23	45
Non Bt Cotton									
				I	UI	Total	Small	Medium	Large
1	Jalgaon	Jalgaon	Nasirabad	2	9	11	0	3	8
2	Jalgaon	Bhusaval	Sakhegaon	2	16	18	8	5	5
3	Jalgaon	Jamner	Gharkheda	3	6	9	4	4	1
4	Biuldhana	Jalgaon	Sungaon	3	7	10	3	3	4
5	Buldhana	Motala	Advihir	1	9	10	0	1	9
6	Buldhana	Bhuldhana	Tharatkhed	10	1	11	8	2	1
Total				21	47	69	23	18	28

The irrigation status of the sampled Bt and Non-Bt cotton farmer households given in Table 3.4 showed that while 56.5 percent of Bt growers had

irrigation, and this was about 30 percent for the non-Bt cotton farmers. The distribution between irrigated and unirrigated and under different farm size, viz., small, medium and large is also given in Table 3.4.

Table 3.4 : Irrigated and Unirrigated Farmer Households under Bt and Non-Bt Cotton

Farm Size	Bt Cotton			Non-Bt Cotton		
	Irrigated	Un-Irrigated	Total	Irrigated	Un-Irrigated	Total
Small (Below 5 Acre)	8	9	17	9	14	23
	47.1	52.9	100.0	39.1	60.9	100.0
Medium (5 to 10 Acre)	14	9	23	5	13	18
	60.9	39.1	100.0	27.8	72.2	100.0
Large (Above 10 Acre)	26	19	45	7	21	28
	57.8	42.2	100.0	25.0	75.0	100.0
Total	48	37	85	21	48	69
	56.5	43.5	100.0	30.4	69.6	100.0

4.3 Age, Education and Experience in Cotton Cultivation

The distribution of the age of the head of households across Bt and non-Bt cotton sample farmer households indicates that there is no large difference in the age of sample farmer households (Table 4.1). However, the level of education of the head of households shows that the percentage of heads of households with higher education tends to be relatively more under the Bt cotton farmers (Table 4.2). For example, about 15 percent of the heads of households under Bt cotton were either graduates or had technical education as opposed to 8 percent under non-Bt cotton. Similarly Bt cotton growers have more experience in the cultivation of cotton than non-Bt cotton (Table 4.3). About 60 percent of heads of households under Bt cotton have more than 15 years experience in the

cultivation of cotton as opposed to just over 25 percent under non-Bt cotton. Thus, Bt cotton appears to be positively associated with education and experience in growing cotton.

Table 4.1: Average Age of Head of Household among Bt and Non-Bt Sample Farmer Households

	Bt-cotton		Non-Bt Cotton	
Age	No. of Farmers	Percent	No. of Farmers	Percent
Below 30	8	9.41	6	8.70
30-40	17	20.00	17	24.64
40-50	25	29.41	19	27.54
50-60	26	30.59	19	27.54
Above 60	9	10.59	8	11.59
Total	85	100	69	100

Table 4.2 : Level of Education of the Head of Household among Bt and Non-Bt Farmer Households

	Bt Cotton		Non-Bt Cotton	
Level of Education	No. of Farmers	Percent	No. of Farmers	Percent
No formal education	30	35.29	31	44.93
Up to Primary	31	36.47	28	40.58
Up to Secondary	11	12.94	6	8.70
Graduate	6	7.06	3	4.35
Others	7	8.24	1	1.45
All Households	85	100	69	100

Table 4.3 : Experience in Cotton Cultivation by the Head of Household among Bt and Bt-Cotton Farmer Households				
	Bt Cotton		Non-Bt Cotton	
Experience in Years	No. of Farmers	Percent	No. of Farmers	Percent
Below 5 years	2	2.35	1	1.45
5 to 10 years	8	9.41	12	17.39
10 to 15 years	24	28.24	38	55.07
Above 15 years	51	60.00	18	26.09
Total	85	100.00	69	100.00

4.4 Farm Size and Irrigation

Next we have examined the farm size and the level of irrigation across the Bt and non-Bt cotton households. The average farm size in terms of area operated and the level of irrigation of Bt and not-Bt sample farmer households are given in Table 4.4. The average farm size of Bt growers is marginally higher. The farm sizes in these dry areas tend to be bigger. The percentage of area irrigated in total operated area is substantially higher on an average among the Bt growers, 46 percent as compared to 28 percent, and this difference exists in all farm sizes.

4.5 Sources of Irrigation

The sources of irrigation in the study area were canal, tube-wells, open wells and ponds (Table 4.5). While canal irrigation was the major source of irrigation for the Bt cotton growers, it was tube-well for the non-Bt growers. Other sources of irrigation among the sample farmer households were open wells and ponds, and more Bt cotton growers had access to these than non-Bt growers.

Table 4.4 : Average Farm Size and Irrigation Status of Bt and Non-Bt Sample Farmer Households (acres)								
	Bt Cotton				Non-Bt Cotton			
	Number of Farmers	Area Operated	Area Irrigated	Percent Area Irrigated	Number of Farmers	Area Operated	Area Irrigated	Percent Area Irrigated
Small	17	3.41	1.59	46.55	23	4.00	1.28	32.07
Medium	23	8.52	5.26	61.73	18	8.39	1.78	21.19
Large	45	22.64	9.84	43.47	28	21.39	6.21	29.05
Total	85	14.98	6.95	46.43	69	12.20	3.41	27.97

Table 4.5 : Sources of Irrigation under Bt and Non-Bt among sample Farmer Households				
Source of Irrigation	Bt-cotton	Percent	Non-Bt Cotton	Percent
Canal	32	58.18	0	0.00
Tube-Well	5	9.09	19	67.86
Open Well	9	16.36	1	3.57
Drip irrigation	0	0.00	7	25.00
Pond	9	16.36	0	0.00
Others	0	0.00	1	3.57
Overall	55	100.00	28	100.00

4.6 Cropping Pattern

The findings indicate that the cropping season in the survey area is predominantly the single season of kharif. About 85 percent of the gross cropped area falls under the kharif season for both Bt and Non-Bt farmers (Table 4.6). This may be due to two reasons: first, kharif is the rainy season and rain-fed agriculture accounts for a major share in the cultivated area. Secondly, cotton the major crop for the sample farmers cotton is a longer duration kharif crop compared to many others. Thus, taking a rabi crop after cotton is difficult. The average area of Bt cotton per household was 1.59 hectares with irrigation and 1.99 hectares without irrigation. This was respectively 0.70 and 2.64 hectares for non-Bt cotton. The other major crops followed by cotton are jowar, pulses and

wheat. The cropping pattern does not show a large difference between Bt and non-Bt farmers. This is examined in the following Table through percentages.

The share of area under cotton for the sample Bt growers was 43.1 percent, whereas the same for the non-Bt growers was 40.1 percent (Table 4.7). This indicates that cotton is the dominant crop. The share of cotton is the highest for unirrigated Non-Bt farmers indicating its great importance in this group. Other major crops grown during the kharif were jowar, maize, pulses etc. As mentioned above, the share of rabi area in gross cropped area is less than 15 percent, and wheat was the major crop grown during the rabi season.

Table 4.6: Cropping Pattern among the Bt and Non-Bt Cotton Sample Farmer Households, Average in Hectares						
	Bt- Farmers			Non-Bt Farmers		
	Irrigated	Unirrigated	Total	Irrigated	Unirrigated	Total
Kharif-2004						
Cotton	1.59	1.99	3.58	0.70	2.64	3.34
Jowar	0.35	1.07	1.46	0.09	1.19	1.27
Maize	0.13	0.36	0.49	0.20	0.30	0.50
Soyabean	0.21	0.40	0.61	0.28	0.32	0.59
Urad+Mung	0.17	0.69	0.86	0.23	0.69	0.92
Banana	0.49	0.06	0.55	0.70	0.00	0.70
Sugarcane	0.56	0.00	0.56	0.04	0.00	0.04
Tur	0.15	0.59	0.74	0.03	0.49	0.52
Chilli	0.06	0.37	0.43	0.20	0.30	0.49
Mango	0.00	0.31	0.31	0.00	0.05	0.05
Total Kharif	3.71	5.84	9.55	2.47	5.98	8.45
Rabi-2004-05						
Wheat	0.58	0.18	0.76	0.46	0.46	0.93
Gram	0.34	0.46	0.72	0.04	0.14	0.18
Sunflower	0.07	0.16	0.19	0.01	0.11	0.11
Jowar	0.12	0.32	0.44	0.07	0.24	0.32
Groundnut	0.02	0.04	0.06	0.00	0.08	0.08
Onion	0.06	0.00	0.06	0.04	0.04	0.09
Total Rabi	1.19	1.16	2.23	0.63	1.08	1.71
Grand Total	4.90	7.00	11.90	3.10	.7.06	10.16

Table 4.7 : Cropping Pattern among Bt and Non-Bt Cotton Farmer Households (Percentage)						
Crops	Bt- Farmers			Non-Bt Farmers		
	Irrigated	Unirrigated	Total	Irrigated	Unirrigated	Total
Kharif-2004						
Cotton	45.36	40.70	43.12	28.97	45.63	40.85
Jowar	5.80	12.68	10.06	2.79	14.69	11.05
Maize	2.13	4.32	3.41	6.01	3.66	4.36
Soyabean	3.48	4.74	4.22	8.15	3.93	5.18
Udad+Mung	2.80	8.15	5.92	6.87	8.48	7.99
Banana	8.12	0.70	3.81	20.60	0.00	6.06
Sugarcane	9.28	0.00	3.89	1.29	0.00	0.38
Tur	2.51	6.97	5.11	0.86	6.07	4.55
Chilli	0.97	4.39	2.96	5.79	3.66	4.29
Mango	0.00	3.62	2.11	0.00	0.63	0.44
Total Kharif	80.46	86.27	84.62	81.33	86.74	85.13
Rabi 2004-05						
Wheat	9.48	2.09	5.27	13.52	5.71	8.14
Gram	5.61	5.44	4.95	1.29	1.70	1.58
Sunflower	1.16	1.95	1.30	0.43	1.34	0.95
Jowar	1.93	3.76	3.00	2.15	2.99	2.75
Groundnut	0.39	0.49	0.45	0.00	0.98	0.69
Onion	0.97	0.00	0.41	1.29	0.54	0.76
Total Rabi	19.54	13.73	15.38	18.67	13.26	14.87
Grand Total	100	100	100	100	100	100

4.7 Access to Market for Cotton

Findings on the access to the markets for cotton for the sample farmers indicated that for about one-third of farmers the nearest cotton market was within a radius of 5 kilometers (Table 4.8). For about 24 percent of the Bt growers and 15 percent of the non-Bt growers the nearest cotton market was beyond 10 kms. On the whole there is no substantial difference in the access to the cotton market across the Bt and non-Bt farmers.

Table 4.8 : Distance of the Farmer Households from the Nearest Cotton Market

	Bt Cotton		Non-Bt Cotton	
Distance in Km.	No. of Farmers	Percent	No. of Farmers	Percent
Below 2 Km	16	18.82	11	15.94
2-5 Km	17	20.00	10	14.49
5 to 8 Km	32	37.65	47	68.12
8 to 10	0	0.00	0	0.00
Above 10	20	23.53	11	15.94
Overall	85	100.00	69	100.00

4.8 Adoption of Bt Cotton: Some Determining Factors

In this section we have examined the determinants of adoption of Bt Cotton. The stratified nature of the sample is a limitation to this analysis. We have related different characteristics of the sample farmers to the adoption/ non-adoption of Bt Cotton. The characteristics include farm size, age, education, experience in cotton cultivation and the area irrigated. A simple linear regression

model is used here. The results presented in Table 4.9 could be summarized as follows. The farm size variable is found to be not significant and in fact it has a negative sign, which indicates that the adoption is scale neutral and not biased towards large farm size. Age of the head of household is also found not significant. However, education, experience with cotton, and irrigated area show positive and significant associations, indicating that that they are positively associated with the adoption of Bt cotton.

Table 4.9 : Adoption of Bt Cotton in Relation to Characteristics of Farmer Households

Independent Variables	Coefficient	t-Value	Level of Significance
Constant	0.1182	0.56	NS
Farm Size	-0.0054	-0.56	NS
Age of head of Household	0.0009	0.03	NS
Experience in Cotton Cultivation	0.0116	2.20	**
Level of Education	0.1073	2.84	***
Irrigated Area	0.0306	2.19	**
*** 99 Percent	** 90 Percent	NS- Non-significant	

Chapter 5

Nature, Performance and Economics of Bt Cotton Cultivation vs Non-Bt Cotton

This chapter provides the findings and analysis on various features such as varieties of cotton cultivated, pest resistance, pesticide use, input use, performance, and the economics, comparing Bt and Non-Bt cotton.

5.1 Varieties Grown by Sample Farmer Households

The sample farmers grew four varieties of Bt cotton: MECH 184, MECH 12, MECH 162 and RASHI 2 (Table 5.1). About 27 percent of the sample households cultivated both RASHI2 and MECH12. RASHI 2 was more popular among large farm size and MECH varieties were more popular among medium and small farms. However there was no difference in the use of these varieties across irrigated and unirrigated conditions. In non-Bt cotton, three varieties were more popular among the growers and they were Ankur, Banny and Ajit. There was no major difference in the use of these varieties among different sizes of farms but Ajit was more popular among small farmers.

Table 5.1: The Varieties of Cotton Grown by the Sample Farmer Households								
Varieties	Number of Farmer Households				Percentage			
	Small	Medium	Large	Total	Small	Medium	Large	Total
Bt- Cotton								
MECH 184	6	9	10	25	35.29	39.13	22.22	29.41
MECH 12	6	5	8	19	35.29	21.74	17.78	22.35
MECH 162	1	3	2	6	5.88	13.04	4.44	7.06
RASHI 2	1	1	10	12	5.88	4.35	22.22	14.12
RASHI 2/ MECH 12	3	5	15	23	17.65	21.74	33.33	27.06
All Varieties	17	23	45	85	100	100	100	100
Non-Bt Cotton								
Ankur	5	4	5	14	21.74	22.22	17.86	20.29
Banny	5	2	4	11	21.74	11.11	14.29	15.94
Ajit	9	4	6	19	39.13	22.22	21.43	27.54
Others	4	8	13	25	17.39	44.44	46.43	36.23
All Varieties	23	18	28	69	100	100	100	100

5.2 Pest Incidence and Resistance

Cotton has many pest problems and the most important reason for the adoption of Bt cotton is its resistance to pests, particularly boll worms, which can be a devastating problem for cotton. In this context, information has been collected regarding the pest problems observed by the farmers in their cotton crops. The results are reported in Table 5.2 below. In the case of boll worms, including American, pink and spotted boll worms, no infestation is indicated by over 70 percent of farmers for Bt cotton, whereas light to heavy incidence is reported in the vast majority of cases by non-Bt cotton farmers. Only about 4-6 percent of the sample for Bt cotton reports moderate to heavy infestation, whereas this number was up to 60 percent in non-Bt cotton. Surprisingly, there is

also a difference in the sucking and foliage feeding pests, where the incidence is mainly none to light in the case of Bt cotton, whereas it is moderate to heavy in the case of non-Bt cotton. Thus, Bt cotton appears to clearly provide resistance to boll worms for a larger majority of farmers, and also to other pests for most of the farmers. However a small number of farmers indicate incidence of boll worms, particularly other kinds of boll worms.

Table 5.2: Pest/Insect Attack on Cotton: Response of Bt Cotton Growers (percent)

	BT					***Non-BT***				
Pest/Insect	Per-cent repo-rting	Infestation reported				Per-cent repo-rting	Infestation reported			
		None	Light	Mode-rate	Heavy		None	Light	Mode-rate	Heavy
Bt Cotton										
A. Boll Worm										
1. American Boll Worm	96.47	74.39	21.95	3.66	0.00	11.76	30.00	50.00	20.00	0.00
2. Pink Boll Worm	87.06	75.68	20.27	4.05	0.00	61.18	3.85	36.54	30.77	28.85
3. Spotted Boll Worm	90.59	72.73	20.78	6.49	0.00	56.47	2.08	41.67	39.58	16.67
4. Others	18.82	50.00	6.25	18.75	25.00	56.47	4.17	41.67	35.42	18.75
B. Sucking Pests										
1. Thrips	96.47	4.88	56.10	35.37	3.66	11.76	30.00	0.00	20.00	50.00
2. Leafhopper	95.29	3.70	58.02	30.86	7.41	58.82	0.00	18.00	56.00	26.00
3. Whitefly	95.29	6.17	58.02	33.33	2.47	57.65	0.00	20.41	55.10	24.49
4. Others	3.53	33.33	0.00	66.67	0.00	60.00	1.96	19.61	47.06	31.37
C. Foilage Feeding Pests										
1. Leaf Roller	94.12	27.50	45.00	26.25	1.25	42.35	2.78	38.89	50.00	8.33
2. Caterpillar	89.41	27.63	40.79	28.95	2.63	40.00	2.94	29.41	61.76	5.88
3. Others	7.06	50.00	33.33	16.67	0.00	5.88	20.00	40.00	40.00	0.00
D. Soil Pests										
1. Termite	88.24	34.67	17.33	36.00	12.00	40.00	2.94	14.71	55.88	26.47

5.3 Pesticide Use

Table 5.3 below indicates the performance of Bt cotton, relative to Non-Bt cotton in the reduction of pesticide use. The information shows that pesticides are still used by farmers after shifting to Bt cotton. However, there is a significant reduction in the number of sprays that are applied as well as the cost of pesticides. The average number of sprays is reduced from 5.28 to 3.37, a 36 percent reduction. The cost per hectare reduces by 21 percent. Thus, even though pesticide spraying is not eliminated, there is a substantial reduction in the pesticide use and cost under Bt cotton.

Table 5.3: Application of Pesticides in Bt and Non-Bt cotton

	Bt Cotton	Non-Bt Cotton
Average Number of Sprays	3.37	5.28
Cost per ha (Rs.)	3242	4120

5.4 Input Use and Cost of Cultivation

In this section we examine the input use pattern under Bt and non-Bt cotton. This has been examined by farm size under irrigated and unirrigated conditions. The total cost of cultivation per hectare, including the marketing cost, were respectively Rs.32368 for Bt cotton and Rs.24102 for non-Bt cotton under irrigated conditions (Table 5.4). The corresponding figures under the unirrigated conditions were respectively Rs.30783 and Rs.22815. Thus the total cost of cultivation of Bt cotton was about 30 percent higher compared to non-Bt cotton irrespective of the irrigation status. There was marked difference in the cost of production per hectare under different farm size. The cost of production per hectare has been comparatively high for large size farmers for both Bt and non-

Bt cotton. This can be mainly attributed to higher dose of fertilizer use, greater cost of irrigation, and high levels of human labour use, particularly for cotton harvesting. The cost shares given in Table 5.4 below would be useful to understand this better.

5.5 Share of Various Inputs in total Cost of Production

As can be seen from Table 5.5, cost of seed accounted for on around 11 to 13 percent of the cost of cultivation for Bt cotton, whereas this was around 5 to 6 percent for non-Bt cotton. The relative share of various inputs in the cost of cultivation of Bt cotton in descending order of their shares are: human labour with 37.10 percent, fertilizer with 22.46 percent, seed at 12.18 percent, pesticides with 10.23 percent and bullock labour with 6.04 percent. For non-Bt cotton they were: human labour with 39.43 percent, pesticides with 17.75, fertilizer with 17.61 percent, bullock labour with 9.16 percent and seed with 5.68 percent. It is interesting to notice that the share of seed and pesticides cost together account for about 23 per cent of the cost equally for both Bt and non-Bt cotton farmers. The share of human labour and fertilizer in total cost of cultivation were higher under medium and large size farms compared to small farms. The shares of the various costs are also compared in the Figures below.

Table 5.4 : Cost of Production of Bt and Non-Bt Cotton among Sample Farmer Households per Hectare in Rupees						
	Bt Cotton			Non-Bt Cotton		
	I	UI	Total	I	UI	Total
Small						
1. Seed	3631	3656	3644	1222	1299	1269
2. Human Labour	8515	9429	8999	7098	8540	7976
3. Bullock Labour	2427	1344	1854	2433	1906	2112
4. Tractor	958	988	974	536	582	564
5. Fertilizer	5535	6789	6199	2893	3469	3244
6. Pesticides	2859	3920	3421	4471	3459	3855
7. Irrigation	1520	0	715	1400	0	548
8. Other Operational Costs	247	380	317	55	71	65
9. Total Operational Cost	25692	26506	26123	20108	19326	19632
10. Total Marketing Cost	572	1245	928	645	1200	983
Total Cost	26264	27750	27051	20753	20528	20616
Medium						
1. Seed	3800	4338	4011	1200	1365	1319
2. Human Labour	10998	11810	11316	9513	9126	9234
3. Bullock Labour	1752	2158	1911	2506	2281	2344
4. Tractor	1183	1019	1119	1597	532	828
5. Fertilizer	7122	6589	6913	4095	4753	4570
6. Pesticides	2626	3637	3022	4074	3969	3998
7. Irrigation	1935	0	1178	1620	0	450
8. Other Operational Costs	300	310	304	346	57	137
9. Total Operational Cost	29716	29861	29773	24951	22083	22880
10. Total Marketing Cost	1245	1282	1259	841	1330	1194
Total Cost	30959	31142	31031	25791	23414	24074
Large						
1. Seed	3808	3932	3860	1293	1383	1361
2. Human Labour	13244	12712	13019	10840	9801	10061
3. Bullock Labour	2010	1835	1936	2900	1694	1996
4. Tractor	984	975	980	738	885	848
5. Fertilizer	7741	7327	7566	4259	4150	4177
6. Pesticides	3127	3504	3286	4014	4548	4415

7. Irrigation	2203	0	1273	1710	0	428
8. Other Operational Costs	390	299	352	388	82	159
9. Total Operational Cost	33507	30584	32273	26142	22543	23443
10. Total Marketing Cost	1141	1131	1137	741	1059	980
Total Cost	35006	32053	33759	27200	23969	24777
Overall						
1. Seed	3776	3963	3857	1240	1354	1319
2. Human Labour	11801	11694	11754	8920	9251	9150
3. Bullock Labour	2004	1794	1913	2606	1915	2125
4. Tractor	1037	989	1016	856	701	748
5. Fertilizer	7193	7017	7116	3984	4131	4086
6. Pesticides	2936	3638	3242	4224	4074	4120
7. Irrigation	2011	0	1136	1556	0	474
8. Other Operational Costs	340	321	332	235	72	122
9. Total Operational Cost	31098	29416	30366	23621	21498	22144
10. Total Marketing Cost	1271	1369	1314	830	1334	1181
Total Cost	32368	30785	31679	24102	22815	23207

Table 5.5 : Percentage Share of various Input Costs in the Total Cost of Production						
	Bt Cotton			Non-Bt Cotton		
	I	UI	Total	I	UI	Total
Small						
1. Seed	13.83	13.17	13.47	5.89	6.33	6.16
2. Human Labour	32.42	33.98	33.27	34.20	41.60	38.69
3. Bullock Labour	9.24	4.84	6.85	11.72	9.28	10.24
4. Tractor	3.65	3.56	3.60	2.58	2.84	2.74
5. Fertilizer	21.07	24.46	22.92	13.94	16.90	15.74
6. Pesticides	10.89	14.13	12.65	21.54	16.85	18.70
7. Irrigation	5.79	0.00	2.64	6.75	0.00	2.66
8. Other Operational Costs	0.94	1.37	1.17	0.27	0.35	0.32
9. Total Operational Cost	97.82	95.52	96.57	96.89	94.14	95.23
10. Total Marketing Cost	2.18	4.49	3.43	3.11	5.85	4.77
Total Cost	100	100	100	100	100	100
Medium						
1. Seed	12.27	13.93	12.93	4.65	5.83	5.48
2. Human Labour	35.52	37.92	36.47	36.88	38.98	38.36
3. Bullock Labour	5.66	6.93	6.16	9.72	9.74	9.74
4. Tractor	3.82	3.27	3.61	6.19	2.27	3.44
5. Fertilizer	23.00	21.16	22.28	15.88	20.30	18.98
6. Pesticides	8.48	11.68	9.74	15.80	16.95	16.61
7. Irrigation	6.25	0.00	3.80	6.28	0.00	1.87
8. Other Operational Costs	0.97	1.00	0.98	1.34	0.24	0.57
9. Total Operational Cost	95.99	95.89	95.95	96.74	94.32	95.04
10. Total Marketing Cost	4.02	4.12	4.06	3.26	5.68	4.96
Total Cost	100	100	100	100	100	100
Large						
1. Seed	10.88	12.27	11.43	4.75	5.77	5.49
2. Human Labour	37.83	39.66	38.56	39.85	40.89	40.61
3. Bullock Labour	5.74	5.72	5.73	10.66	7.07	8.06
4. Tractor	2.81	3.04	2.90	2.71	3.69	3.42
5. Fertilizer	22.11	22.86	22.41	15.66	17.31	16.86
6. Pesticides	8.93	10.93	9.73	14.76	18.97	17.82
7. Irrigation	6.29	0.00	3.77	6.29	0.00	1.73
8. Other Operational Costs	1.11	0.93	1.04	1.43	0.34	0.64
9. Total Operational Cost	95.72	95.42	95.60	96.11	94.05	94.62

10. Total Marketing Cost	3.26	3.53	3.37	2.72	4.42	3.96
Total Cost	100	100	100	100	100	100
Overall						
1. Seed	11.67	12.87	12.18	5.14	5.93	5.68
2. Human Labour	36.46	37.99	37.10	37.01	40.55	39.43
3. Bullock Labour	6.19	5.83	6.04	10.81	8.39	9.16
4. Tractor	3.20	3.21	3.21	3.55	3.07	3.22
5. Fertilizer	22.22	22.79	22.46	16.53	18.11	17.61
6. Pesticides	9.07	11.82	10.23	17.53	17.86	17.75
7. Irrigation	6.21	0.00	3.59	6.46	0.00	2.04
8. Other Operational Costs	1.05	1.04	1.05	0.98	0.32	0.53
9. Total Operational Cost	96.08	95.55	95.86	98.00	94.23	95.42
10. Total Marketing Cost	3.93	4.45	4.15	3.44	5.85	5.09
Total Cost	100	100	100	100	100	100

Figure 5.1: Per hectare Cost of Production: Bt and Non-Bt under Irrigated Conditions

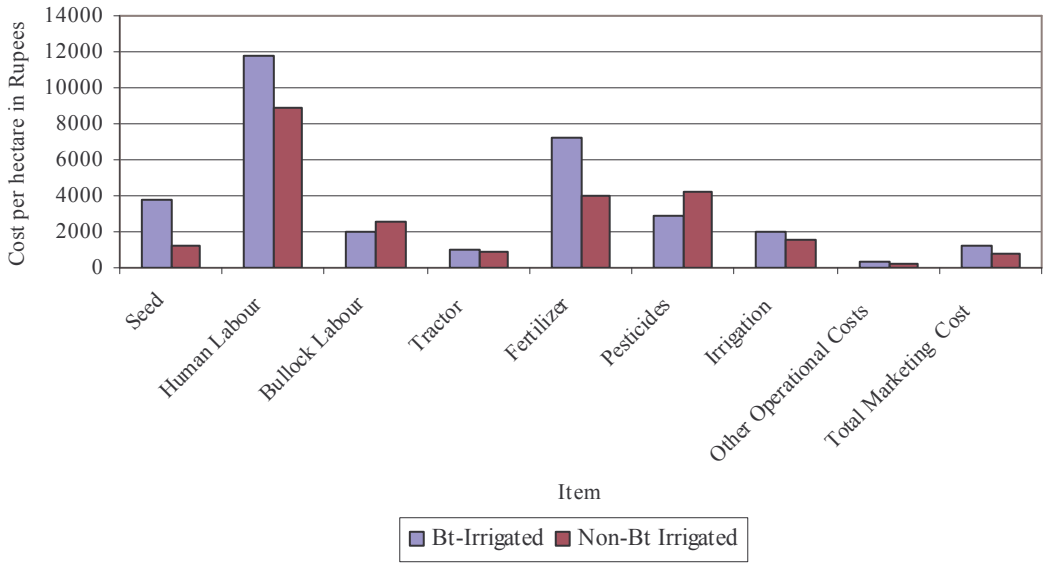


Figure 5.2: Per Hectare Cost of Production: Bt and Non-Bt under Unirrigated Conditions

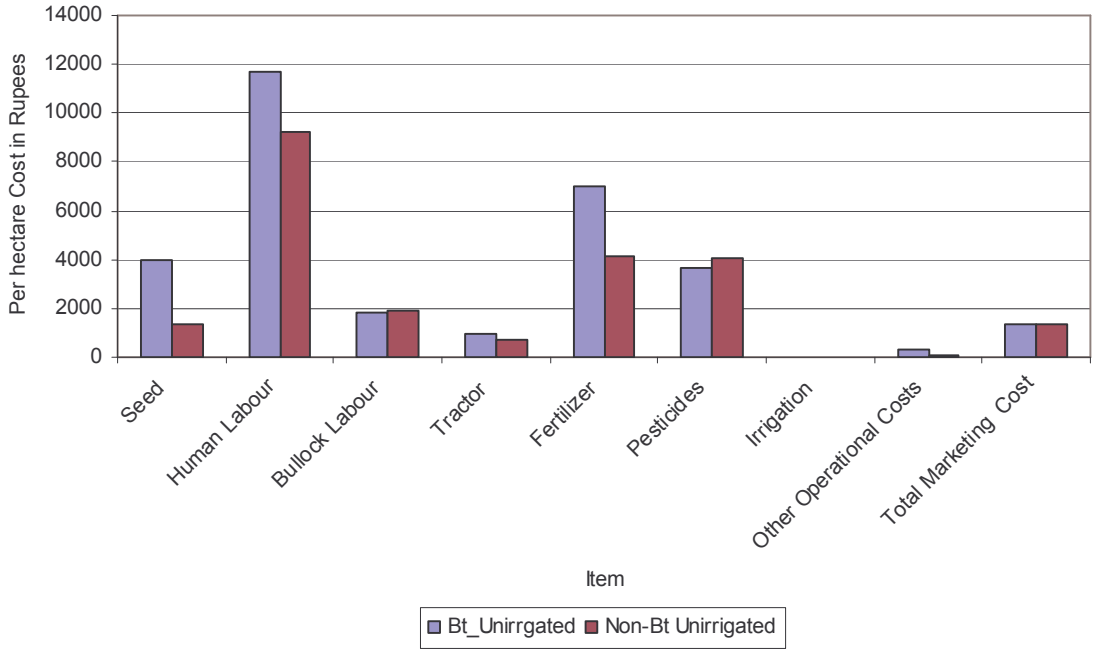
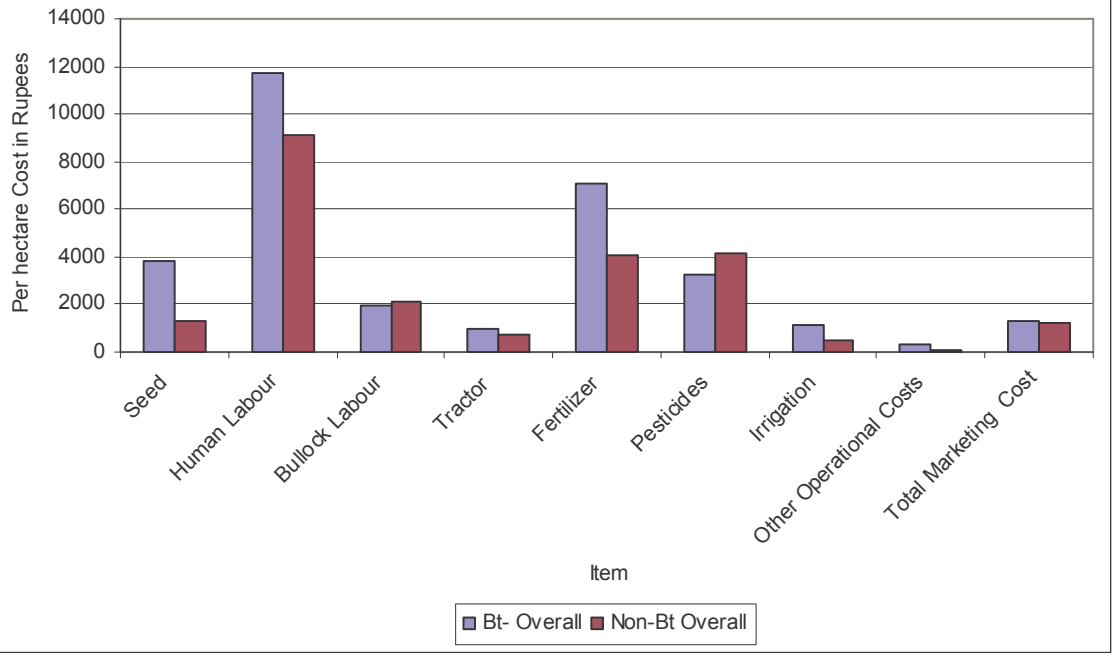


Figure 5.2a: Per Hectare Cost of Production: Bt and Non-Bt Overall



5.6 Cotton Pickings, Yields and Value of Output

Most sample farmers, over 90 percent, report at least five cotton fibre pickings and the rest had up to 6 pickings. The average yield per picking under Bt cotton was invariably higher (Table 5.6 and figures 5.3 to 5.5). However, the percentage distribution pattern of quantity of cotton realized under each picking did not differ much for both Bt and Non-Bt cotton. Thus, there is not much difference between Bt and Non-Bt in the number of pickings or the distribution across pickings. The main difference is the quantity obtained in each picking especially from the second picking onwards.

Table 5.6 : Yield per hectare in Kilogram per Picking among Bt and Non-Bt Cotton Farmer Households							
	Pickings						
	First	Second	Third	Fourth	Fifth	Sixth	Total
	Bt Cotton						
	Small						
Irrigated	256	525	710	571	216	185	2465
Unirrigated	343	633	529	402	193	46	2146
Total	302	582	614	481	204	112	2296
	Medium						
Irrigated	316	750	733	485	309	88	2681
Unirrigated	448	696	626	417	232	31	2449
Total	368	729	691	459	279	66	2590
	Large						
Irrigated	333	708	813	623	347	62	2885
Unirrigated	351	663	780	475	221	26	2517
Total	340	689	799	560	294	47	2729
	Overall						
Irrigated	315	690	772	574	314	90	2755
Unirrigated	373	664	682	443	217	32	2410
Total	340	679	733	517	272	65	2605
	Non-Bt Cotton						
	Small						
Irrigated	350	480	494	343	170	27	1866
Unirrigated	270	438	358	327	189	18	1609
Total	301	455	411	333	182	21	1709
	Medium						
Irrigated	242	371	494	482	128	25	1742
Unirrigated	204	475	532	319	185	23	1739
Total	215	446	522	364	170	23	1740
	Large						
Irrigated	282	530	530	406	159	18	1924
Unirrigated	181	470	565	397	200	32	1844
Total	206	485	556	399	190	29	1864
	Overall						
Irrigated	302	471	506	397	157	24	1856
Unirrigated	213	462	496	355	193	25	1747
Total	240	465	499	368	182	25	1780

Figure 5.3: Average Yield per Picking: Bt and Non-Bt Irrigated

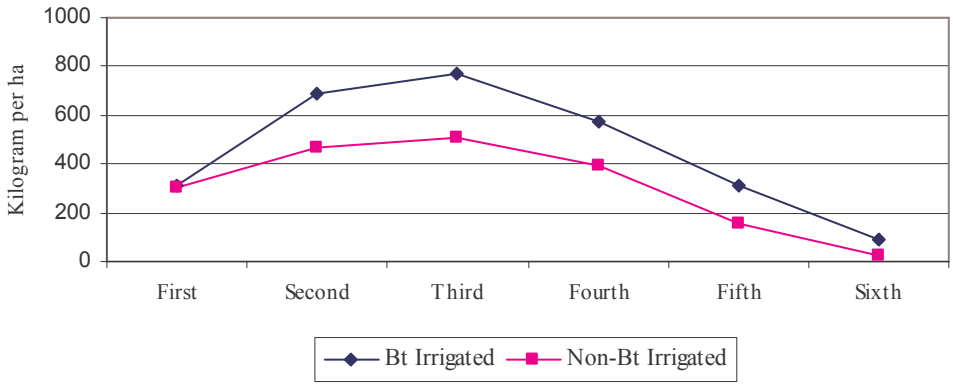


Figure 5.4: Average Yield per Picking: Bt and Non-Bt Unirrigated

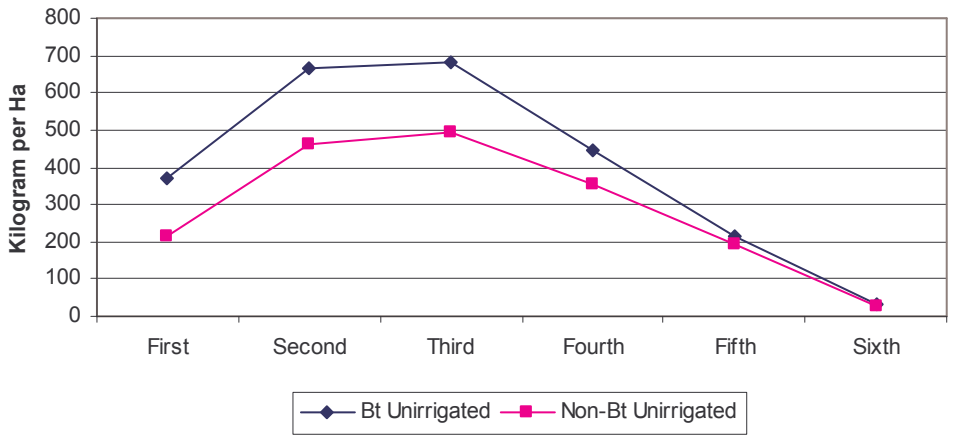
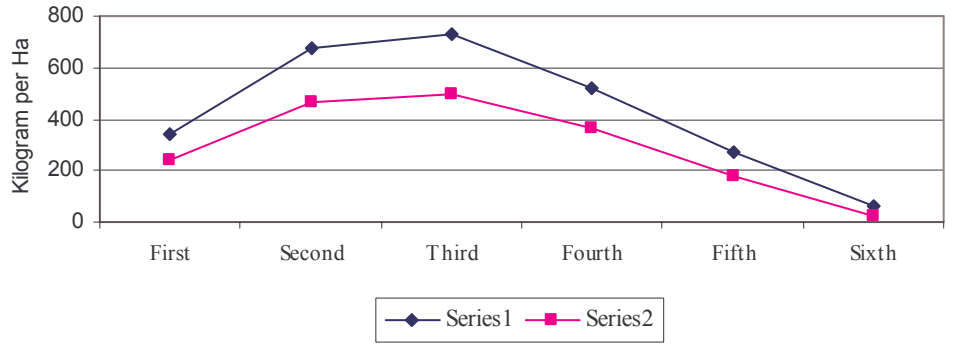


Figure 5.5: Average Yiled per Picking : Bt and Non-Bt



The Table 5.7 provides a summary comparison of the performance of Bt and Non-Bt cotton in terms of their yield and value of output under irrigated and unirrigated conditions. The table shows that in all cases, the yields of Bt cotton are higher than the yields of Non-Bt cotton. This is found to be true under irrigated as well as unirrigated conditions. The yields obtained with irrigations are typically higher than those without irrigations. The results indicate a sizeable impact of Bt cotton on the yield and value of output under both irrigated and unirrigated conditions.

Table 5.7: The yield and value of output from Bt and Non-Bt cotton

	Bt Cotton			Non-Bt Cotton		
	Irrigated	Unirrigated	Total	Irrigated	Unirrigated	Total
Yield (Kg/Ha)	2755	2410	2605	1856	1747	1780
Value of output (Rs.)	57262	50487	54313	39948	38973	39270

5.7 Value of Output and Net Profit

The Table 5.8 and figures 5.6 to 5.9 below give the findings on the value of production, cost of production, and net profit per hectare for Bt and Non-Bt farmer households. The net profit per hectare under Bt cotton was Rs.24894 under irrigated and Rs.19702 under unirrigated conditions. The net profit per hectare under Non-Bt cotton was Rs.14871 under irrigated and Rs.14075 under unirrigated. Thus, both under irrigated and unirrigated conditions the net profits are found to be substantially higher with Bt cotton. There is some positive association with the farm size but even small farmers are able to realize substantial gains in net profits. In percentage terms, under Bt cotton as

compared to non-Bt cotton for all sample farmers together, the total cost of production of Bt cotton was higher by 34.3 percent under irrigated and 34.9 percent under unirrigated conditions. The value of output of Bt cotton was higher by 46.9 percent under irrigated area and 36.9 percent under unirrigated area. The net profit of Bt cotton under irrigated and unirrigated area as compared to those under non-Bt cotton was 67.4 percent and 40 percent higher respectively. Thus, even though the cost of production is higher with Bt cotton, the value of production, and net profits are substantially higher in Bt cotton as compared to non-Bt.

Table 5.8 : Economics of Bt Cotton over Non-Bt Cotton among Sample Farmer Households (Rupees per Hectare)

	Bt Cotton			Non-Bt Cotton			Bt over Non-Bt Cotton (%)		
	I	UI	Total	I	UI	Total	I	UI	Total
Small									
Total Cost	26264	27750	27051	20753	20528	20616	26.6	35.2	31.2
Value of Output	49210	42206	45502	36276	32118	33745	35.7	31.4	34.8
Net Profit	22946	14456	18451	15523	11590	13129	47.8	24.7	40.5
Medium									
Total Cost	30959	31142	31031	25791	23414	24074	20.0	33.0	28.9
Value of Output	56160	47955	52949	39158	37090	37664	43.4	29.3	40.6
Net Profit	25201	16813	21918	13367	13676	13590	88.5	22.9	61.3
Large									
Total Cost	35006	32053	33759	27200	23969	24777	28.7	33.7	36.3
Value of Output	60333	55609	58338	42309	39948	40538	42.6	39.2	43.9
Net Profit	25327	23556	24579	15109	15979	15761	67.6	47.4	55.9
Overall									
Total Cost	32368	30785	31679	24102	22815	23207	34.3	34.9	36.5
Value of Output	57262	50487	54313	38973	36890	37524	46.9	36.9	44.7
Net Profit	24894	19702	22634	14871	14075	14317	67.4	40.0	58.1

Figure 5.6: Economics of Bt and Non-Bt Cotton: Small Farms

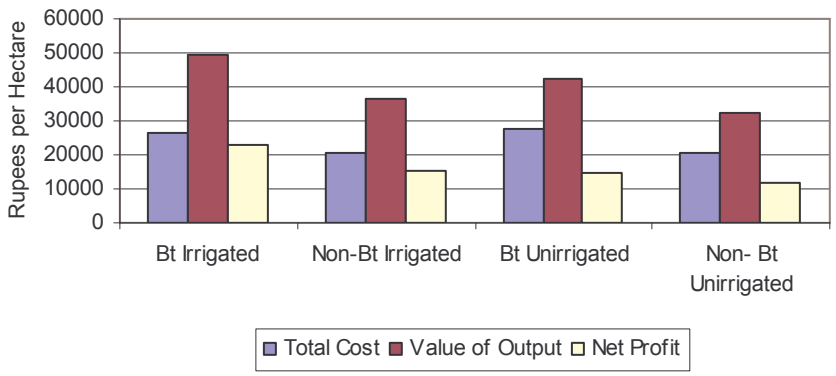


Figure 5.7: Economic of Bt and Non-Bt Cotton: Medium Farms

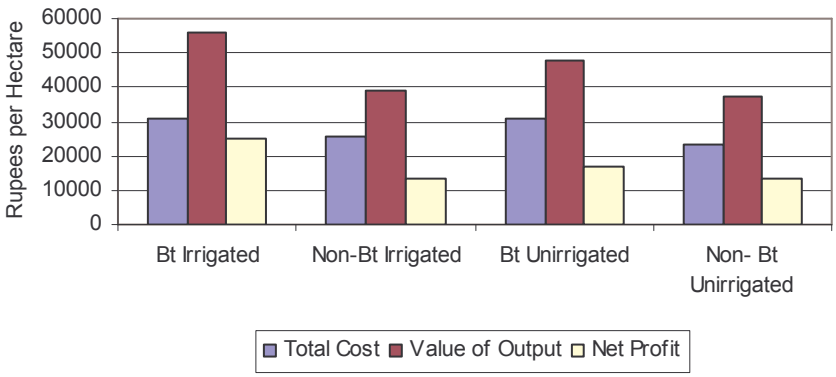
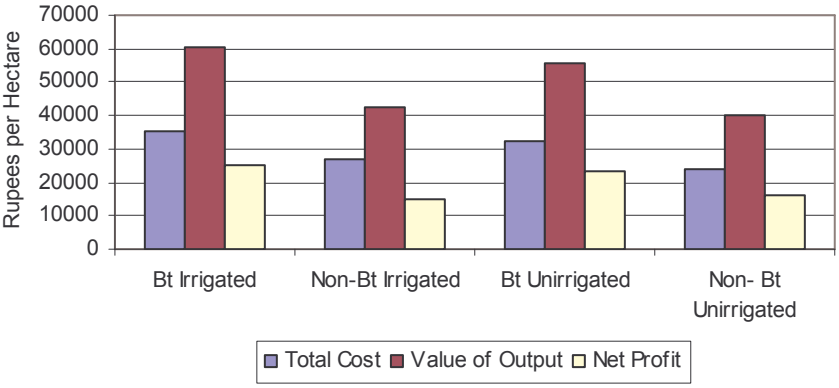
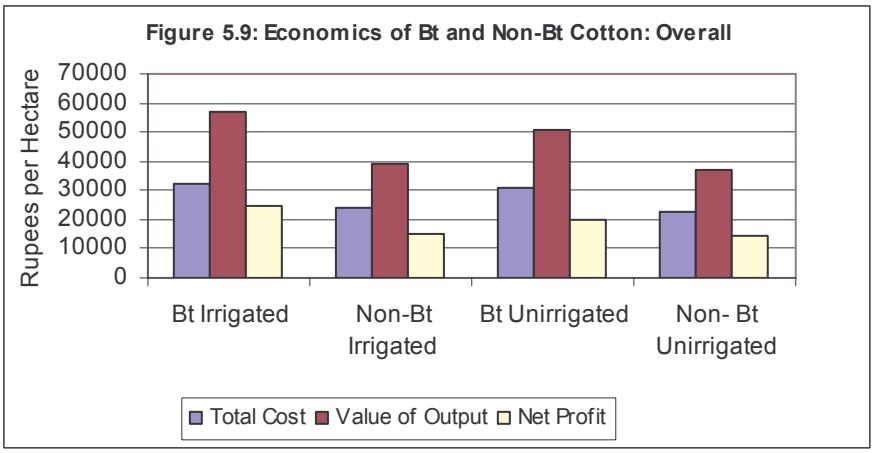


Figure 5.8: Economics of Bt and Non-Bt Cotton: Large Farms





5.8 Econometric Analysis of the Impact Bt on Performance and Costs

Given the variation in the sample, it is important to examine the statistical significance of impact of Bt on the economics of cotton cultivation. This has first been examined through a regression approach relating yield with a dummy variable for Bt cotton, which is 1 for Bt cotton and 0 for Non-Bt cotton. The results would be identical to those obtained through analysis of variance (ANOVA). The results (Table 5.9) below indicate that Bt cotton clearly has a statistically

Table 5.9: Regression Results: Impact of Bt Cotton				
		Independent Variables		N=154
Dependent Variable		Constant	Bt	Percent Impact of Bt
Yield	Coefficient	1821	777.01	42.67
	t-stat	29.04	9.21	
	Signifi.	***	***	
Value of Output	Coefficient	38944	16663	42.79
	t-stat	25.29	8.04	
	Signifi.	***	***	
Total Cost	Coefficient	26198	1357.71	5.18
	t-Stat	31.63	1.22	
	Signifi.	***	NS	
Pesticide Cost	Coefficient	8241.22	-1844.21	-22.38
	t-Stat	22.96	-3.82	
	Signifi.	***	***	
Seed Cost	Coefficient	1319.28	2487.20	188.53
	t-Stat	38.42	53.81	
	Signifi.	***	***	
Price	Coefficient	21.36	-0.0415	-0.1943
	t-Stat	89.92	-0.13	
	Signifi.	***	NS	
Profit	Coefficient	12746	15305	120.08
	t-Stat	8.18	7.29	
	Signifi.	***	***	
Note: *** = significant at 99 percent, ** = significant at 95 percent, * = significant at 90 percent, NS = not significant				

significant impact on the yield, significant at the 99 percent level, and the mean impact is estimated to be 43 percent. The seed cost increases and the pesticide cost reduces, but the impact on the total cost is relatively low and not statistically significant. Pesticide cost is reduces by 22.38 percent, and the profit increase is 120.08 percent and statistically highly significant at 99 percent. This indicates that the technology is highly profitable.

Even though Bt appears to have a dominant effect, perhaps it is also pulling in other inputs to boost the profitability. The performance can also be examined through a function including various inputs and factors.

5.9 Econometric Analysis of the Determinants of Yield, Value of Output and Profit

This section examines the relationship of various factors to the yield, value of output and profit of cotton cultivation reported by the sample farmer households. This is examined by using regression models of both linear and logarithmic forms. The determinant variables used based on the information obtained in the survey includes the costs of seeds, fertilizers, pesticides, human labour, and farm power (including tractor, bullock, and irrigation). The irrigation costs could not be considered separately due to data limitations. The results of the linear and logarithmic models are presented in Table 5.10 and Table 5.11 below respectively.

The results indicate that Bt even by itself has a positive and statistically significant impact on the yield. The impacts of fertilizers and human labour are also positive and statistically significant. Though the cost of seed is negatively associated with the yield, it was statistically not significant – perhaps due to multi-collineartiy with Bt. Although the cost of pesticides and farm power are positive associated, but they are statistically non-significant. These results remain similar for the value of output. While the cost of pesticides has a strong and negative influence in determining the profit levels, fertilizer and Bt variety have a strong and positive influence. The overall results based on the linear and logarithmic

models are very similar - both confirm the statistically significant and positive association of Bt cotton with the yield, revenue and profits in cotton.

Table 5.10: Contribution of various factors to Yield, Value of Production and Profit of Cotton: Linear Model

Dependent Variable	Particulars	Constant	Bt Cotton Dummy	Seed Cost	Fertilizer Cost	Pesticide Cost	Human Labour Cost	Farm Power Cost$
		All Sample Farmer Households						
Yield	Coefficient	761.09	948.39	-0.109	0.136	0.003	0.062	0.009
	t-Value	3.97	3.55	-1.04	9.31	0.33	3.26	0.28
	Significance	***	***	NS	***	NS	***	NS
	N	154						
	Adjusted R^2	0.71						
	F-Statistics	62.01						
Value of Output	Coefficient	9296.5	15235.89	-0.38	3.125	-0.005	1.778	0.584
	t-Value	1.99	2.34	-0.15	8.77	-0.02	3.82	0.786
	Significance	**	**	NS	***	NS	***	NS
	N	154						
	Adjusted R^2	0.68						
	F-Statistics	55.81						
Profit	Coefficient	9601.96	14914.28	-1.336	2.061	-1.007	0.648	-0.583
	t-Value	2.07	2.31	-0.524	5.83	-4.19	1.39	-0.79
	Significance	**	**	NS	***	***	NS	NS
	N	154						
	Adjusted R^2	0.57						
	F-Statistics	34.76						

*** 99 Percent ** 95 Percent * 90 Percent.
$ Includes cost of irrigation

Table 5.11 : Contribution of various factors to Yield, Value of Production and Profit of Cotton: Logarithmic Model								
Dependent Variable	Particulars	Constant	Bt Cotton Dummy	Seed Cost	Fertilizer Cost	Pesticide Cost	Human Labour Cost	Farm Power Cost #
		All Sample Farmer Households						
Yield	Coefficient	3.87	0.45	-0.11	0.33	0.01	0.16	0.01
	t-Value	4.95	4.18	-1.15	7.02	0.24	3.56	0.19
	Significance	***	***	NS	***	NS	***	NS
	N	154						
	Adjusted R^2	0.66						
	F-Statistics	50.83						
Value of Output	Coefficient	6.04	0.43	-0.10	0.36	-0.01	0.22	0.04
	t-Value	6.84	3.58	-0.95	6.69	-0.33	4.29	0.96
	Significance	***	***	NS	***	NS	***	NS
	N	154						
	Adjusted R^2	0.64						
	F-Statistics	45.80						
Profit	Coefficient	11.70	1.35	-0.50	0.45	-0.37	0.15	-0.10
	t-Value	3.14	2.64	-1.08	1.98	-2.59	0.69	-0.52
	Significance	***	***	NS	**	***	NS	NS
	N	154						
	Adjusted R^2	0.32						
	F-Statistics	12.80						

*** 99 Percent ** 95 Percent * 90 Percent.
# Includes cost of irrigation

Chapter 6

Farmers' Perceptions on Various Features of Bt Cotton

This chapter examines the findings on various perceptions of the sample farmers households growing Bt cotton on various aspects including economic benefits, availability of Bt seeds, their characteristic features, environmental impact, extension activities, and so on.

6.1 Some Basic Features of Bt Cotton: Views of Bt Cotton Sample Farmer Households

The responses indicate that Bt cotton growers were not approached or pressured by private sales agents for the promotion of Bt cotton (Table 6.1). As regards to plant size and boll size, the respondents did not indicate any major difference compared to non-Bt cotton. About 96.5 percent of the sample farmer households indicated that the number of picking under Bt and non-Bt cotton are same. No government agencies had approached them for the inspection of Bt cotton, and none of the sample households felt specific problems with respect to the marketing of Bt cotton fibre. None of the Bt growers had observed any adverse environmental impact as a result of the cultivation of Bt cotton. They also did not indicate any increase in the pest attack on other crops as a result of the cultivation of Bt cotton. All the sample farmers indicated that they need to buy Bt seed every year for cultivation. Almost 98 percent of the sample farmers did not face any difficulty in getting quality Bt seeds in time. As high as 94.1 percent of the sample farmers were positive on continuing with Bt cultivation in the future.

Table 6.1 : Response of Bt Cotton Sample Farmer Households on Various Aspects			
Particulars	Yes	No	No Opinion
1. Did any private sales agent approach you for promoting Bt cotton?	0	100	0
2. Is Bt cotton plant shorter?	0	100	0
3. Does Bt cotton have smaller bolls?	0	100	0
4. Does Bt cotton give lesser number of cotton pickings?	0	96.5	3.5
5. Did any Government agency approach you for inspecting the cotton variety you have sown?	0	100	0
6. Do you face any problem in marketing Bt cotton Kapas?	0	100	0
7. In your opinion is Bt cotton is more pest resistant than non-Bt?	82.4	14.1	3.5
8. Do you need to buy Bt cotton seed every year?	100	0	0
9. Is Bt cotton seed easily available	97.6	2.4	0
10. Will you continue with Bt cotton cultivation?	94.1	2.4	2.4
11. Do you feel that the pest/insect attack on other crop is higher or lower, when Bt Cotton is cultivated??	0	0	100
12. Have you observed any adverse effect on the environment due to Bt Cotton cultivation??	0	100	0

6.2 Awareness and Adoption of Bt Cotton

Over 50.6 percent of the sample households adopted Bt seeds with the recommendation of fellow farmers, and another major sources of information was seed company/dealer (Table 6.2). Some farmers came to know about the Bt technology from the village cooperatives and the village leaders. But government extension agencies did not play much role in creating farmer awareness of Bt cotton. The main communication was about its superiority in terms of better

profits and lesser amount of pesticides sprays, more bolls per plant, no bolls shedding etc (Table 6.3).

Table 6.2 : Bt Cotton Farmer Households' Response to "Who Recommended" in Growing Bt Cotton (Percentage)	
Percent of Farmers Responding	95.30
1.Extension Worker	2.47
2. Fellow Farmer	50.62
3. Village Leader	7.41
4. Village Cooperative	7.41
5. Seed Company	20.99
6. Seed Dealer	11.11

Table 6.3 : Advantages of Bt Seed as opposed to traditional Cotton Conveyed by Agents Referred in Above Table (Percentage)	
Percent of Farmers Responding	83.53
1. More Profit	73.24
2. Less Pesticides Spraying	66.20
3. No Boll Shedding	15.49
4. Comparatively more Bolls	59.15

Regarding the seed rate for Bt cotton as compared to non-Bt cotton, all of them indicated that the seed rate used for Bt was lower compared to non-Bt. About 57.65 percent of them reported the seed rate used was lower by up to 25 percent, and the rest 42.35 percent reported 25 to 50 percent lower seed rate compared to non-Bt cotton (Table 6.4). This indicates an adjustment to the high price of seeds and their more efficient use.

Table 6.4 : Seed Rate Used in Bt Compared to Non-Bt	
Percent of Farmers Responding	100
Percentage of Farmers Reporting Use of Lower Seed Rate	100
25%	57.65
25 to 50 %	42.45

6.3 Agronomic Features of Bt Cotton: Response of Bt Growers

All the sample farmer households reported early flowering of Bt cotton compared to non-Bt cotton. About 50.6 percent of them reported that Bt cotton flowers 1 to 10 days early, 36.5 percent reported it at 10 to 20 days earlier, and 12.9 percent reported that Bt cotton flowers more than 20 days earlier than non-Bt cotton (Table 6.5).

Table 6.5 : Farmers Response on Early Flowering of Bt Cotton	
Percent of Farmers Responding Early Flowering	100
1 to 10 Days	50.59
10 to 20 Days	36.47
Above 20 Days	12.94

The sample farmers were asked about the reasons behind their preference and comparison of Bt cotton over non-Bt cotton. Over 74 percent of the households responded to this question (Table 6.6). Better yield, more bolls, and less pest attack were the major reasons expressed by them. On the other hand, 83 percent of them expressed that the cost of Bt cotton seed was very high.

Table 6.6 : Response on Comparison of Bt vis-a-via Traditional Varieties by Sample Farmer Households	
Percent of Farmers Responding	74.12
1. More Bolls	66.23
2. Better Yield	71.56
3. Less Pest Attack	30.00
4. High cost of seeds	82.56

6.4 Measures Suggested by Sample Farmer Households to Improve the Acceptance of Bt Cotton Technology

The sample farmers were asked about their suggestion to improve the Bt technology and 74.12 percent of the sample households responded to it (Table 6.7). The most important suggestion given was to reduce the cost of Bt cotton seed. Other suggestions in order of their importance are: arranging field demonstrations, seed packages with smaller quantities, and assurance of seed quality.

Table 6.7 : Suggestion by Bt Cotton Farmer Households for Improving the Acceptance of Bt Cotton	
Percent of Farmers Responding	74.12
1. Reduce Seed Cost	53.97
2. Seed Packages with Less Quantity seeds	14.29
3. Field Demonstration	33.33
4. Assurance of Seed Quality	6.35

6.5 Advantages and Disadvantages of Bt Cotton over non-Bt Cotton

The Bt cotton sample farmer households were specifically asked about their opinion on advantages and disadvantages of Bt cotton. The major advantages of Bt cotton that are expressed by majority of the sample farmer

households are yield superiority, more profit, lesser need of pesticides, better quality, and its suitability for early sowing (Table 6.8). On the other hand a common disadvantage expressed was the high cost of seed. Other issues expressed include higher fertilizer and irrigation cost, and higher harvest cost. No major differences were observed in other matters.

Table 6.8 : Advantages or disadvantages of Bt cotton-G vis-à-vis non-Bt Cotton Reported by Bt Cotton-Growers: Percentage

		Strong Advantage	Advantage	No Difference	Disadvantage	Strong Disadvantage
1	Availability of seeds	0.0	11.0	80.5	8.5	0.0
2	Seed cost/price	0.0	3.7	2.5	35.8	58.0
3	Quality of avail. Seeds	4.8	46.4	44.0	4.8	0.0
4	Pest Incidence/problem	3.6	58.3	23.8	14.3	0.0
5	Pesticide need/cost	8.3	60.7	23.8	6.0	1.2
6	Fertilizer need/cost	1.2	15.9	47.6	35.4	0.0
7	Labour need/cost	2.4	8.4	73.5	15.7	0.0
8	Machine need/cost	2.4	6.0	89.3	1.2	1.2
9	Irrigation need/cost	4.8	12.0	45.8	37.3	0.0
10	Harvesting cost	2.4	6.0	56.0	34.5	1.2
11	Cotton quality	4.8	51.8	41.0	2.4	0.0
12	Market preference	2.4	16.7	73.8	6.0	1.2
13	Staple length	2.4	34.9	50.6	12.0	0.0
14	Fibre colour	2.4	16.7	73.8	6.0	1.2
15	Cotton price	2.4	2.4	88.0	7.2	0.0
16	Easy marketing	2.4	15.7	74.7	7.2	0.0
17	By-product output	2.4	9.6	88.0	0.0	0.0
18	Yield	14.5	81.9	2.4	1.2	0.0
19	Profit	12.0	77.1	9.6	1.2	0.0
20	Livestock feeding	2.4	7.2	90.4	0.0	0.0
21	Water saving	8.5	20.7	53.7	17.1	0.0
22	Suitable for early sowing	14.6	58.5	26.8	0.0	0.0
23	Suitable for late sowing	2.4	2.4	79.3	15.9	0.0

Chapter 7
Summary and Conclusions

The study examines the performance and returns to Bt cotton vs Non-Bt cotton in the state of Maharashtra. The study has been undertaken at the request of Ministry of Agriculture, Government of India. It is part of a coordinated project undertaken to examine this issue across the states of Gujarat, Maharashtra, Andhra Pradesh and Tamil Nadu.

7.1 Bt Cotton Technology

There have been major advances in biotechnology in the recent years and this has made it possible to directly identify genes, isolate them, know their functions, sequence them and transfer them from one organism to another. These developments have spanned the entire biological sciences. The development of Bt cotton is one outcome. Between 1996 and 2003 the global area under transgenic crops has increased 25 fold from 1.7 million hectare to 68 million hectare. In the year 2005, which marked the 10^{th} anniversary of commercialization of transgenic or biotech crops, the global area was estimated to be around 90 million hectares. This came from 21 countries, 11 developing and 10 industrialized countries. Bt Cotton was developed by Monsanto and it is now one of the most widely grown transgenic crops currently grown in many countries including United States, China, India, Australia, Argentina, South Africa and Indonesia. The adoption of Bt cotton has been rapid, from an estimated 0.8 million hectares in 1996 to about 6 million hectares in 2003 globally.

The reported advantages of Bt cotton include agronomic, economic and environmental benefits. The major agronomic advantage of Bt cotton over the conventional cotton is the resistance to the bollworm pest. The major economic benefits are reduced need for pesticides and, yield superiority through the resistance over non-Bt cotton varieties. Even though there are some potential environmental risks, the major environmental benefits include reduction in number of pesticides sprays, less exposure to pesticides for human beings and animals, and less pesticides in the water and soil.

Many countries have reported positive experiences with Bt cotton. This includes USA, China and Australia. Bt cotton has spread rapidly in China. Great demand for it is reported from the farmers since it reduces the cost of pesticide applications and provides effective yield superiority. India entered late after much hesitation. The Government of India allowed the growing of three genetically modified Bt cotton hybrids initially for three years from April 2002 to March 2005. The Indian trial data over several years demonstrated the superiority of Bt technology in terms reduced pesticides application and increase in effective yield. Even though the performance of Bt cotton has been projected to be satisfactory, there is great discontent in some quarters. Those in favour indicate reduction in the use of insecticides, better yield per unit of input use, equal or better quality, and lesser residue of pesticides in the fibre. Those against indicate concerns such as: the gene may spread have adverse impact in the eco-system, Bt cotton seed is expensive compared to non-Bt seeds, inadequate resistance so the farmers may still require to use insecticides, and other issues. It is in this

context that this study has been undertaken to examine the advantages/ disadvantages, the economics Bt cotton vs non-B cotton at the farmer level, and other aspects such as pest incidence, impact on environment etc.

7.2 Cotton in India

Though India ranks first in area cultivated of cotton in the world, it occupies the third position in production after China and US because of low ranking in yields. About 65 per cent of the cotton cultivation in India is unirrigated and therefore less productive and subject to vagaries of monsoon. Cotton fiber accounts for about 73 per cent of the total raw material mix of the textile industry. The cotton crop is highly susceptible to insects/pests and about 166 different species of insects pests are reported to attack cotton at various stages of its growth. It is estimated that the pests and diseases cause over 50 percent damage to cotton in India, compared to 24.5 percent world over. Of about 96,000 metric tons of technical grade pesticides produced in the country, about 54 percent is estimated to be used on cotton.

Area under cotton in India is about 9 million hectares which is about 5 percent of the total cropped area in the country. Large variation in the area under cotton is observed from year to year due to the vagaries of rainfall, as well as prices and profitability of cotton. The estimated production of cotton during 2004-05 is a record in the history of cotton cultivation in the country at 21.3 million bales (1 bale = 170 kilogram). The cotton yield in India is one of the lowest in the world and it stagnated or declined during the 1990s. However, there is significant growth in the last three years. The cotton yield from 1990-91 to 2000-

01 shows an annual growth of merely 0.4 percent, but taken between 1990-91 and 2004-05, it is four times higher at 1.7 percent per annum. The highest cotton yields were recorded during the year 2004-05.

The Bt cotton was approved for commercial cultivation in India in 2002. In March 2002 the Genetic Engineering Approval Committee (GEAC), the regulatory authority for transgenic crops in India, approved the commercial cultivation of three Bt cotton varieties viz., Bt Mech 12, Bt Mech 162 and Bt Mech 184. This remained and only after several years in 2005, the GEAC approved large scale field trials and seed production of 12 more varieties of Bt hybrids. Gujarat and Maharastra were the early adopters of Bt cotton on a large scale that commenced from 2002, followed by Andhra Pradesh, Karnataka, Tamil Nadu and Madhya Pradesh.

7.3 Cotton in Maharastra and in the Sample Districts

Cotton has been traditionally a very important crop in Maharastra. Area under cotton in Maharastra is about 3 million hectares and this accounts for about 30 percent of the cotton area in the country. As against its share area, its share in production is low due to low productivity. Besides, Maharashtra experiences wide fluctuation in production due to vagaries of rainfall since the cultivation is largely rainfed. The two districts sampled for the indepth study, Buldhana and Jalgaon, are important cotton growing districts in Maharastra belonging to different agro-climatic zones. Jalgaon has better irrigation facilities whereas Buldhana is predominantly rainfed. Cotton yields in Buldhana are

significantly lower than in Jalgaon. While cotton area registered a marginal decrease in Buldhana since the mid-1990s, it has increased in Jalgaon.

7.4 Sampling Design and Methodology

The study is mainly based on primary field survey data. The data was collected through a sample survey of farmers in the above mentioned two districts of Maharastra state, Jalgaon and Buldhana. Data is for the agricultural year 2004-05. The sample size of the study is 154, consisting of 85 farmer households growing Bt cotton and 69 growing non-Bt cotton. About 82.3 percent of the sample households under the Bt cotton farmers took up Bt cultivation for the first time in 2003-04 and the rest during 2004-05, i.e. the survey year.

7.5 Characteristics of the Farm Households and Adoption of Bt Cotton

There is no significant difference in the age of sample farmer households growing Bt cotton and non-Bt cotton. However, the level of education of the head of households showed that the Bt cotton farmers are somewhat more educated. Similarly Bt cotton growers tend to have more experience in cotton cultivation than non-Bt cotton farmer. The average farm size in terms of area operated indicates that the average farm size of Bt growers is marginally higher. The percentage of area irrigated in total operated area was greater among the Bt growers. The intensity of irrigation was also higher under Bt cotton compared to non-Bt cotton. While irrigation through canal was the major source of irrigation for the Bt cotton growers, it was tubewell for the non-Bt growers

Cotton is the major crop in the cropping pattern among the sample farmer households. The average area under Bt cotton per household was 1.59 hectares

under irrigated conditions and 1.99 hectares under unirrigated conditions. The cropping pattern composition of the Bt and non-Bt farmer households did not show major differences. The percentage share of cotton in Bt growers was 43.1 percent, whereas the same for the non-Bt growers was 40.1 percent. Other major crops grown by the sample farmer households during the kharif reason were jowar, maize, and pulses. The access to cotton markets of the sample households indicated that was no significant difference in the access to the nearest cotton market between the Bt and non-Bt farmers.

7.6 Determinants of Adoption of Bt Cotton

The influence of factors such as farm size, age, education and experience in cotton cultivation, and the area irrigated on the adoption of Bt cotton was examined using a regression model Results showed that the level of education, experience in the cultivation of cotton, and the irrigated area had a positive and statistically significant association with the adoption of Bt cotton. However, the association with farm size, and the age of the head of household were statistically not significant.

7.7 Varieties Grown and Pest Resistance

The sample farmers used four varieties of Bt cotton, namely MECH 184, MECH 12, MECH 162 and RASHI 2, and about 27 percent of the sample households cultivated both MECH12 and RASHI 2. While RASHI 2 was more popular among large farms, MECH varieties were more popular among medium and small farms. However there was no difference in the use of these varieties between irrigated and unirrigated farms. Three non-Bt cotton varieties were more

popular among the non-Bt growers: Ankur, Banny and Ajit and there was no major difference in their use by different size of farms.

Cotton has many pest problems and the most important reason for the adoption of Bt cotton is its resistance to pests, particularly boll worms, which can be devastating for cotton. According to the survey findings, for boll worms including American, Pink and Spotted boll worms, no infestation is indicated in Bt cotton by over 70 percent of Bt cotton growers, whereas light to heavy incidence is reported in the vast majority in non-Bt cotton. Only about 4-6 percent of the sample for Bt cotton reports moderate to heavy infestation, whereas this number was up to 60 percent in non-Bt cotton. Surprisingly, there is also a difference in the sucking and foliage feeding pests, where the incidence is mainly none to light in the case of Bt cotton, whereas it is moderate to heavy in the case of non-Bt cotton. Thus, findings indicate that Bt cotton appears to provide good resistance to boll worms for a larger majority of farmers, and also to other pests for most of the farmers. There is some incidence of other kinds of boll worms.

7.8 Cost of Cultivation

The total cost of cultivation per hectare under irrigated conditions, including the marketing costs, were respectively Rs.32368 for Bt cotton and Rs.24102 for non-Bt cotton. The corresponding figures under the unirrigated conditions were respectively Rs.30783 and Rs.22815. This shows that the cost of production under Bt cotton is about 30 percent higher compared to non-Bt cotton irrespective of the irrigation status. The total cost of production per hectare was relatively higher for the large size farmers for both Bt and non-Bt cotton. Seed

cost accounted for on an average 11 to 13.5 percent of the total cost of cultivation for Bt cotton, whereas it was around 5 to 6 percent for non-Bt cotton. The relative shares of various inputs in total cost of cultivation for the Bt and non-Bt varieties of cotton were as follows. For Bt cotton they were: human labour 37.10 percent, fertilizer 22.46 percent, seed 12.18 percent, pesticides 10.23 percent and bullock labour 6.04 percent. For non-Bt cotton they were: human labour 39.43 percent, pesticides 17.75, fertilizer 17.61 percent, bullock labour 9.16 percent and seed 5.68 percent. The figures show that the share of seed cost and pesticides cost together accounted for about 23 per cent of the cost of production in both Bt and non-Bt cotton.

7.9 Performance: Cotton Pickings, Yields and Value of Output

Over 90 percent of the sample farmers report at least five cotton pickings and the rest had up to 6 pickings. The average yield per picking under Bt cotton was invariably higher. However, the percentage distribution of quantity of cotton obtained under each picking did not differ much between Bt and Non-Bt cotton. This shows that there is not much difference between Bt and Non-Bt in the number of pickings and the output distribution across pickings. The main difference is the quantity obtained in each picking especially from the second picking onwards where Bt is considerably higher.

A comparison of the performance of Bt and Non-Bt cotton in terms of their yield and value of output under irrigated and unirrigated conditions shows that in all cases, the yields of Bt cotton are higher than the those of Non-Bt cotton. This

is found to be true under irrigated as well as unirrigated conditions. The yields under irrigations are typically higher than those without irrigations. The results indicate a sizeable impact of Bt cotton on the yield and value of output under both irrigated and unirrigated conditions.

7.10 Net Profit

The net profit per hectare under Bt cotton was Rs.24894 under irrigated and Rs.19702 under unirrigated conditions. The net profit per hectare under non-Bt cotton was Rs.14871 under irrigated and Rs.14075 under unirrigated. Thus, both under irrigated and unirrigated conditions the net profits are found to be substantially higher with Bt cotton.

There is some positive association with the farm size but even small farmers are able to realize substantial gains in net profits. In percentage terms, under Bt cotton as compared to non-Bt cotton for all sample farmers together, the total cost of production of Bt cotton was higher by 34.3 percent under irrigated and 34.9 percent under unirrigated conditions. The value of output of Bt cotton was higher by 46.9 percent under irrigated area and 36.9 percent under unirrigated area. The net profit of Bt cotton under irrigated and unirrigated area as compared to those under non-Bt cotton was 67.4 percent and 40 percent higher respectively. Thus, even though the cost of production is higher with Bt cotton, the value of production, and net profits are substantially higher.

7.11 Determinants of Yield, Cost, Value of Production and Profit

The impact of Bt cotton on yield, costs of production, value of output and profit were examined through regression analysis. The results indicate that Bt cotton clearly has a statistically significant impact on the yield, significant at the 99 percent level. The impact on the total cost is positive but low. Pesticide cost reduced by 22.38 percent, and the profit increase is 120.08 percent. This indicates that the technology is very profitable.

The relative contribution of factors such as seed, fertilizer, pesticides, human labour, and farm power use to yield was analyzed using regression analysis. Results indicate that the Bt, cost of fertilizer and human labour were positive and statistically significant in explaining the variation in yield. Though the cost of seed is negatively associated with the yield, it was statistically non-significant. Although the cost of pesticides and farm power have positive associations, they were statistically non-significant. These results continue to be similar for the value of output, since there little difference in the price of cotton across varieties. While the cost of pesticides has a strong and negative influence in determining the profit levels, Bt and fertilizers have a strong and positive association. The findings remain more or less the same for linear and logarithmic models.

7.12 Farmers' Perception on various Features of Bt Cotton

The perception of the sample farmers households on different aspects including agronomic, economic and environmental characteristics of Bt cotton studied here could be summarized below. The sample farmers growing Bt cotton

indicated that they were not pressured by private sales agents for the promotion of Bt cotton. Over 50.6 percent of the sample households adopted Bt seeds through the information of fellow farmers, and the rest through information of seed companies/ dealers or from the village cooperative and the village leader. The information conveyed to the farmers was about its superiority in terms of better profits and lesser amount of pesticide sprays, more bolls per plant, less bolls shedding etc. The government extension agencies did not play much role in the awareness about Bt technology.

As regards to plant size and boll size, the respondents did not notice any major difference between Bt and non-Bt cotton. About 96.5 percent of the sample farmer households indicated that the number of picking under Bt and non-Bt cotton are same. No government agencies had approached them for the inspection of Bt cotton, and none of the sample households had problems with respect to the marketing of Bt cotton. None of the Bt growers had observed any adverse environmental impact as a result of the cultivation of Bt cotton including attack on other crops. All the sample farmers were aware that they had to buy Bt seed every year for cultivation. Almost 98 percent of the sample farmers did not face any difficulty in getting quality Bt seeds in time. As high as 94.1 percent of the sample farmers indicated that they would continue with Bt cultivation.

Majority of the sample farmers indicated that they use lower seed rate for Bt is low compared to non-Bt. About 57.65 of them reported the seed rate lesser by up to 25 percent, and the rest reported at 25 to 50 percent lower seed rate. All the sample farmer households reported early flowering of Bt cotton compared to

non-Bt cotton: about 50.6 percent reported 1 to 10 days early flowering, 36.5 percent reported 10 to 20 days early and 12.9 percent reported more than 20 days early flowering. As regards to the reasons for their preference to Bt cotton over non-Bt cotton, over 74 percent of the households reported better yield, more bolls, and less pest attack. However, as high as 83 percent of them expressed that Bt cotton seed is very expensive compared to non-Bt cotton.

Major advantages of Bt cotton observed by majority of the sample farmer households include relatively lesser use of pesticides, higher yield, higher profit, good quality, and its suitability for early sowing. On the other hand the major disadvantage expressed was its high cost of seed. No major differences were indicated by the sample households between Bt and non-Bt in input use pattern, market preference or price. When asked for their suggestion on improving the Bt technology, the most common suggestion was to reduce the cost of Bt cotton seed. Other suggestions were: to arrange field demonstrations to show how best to use of the technology, seed packages with smaller quantities, and assurance of seed quality.

7.13 Implications and Further Research

Overall, the study finds a consistent positive impact of Bt cotton on the yields with strong statistically significance: Bt cotton yields are found to be 42.67 percent higher. The pesticide costs are reduced, but the seed costs rise, and as a result, the overall cost increases by 5.18 percent. The value of output rises by 42.79 percent, and the profit rise is statistically highly significant and is estimated

to be more than double at 120.08 percent. No adverse environmental impacts are reported.

In order to improve the impact of the technology, it would be very useful to release many more Bt varieties. The areas typically differ substantially in agro-ecology and the release of only a few varieties, as was done in the beginning, greatly reduced the possibility of success. The experience in other crops also indicates the need for a large number of varieties. Another important measure would be to improve the availability of the seeds by allowing multiple companies and agencies to compete and work perhaps through licensing. This would improve the reach and make sure that the right seeds are available at the right time, also encouraging more research. Besides, there is wide concern about the high price of the seeds. Any measures to assist the farmers on this would be useful but they should be such as to not destroy the incentives for availability of future technology and research. A win-win solution needs to be reached.

There is also great need to prevent the sale of spurious and sub-standard seeds. This is a great risk for the farmers and needs special attention on the policy and legislative front. Further, a substantial lack of awareness exists on how to get the best from this new technology. Thorough extension/ information dissemination efforts from both public and private agencies are extremely important for conveying to the farmers the correct package of practices to follow with this technology. This should also include the correct pesticides, if any, to be used. This would go a long way in creating awareness and reducing the risks associated with the use of the technology.

Long-term trials and research would be useful to track the environmental effects. More specific research and information systems are also required to identify the varieties which would perform the best in each area. Research through modeling would also be useful to arrive at the optimal crop-mix and cropping pattern to have in different cotton growing regions of the state, and to arrive at the optimal package of practices for the cotton farmers in each region.

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