Final Report

ECONOMICS OF BT COTTON VIS-À-VIS NON-BT COTTON IN INDIA: A STUDY ACROSS FOUR MAJOR COTTON GROWING STATES

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Contents

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Chapter 1

Introduction and Objectives of the Study

1.1 Introduction

Cotton is a very important cash crop in India and the country ranks first in cotton area in the world and third in cotton production. About 15 million farmers in the country spread across 10 states are engaged in cotton production and farm it on an area of about 10 million hectares. India also holds a prominent position in cotton textile industry in the world manufacturing products for a large number of end uses in India and abroad. Despite being one of the top most cotton growing countries in the world, the cotton yields in India are one of the lowest. A major reasons for this low productivity is the severe insect pest incidence which causes extensive crop damage. The major cotton producing states in the country are Maharashtra, Gujarat, Andhra Pradesh, Punjab and Tamil Nadu, and among them Maharashtra alone accounts for over one-third of the cotton area in the country.

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Following a long history of cultivation of traditional varieties, hybrid cotton was introduced in India for the first time in 1970. This was in the state of Gujarat and by virtue of its high yield potential it became extremely popular. A large number of hybrids were released. However, it was soon realized that the hybrids were highly susceptible to pest attack and damage. This became a severe problem especially from 1993-94 onwards, leading to frequent crop failures as well as fluctuating and declining yields. Over 150 different insect pests species are reported to attack cotton at various stages of its growth causing sever reduction in yields, and resulting in massive pesticide use by farmers and high cost of cultivation. It is estimated that over 55 per cent of the pesticides sold in the country are used on cotton. As a result of this situation, the farmers have been highly dissatisfied and have been looking for cotton varieties that have pest resistance. Its was at this juncture that the transgenic varieties with Bt arrived on the world stage and then in the country.

It was after much hesitation and delay that the Government of India allowed the cultivation of three genetically modified Bt cotton hybrids in April 2002 for a period of three years. This followed the controversial unauthorized cultivation of Bt cotton hybrids in some areas of the country. Analysis from several years of Indian trial data had demonstrated the superiority of Bt technology in terms reduced pesticides application and increase in effective yield. The impact assessment commissioned by Mahyco-Monsanto Biotech claimed sizable benefits for Bt adopters (AC Nelson, 2004). However anti biotechnology activist declared the technology as a complete failure (e.g. Shiva

and Jafri, 2003). Even though the performance of Bt cotton has been projected to be satisfactory in government circles, there is great discontent in different quarters with Bt cotton. Strong views both for and against Bt technology have surfaced. The major advantages claimed for Bt Cotton include reduction in the use of insecticides by almost 50 percent, reduction in the harmful effect on the environment, good quality of cotton fibre at par with that of non-Bt cotton, better yield per unit of input use, and lesser residue of pesticides in the fibre resulting in reduced harmful effects such as allergic reactions. However, the voices against Bt Cotton indicate that the gene may spread and its impact on the eco-system is not known, the Bt Cotton seed would be very expensive compared to Non-Bt seed for the farmers, some companies may have a monopoly on Bt seed, the Bt cotton farmers may still need to use insecticides, the Bt cotton seed cake will cause harm to the animals, Bt may enter in the human food chain and cause harm, transgenic varieties will lead to disappearance of native varieties and biodiversity in the country, and insects will soon become resistant to Bt Cotton making the pest control even more difficult in the near future.

Despite these concerns, Bt cotton cultivation has spread quite rapidly in India and elsewhere and farmers in developing countries are willing to adopt this technology. In view of the above mentioned diverse views on Bt cotton and considering the importance of cotton in Indian agriculture, it seemed important to undertake a comprehensive and systematic review to study the economic returns and other related aspects of the cultivation of Bt cotton as opposed to non-Bt cotton in major cotton producing states in the country.

This study was undertaken at the request of Ministry of Agriculture, Government of India, as a coordinated study in four states namely Andhra Pradesh, Gujarat, Maharashtra and Tamil Nadu, under the leadership of the Centre for Management in Agriculture (CMA) Indian Institute of Management, Ahmedabad, along with the Agro-Economic Research Centres (AERC) in these states. While the study in Maharashtra as well as the consolidated study were carried out by CMA, the other studies were done by the respective AERCs in these states in coordination with CMA.

1.2 Objectives of the Study

1 To examine the development and the advantages and disadvantages of Bt cotton as a pest-resistant variety under both irrigated and unirrigated conditions in selected states

2 To assess the cost of cultivation and economics 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

4 To examine the observations of the farmers on Bt cotton with respect to the technology, crop performance, pest incidence, and impact on other crops and the environment

5 To comment on the usefulness of the Bt cotton technology under Indian conditions and indicate ways for further improvement.

1.3 Organization of the Report

This report is organized into eight chapters including this introductory chapter. Chapter 2 provides an overview of cotton cultivation in India, and Chapter 3 deals with the development and adoption of Bt cotton by farmers. Chapter 4 explains the sampling and the methodology adopted by the study. Findings on the cotton cultivation practices in the selected states have been provided in Chapter 5. Findings on the economics of Bt cotton vis-à-vis traditional cotton varieties have been analyzed in Chapter 6. Chapter 7 covers the findings on the observations and perceptions of cotton cultivators about the Bt technology. Chapter 8 summarizes the major findings of the study.

Chapter 2

An Overview of Cotton in India

2.1 Introduction

In this chapter we briefly describe the position of India in world cotton economy, India's recent performance in cotton production and also the performance of cotton production in the four selected states.

2.2 World Scenario

The world annual production of cotton is estimated be about 100 million bales (one bale equals 480 lbs) (Table 2.1). China occupies the top position with a share of 23.8 percent of the global production, followed by USA with a share of 18.9 percent, and India has a share of 14 percent. The other two countries with a share of over 5 percent of the world cotton production are Pakistan and Brazil. Although India occupies the top position in terms of area under cotton, its share is low in global production is due to low yields. The cotton yields in the country is hardly one-third that of China and little over 40 percent that of USA (Table 2.2). The yield in India is less than one-fourth of that of some of the smaller cotton producing countries such as Australia, Syria and Greece.

Table 2.1: World Cotton Production: Average for 2002-03 to 2004-05			
	Country	Millions Bales of 480 lbs.	Percentage to World Total
1	China	24.63	23.75
2	United States	19.60	18.89
3	**India**	**14.47**	**13.95**
4	Pakistan	8.97	8.64
5	Brazil	5.27	5.08
6	Uzbekistan	4.63	4.47
7	African Franc Zone	4.50	4.34
8	Turkey	4.17	4.02
9	European Union	2.17	2.09
10	Australia	2.13	2.06
11	Greece	2.10	2.02
12	Syria	1.33	1.29
13	Egypt	1.17	1.12
14	Turkmenistan	0.83	0.80
15	Tajikistan	0.77	0.74
16	Kazakhstan	0.60	0.58
17	Iran	0.60	0.58
18	Argentina	0.30	0.29
19	Paraguay	0.30	0.29
20	Other	5.20	5.01
	World Total	103.73	100

Source: Derived from Ministry of Textiles, Govt. of India.

Table 2.2: Area, Production and Yield of Cotton in Major Cotton Producing Countries: 2005				
		Area (000HA)	Production (000 Tonnes)	Yield (Kg/ha)
1	China	6723	11402	1696
2	United States	5579	7710	1382
3	**India**	**8823**	**5003**	**567**
4	Pakistan	3102	4430	1428
5	Uzbekistan	1472	2470	1678
6	Brazil	1256	1804	1436
7	Turkey	580	1125	1940
8	Australia	335	844	2519
9	Greece	364	721	1981
10	Syria	218	559	2566
11	Egypt	315	335	1064
Source: http://faostat.fao.org/				

2.3 Cotton Cultivation in India: Recent Performance

This section examines the trends in cotton area, production, and yield in India since 1950-51, with particular emphasis on its performance since 1990-91. The performance during the period 1990-91 to 2007-08 has been scrutinized in two periods viz., 1990-91 to 2001-02 and 1990-91 to 2007-08. This is to see the likely impact of adoption of Bt cotton in the country initiated in 2002-03. The following observations on the impact can be made from the data and results presented in the Table below.

During the period 1990-91 to 2001-02 the lowest and highest levels of cotton production in the country was respectively 117 and 178 lakh bales or a difference of about 60 lakh bales, in a span of 12 years (table 2.3 and figures 2.1 and 2.2). However, the lowest and highest levels of production achieved during 2002-03 and 2007-08, i.e., in six years, was 136 and 229 lakh bales respectively, that is higher. The production level during 2007-08 was greater by 50 lakh bales than even the previous peak of 178 lakh bales achieved during 1996-97. The variability in production during the second period was also somewhat greater than the first period - the coefficient of variation increased from 16.91 to 23.84. This was mainly due to the crash in cotton production to 136 lakh bales in 2002-03. The annual rate of growth of cotton production during the period 1990-91 to 2007-08 was at 3.92 percent compared to 3.38 percent during 1990-91 to 2001-02. The growth in cotton production during the former period was mainly due to growth in area rather than growth in yield witnessed during 1990-91 to 2007-08. The average cotton yield during 1990-91 to 2001-02 was about 300 Kg. per hectare and it increased substantially to over 400 Kg. per hectare during 2002-03 to 2007-08.

Table 2.3: Growth in Production, Area and Yield of Cotton : All India			
Year	Production in Lakh Bales	Area in Lakh Hectare	Yield: in Kg per Ha.
1950-51	32.8	58.8	95
1960-61	56.8	76.1	127
1970-71	53.5	76.1	120
1980-81	78.0	78.2	170
1990-91	117	73.9	269
1991-92	118	73.8	271
1992-93	138	75.4	311
1993-94	121.5	74.4	278
1994-95	138.5	78.6	300
1995-96	170.7	90.6	320
1996-97	177.9	91.7	330
1997-98	158	88.3	307
1998-99	165	92.9	302
1999-00	156	87.3	304
2000-01	140	85.8	278
2001-02	158	87.3	308
2002-03	136	76.7	302
2003-04	177	77.9	387
2004-05	213	89.7	404
2005-06	185	86.8	362
2006-07	226	91.4	421
2007-08	229	94.3	466
Coefficient of Variation			
1990-91 to 2001-02	16.91	9.04	13.81
1990-91 to 2007-08	23.84	8.52	23.20
Annual Compound Growth Rate(%)			
1990-91 to 2001-02	3.38	1.90	1.45
1990-91 to 2007-08	3.92	0.88	3.01

Figure 2.1: Production and Area of Cotton in India: Production in million Bales and Area in Million Hectare

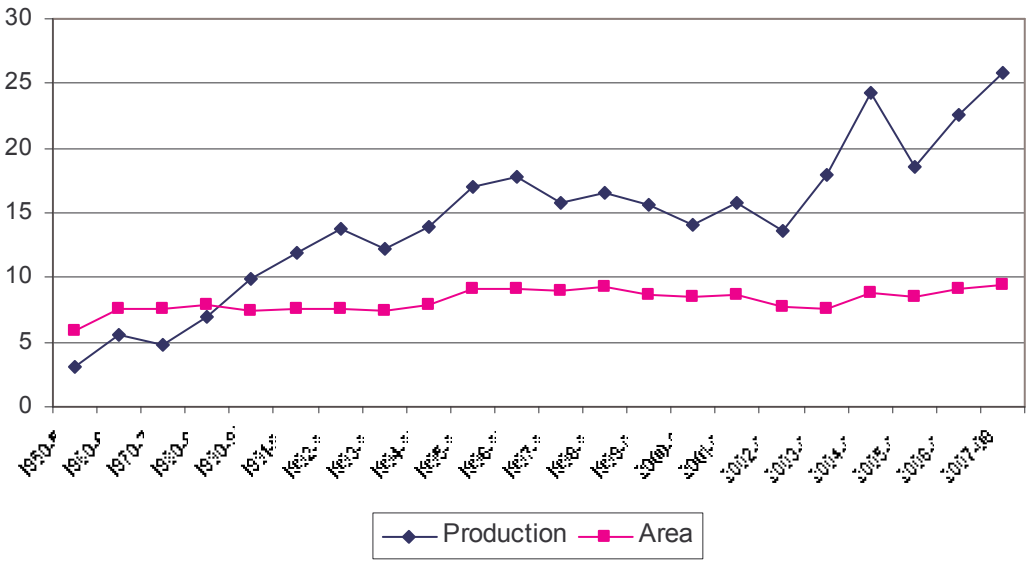
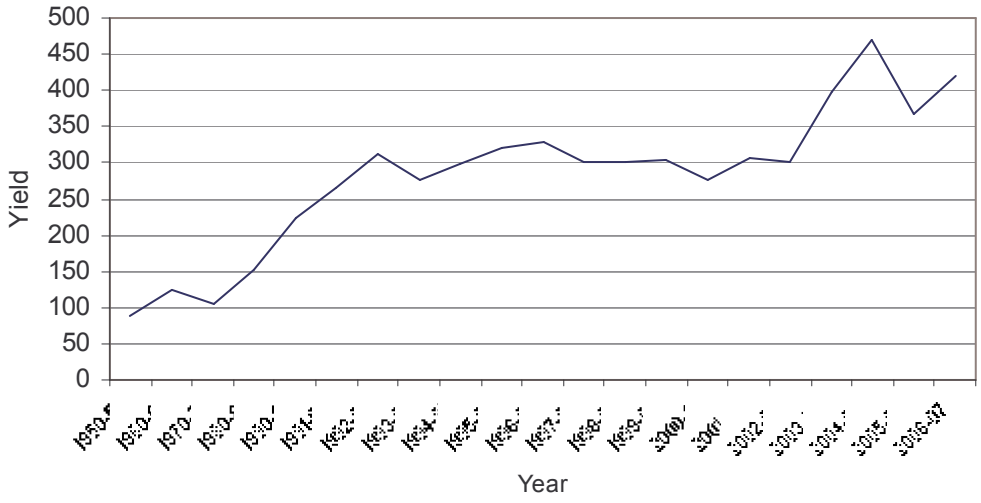


Figure 2.2: Yield of Cotton in India (Kilogram/hectare)



2.4 Geographical Distribution of Area and Production of Cotton

Based on cotton production during the recent triennium ending 2007-06, Gujarat ranks at the top with a share of 36 percent, followed by Maharashtra with 17.8 percent and Andhra Pradesh with 13.2 percent (Table 2.4). Tamil Nadu has a share of only 1.86 percent in the national production. Together, Gujarat, Maharashtra, Andhra Pradesh and Tamil Nadu accounted for 69 percent of the cotton production in India in the triennium ending 2007-08. In terms of area under cotton, Maharashtra occupies the top position with a share of 33.2 percent in the 9.2 million hectares of area under cotton cultivation in the country, followed by Gujarat with 25.36 percent and Andhra Pradesh with 11.3 percent during triennium ending 2007-08. However, the average yield of cotton is one of the lowest in Maharashtra at 273 Kg per hectare as against 514 kg per hectare for the country as a whole.

2.5 Recent Performance of Cotton Cultivation in the Selected States

Andhra Pradesh recorded an annual rate of growth of 3.84 percent in cotton production during the period 1990-91 to 2001-02. The sources of growth during 1990-91 to 2007-08 on account of area and yield were at 2.21 percent and 3.74 percent respectively to achieve the overall production growth rate of over 6 percent (Table 2.5 and Figures 2.3 to 2.5).

Table 2.4 Production, Area and Yield of Cotton in Major States of India: Triennium ending 2007-08				
	State	Production (Lakh Bales of 170 Kg)	Area in Lakh Ha	Yield in Kilogram,/ha
1	Maharashtra	49.33	30.50	273.28
		(17.75)	(33.22)	(9)
2	Gujarat	100.00	23.38	729.82
		(35.97)	(25.36)	(1)
3	Andhra Pradesh	36.67	10.35	590.27
		(13.19)	(11.27)	(4)
4	Madhya Pradesh	19.00	56.34	509.33
		(6.83)	(6.90)	(5)
5	Haryana	15.00	5.30	496.74
		(5.40)	(5.78)	(6)
6	Punjab	23.33	6.04	666.31
		(8.39)	(6.58)	(3)
7	Karnataka	6.83	3.99	294.85
		(2.46)	(4.34)	(8)
8	Rajasthan	9.33	3.97	400.40
		(3.36)	(4.32)	(7)
9	Tamil Nadu	5.17	1.27	691.83
		(1.86)	(1.38)	(2)
.	Others	1.00	0.64	273.15
		(0.48)	(0.76)	(8)
	Total	298.37	91.80	514.01*
		(100)	(100)	

1. Figures in brackets under Production and Area represent the percentage to total production and area respectively
2. Figures in brackets under Yield shows their respective ranks in yield
3. States have been arranged in descending order of total area under cotton

* These estimates vary from that of the all India estimates given in table 2.3

Table 2.5: Growth in Production, Area and Yield of Cotton in Andhra Pradesh			
Year	Production (Lakh bales)	Area (Lakh hectares)	Yield (Kg.per hectare)
1990-91	11.10	6.55	288
1991-92	12.99	7.06	313
1992-93	11.47	8.05	242
1993-94	13.49	7.28	315
1994-95	14.26	8.45	287
1995-96	16.10	10.59	258
1995-97	18.78	10.15	315
1997-98	13.20	9.06	248
1998-99	15.22	12.81	202
1999-00	15.79	10.46	257
2000-01	16.63	10.22	277
2001-02	18.77	11.08	288
2002-03	10.86	8.03	230
2003-04	18.90	8.37	384
2004-05	21.90	11.78	316
2005-06	32.01	10.73	492
2006-07	35.02	9.72	612
2007-08	43.11	10.96	667
Coefficient of Variation			
1990-91 to 2001-02	15.52	18.33	13.04
1990-91 to 2007-08	46.61	16.81	39.47
Annual Compound Growth Rate(%)			
1990-91 to 2001-02	3.84	4.99	-1.09
1990-91 to 2007-08	6.07	2.21	3.74

Gujarat has experienced high variability in cotton production during the 90s largely due to yield fluctuation (Table 2.6 and Figures 2.3 to 2.5). The state

experienced a decline in the growth rate in yield during 1990-91 to 2001-02. Since 2001-02, the growth in cotton production in the state was been phenomenal, and the state's annual rate of growth of production shot up from 1.55 percent to 9.29 percent comparing 1990-91 to 2001-02 and 1990-91 to 2007-08.

Table 2.6: Growth in Production, Area and Yield of Cotton in Gujarat

Year	Production (Lakh bales)	Area (Lakh hectares)	Yield (Kg.per hectare)
1990-91	14.9	9.2	274.8
1991-92	14.9	11.4	223.6
1992-93	22.3	11.5	329.3
1993-94	19.8	11.3	208.3
1994-95	26.6	12.1	375.1
1995-96	32.2	14.1	388
1995-97	34.3	14.9	392
1997-98	42.0	15.2	470
1998-99	47.0	16.1	497
1999-00	20.8	15.4	230
2000-01	11.6	16.2	112
2001-02	16.9	17.5	165
2002-03	16.9	16.4	175
2003-04	40.4	16.5	417
2004-05	73.0	19.1	651
2005-06	89.0	20.8	728
2006-07	101.0	23.9	718
2007-08	110.1	25.1	743
Coefficient of Variation			
1990-91 to 2001-02	43.43	15.70	41.35
1990-91 to 2007-08	74.69	24.85	51.95
Annual Compound Growth Rate(%)			

1990-91 to 2001-02	1.55	5.31	-3.21
1990-91 to 2007-08	9.29	4.91	4.56

Maharashtra accounts for the largest share of area under cotton in the country but with lowest levels of cotton yield in the country. Despite low levels of yield the area under cotton in the state has been very stable over the years. The state could achieve less than one percent growth in cotton production during 1990-91 to 2002-03 and there was negative growth in yield. But during the period 1990-91 to 2007-08 the state achieved an annual growth in cotton production of almost 3 percent largely due to growth in yield (Table 2.7 and figures 2.3 to 2.5). Tamil Nadu, despite decline in cotton area, could maintain a positive growth in cotton production due to yield growth (Table 2.8 and Figures 2.3 to 2.5).

Table 2.7: Growth in Production, Area and Yield of Cotton in Maharashtra

	Production (Lakh bales)	Area (Lakh hectares)	Yield (Kg.per hectare)
1990-91	31.88	27.21	199
1991-92	19.65	27.59	121
1992-93	32.14	25.74	212
1993-94	44.65	24.81	306
1994-95	44.63	27.6	275
1995-96	47.81	30.78	264
1996-97	31.43	30.85	173
1997-98	17.53	31.39	95
1998-99	26.19	31.99	139
1999-00	30.99	32.54	162
2000-01	30.64	30.77	169
2001-02	45.72	31.05	250
2002-03	44.24	28.00	269
2003-04	31.00	27.66	191
2004-05	52.00	30.49	290

2005-06	36.00	28.89	212
2006-07	52.00	30.70	288
2007-08	60.01	31.91	320
Coefficient of Variation			
1990-91 to 2001-02	31.38	8.94	34.99
1990-91 to 2007-08	31.44	7.75	48.27
Annual Compound Growth Rate(%)			
1990-91 to 2001-02	0.64	2.03	-1.36
1990-91 to 2007-08	2.97	0.77	2.19

Table 2.8: Growth in Production, Area and Yield of Cotton in Tamil Nadu

Year	Production (Lakh bales)	Area (Lakh hectares)	Yield (Kg.per hectare)
1990-91	4.08	2.39	290
1991-92	4.37	2.64	281
1992-93	4.72	2.71	296
1993-94	4.26	2.29	316
1994-95	5.90	2.96	339
1995-96	3.39	2.61	221
1996-97	5.34	2.52	360
1997-98	5.60	2.48	385
1998-99	4.92	2.43	345
1999-00	5.50	1.85	505
2000-01	5.50	1.93	484
2001-02	5.00	2.00	425
2002-03	3.00	0.85	600
2003-04	3.50	1.03	578
2004-05	5.00	1.29	725
2005-06	5.50	1.36	688
2006-07	5.24	1.22	697
2007-08	5.22	1.29	691
Coefficient of Variation			
1990-91 to 2001-02	14.81	14.59	23.83
1990-91 to 2007-08	17.56	34.26	35.87
Annual Compound Growth Rate (%)			
1990-91 to 2001-02	2.26	-2.66	5.07
1990-91 to 2007-08	0.50	-5.70	6.63

Figure2.3 : Growth in Cotton Production in Selected States

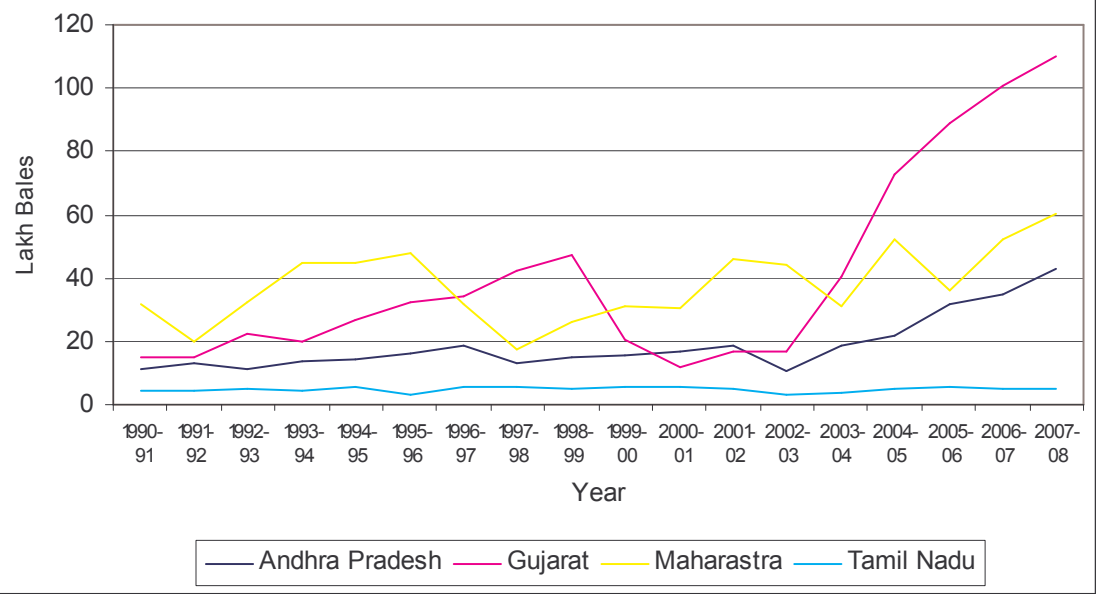


Figure 2.4 : Growth in Area under Cotton in Selected States

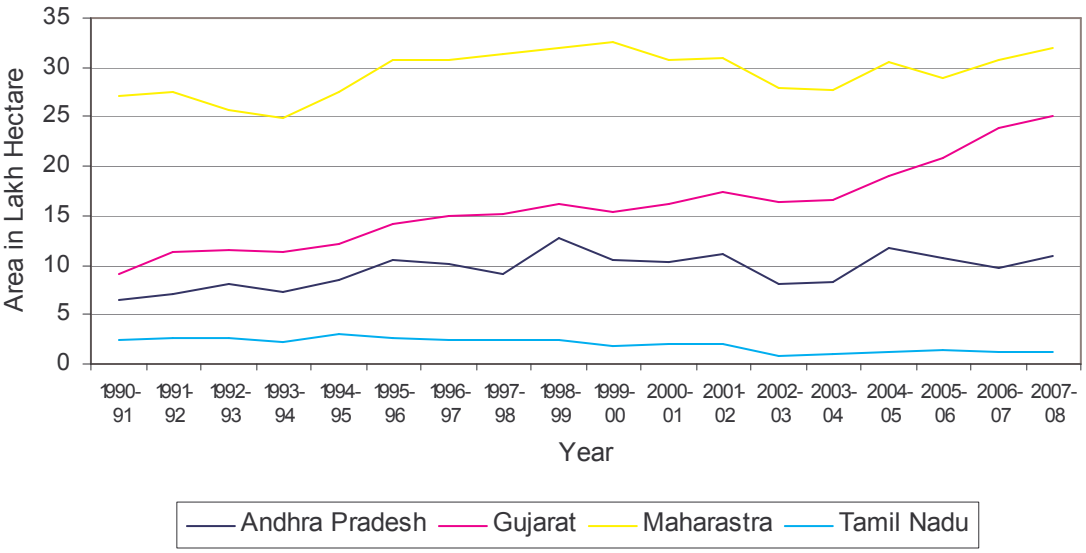
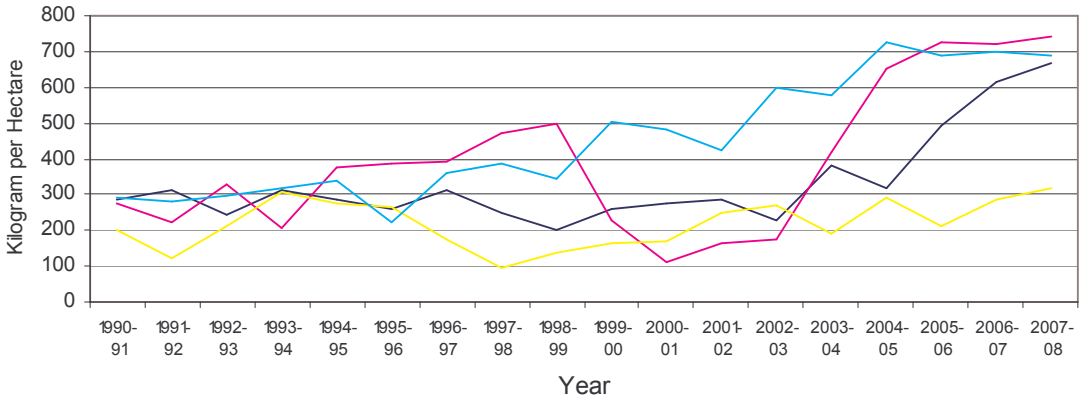


Figure 2.5 : Grow th in Cotton Yield n in Selected States



Chapter 3

Development and Adoption of Bt Cotton

3.1 Introduction

Bt cotton gets its name from a bacteria called *Bacillus thuringiensis*. Bt Cotton contains a foreign gene obtained from *Bacillus thuringiensis,* which is an aerobic bacterium, a natural enemy of boll worms, characterized by its ability to produce crystalline inclusions during sporulation. This bacteria was first discovered by a Japanese bacteriologist in 1901 and subsequently in 1915 a German scientist isolated crystal toxin in Thuringen region of Germany. B.thuringiensis was 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 advent of biotechnology, this bacterial gene was introduced genetically into the cotton genome, and it protects the plants from bollworm, the major pest of cotton. The worms feeding on the leaves of a Bt cotton plant become lethargic and sleepy, and are finally eliminated.

The first Bt cotton varieties were introduced commercially through a licensing agreement between the gene discoverer, Monsanto, and the leading American cotton germplasm firm, Delta and Pine Land Company (D&PL). These varieties contain the Cry1Ac gene and are commercialized under the trade name Bollgard®. Varieties with transgenes for insect resistance and herbicide tolerance (Bt/HT) stacked together were introduced in the United States in 1997. Further,

Monsanto recently received regulatory approval in some markets for a new product that incorporates two Bt genes, Cry1Ac and Cry2Ab2. This product, known as Bollgard II®, was commercialized in 2003. The incorporation of two Bt genes is believed to improve the effectiveness of the product and delay the development of resistant pests.

The chronological progress of field trials and the adoption of Bt cotton across countries is given in Chart 1 and Table 2.1.The Commercial cultivation of Bt cotton has been taken up in the United States of America, Australia and Mexico since 1996 and in 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 over 6 million hectares by the year 2004 (Table 3.2, Figure 3.1).

Chart 3.1 : Progress of Field Trials and Commercial Releases of Bt Cotton Around the World	
Argentina	Monsanto's Bt cotton approved in 2001, yet only planted on an estimated 5% of total cotton area in 2002/2003.
Australia	Bt cotton introduced in 1996. By 2002/2003, 30% of total cotton crop is Bt cotton and this increases to 80% in 2004 with the release of Monsanto 's Bollgard II variety, which involves less stringent insect resistance management plans.
Brazil	In March 2005, following the adoption of a new biosafety law strengthening its powers, the pro-GM National Technical Biosafety Committee approves the commercial release of Monsanto's Bt cotton
China	Bt cotton released in 1997. Currently Bt cotton is planted on over half of the national cotton area
Colombia	Monsanto imports Bt cotton in 2002, without an environmental clearance. Popular legal action results in the suspension of the authorisation.
Costa Rica	Monsanto began field trials without regulatory oversight in 1992. In 2004, 638 ha of Bt cotton were planted, mainly for the export of seeds.

Egypt	Monsanto and Egypt's Agriculture Genetic Engineering Research Institute currently collaborating in field trials of Bt cotton. They claim commercial introduction could take place as early as 2006.
India	Commercial introduction of Bt cotton occurs in 2002. By 2004, Bt cotton accounts for 6% of total cotton area and is only permitted for cultivation in six states.
Indonesia	Monsanto's Bt cotton commercialized in South Sulawesi province in 2001. However, two years later it is withdrawn after its failure to perform triggers farmer protests
Kenya	Monsanto imports Bt cotton into Kenya in 2004 for field trials.
Mexico	Bt cotton introduced in 1996. Government subsidises purchase of Bt cotton seeds. In 2002/3, 25% of the national cotton area planted to Bt cotton, slightly less than the percentage in 2000.
Paraguay	In July 2005, The Minister of Agriculture announces that it will approve Monsanto's GM cotton as part of a joint project with the company.
Philippines	In January 2005, the Cotton Development Authority signs a memorandum of agreement with the Philippine Rice Research Institute to begin field trials of Bt cotton.
South Africa	Bt cotton approved for commercial planting in 1997. Adoption very rapid and by 2002/3, an estimated 75% of national cotton area planted to GM cotton.. In 2003/4 only 35,700ha of cotton was planted, an 80% reduction since 2000, ascribed to low world prices and droughts. In 2004/5 the area planted was 21,700 ha, an extraordinary 40% drop in area planted to cotton in one year
USA	Around 40% of the cotton area in the US is Bt cotton. Studies show reduction in pesticide use since Bt cotton introduced in 1996, but now secondary pests are becoming an increasing problem.
Derived from http://grain.org/go/btcotton	

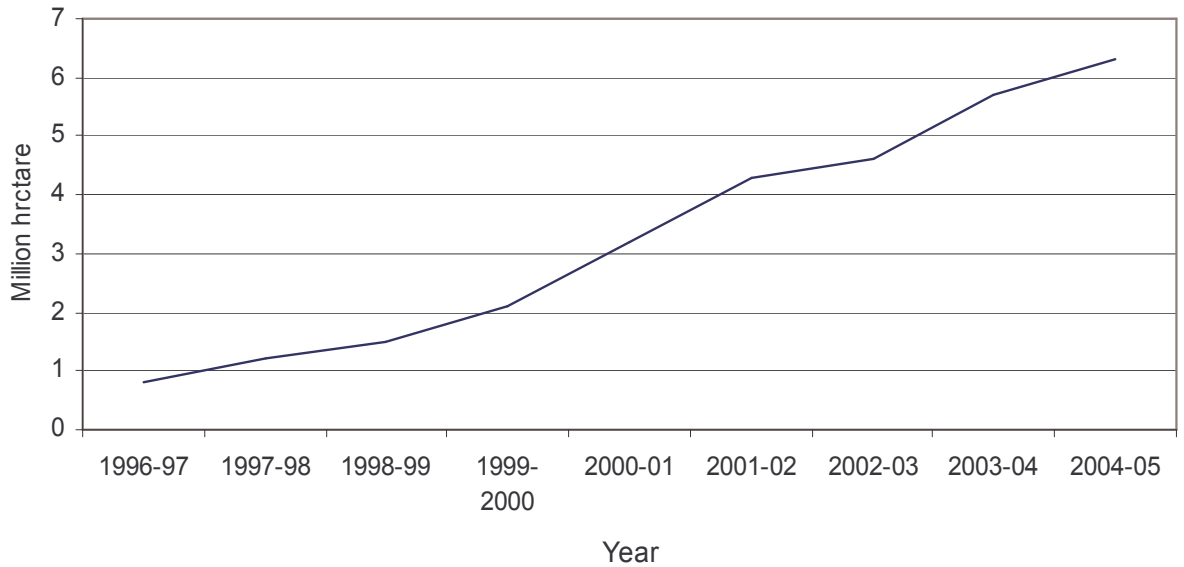
Table 3.1 : Adoption of Bt Cotton in Major Cotton Growing Countries

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
USA	√	√	√	√	√	√	√	√	√	√
Australia	√	√	√	√	√	√	√	√	√	√
China		√	√	√	√	√	√	√	√	√
India							√	√	√	√
Indonesia							√	√		
Mexico	√	√	√	√	√	√	√	√	√	√
Argentina			√	√	√	√	√	√	√	√
Colombia							√	√		

South Africa		√	√	√	√	√	√	√	√	√
Costa Rica									√	√
Pakistan										√
Paraguay										√
Source: www.grain.org/research										

Table 3.2: Global Adoption of Bt and HT Cotton (Million Hectare)			
Year	Bt Cotton	Bt and HT Cotton	Total
1996	0.8	0.0	0.8
1997	1.1	.1	1.2
1998	1.4	.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
2004	3.3	3.0	6.3
Source: James C (2003). HT stands for herbicide tolerant, also developed through biotechnology.			

Figure3.1: Global Adoption of Bt/Ht Cotton



3.2 Adoption of Bt Cotton in India

After much hesitation and delay, Bt cotton was approved by the Government of India for commercial cultivation in India in 2002. After the unauthorized appearance of Bt Cotton in Gujarat in 2001, in March 2002 the Genetic Engineering Approval Committee (GEAC), the regulatory authority of the Government of India for transgenic crops approved the commercial cultivation of three 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) and were meant for commercial cultivation in central and southern India. Later, the GEAC approved large scale field trials and seed production of 12 more varieties of Bt cotton 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 variety to be approved for commercial cultivation in the country.

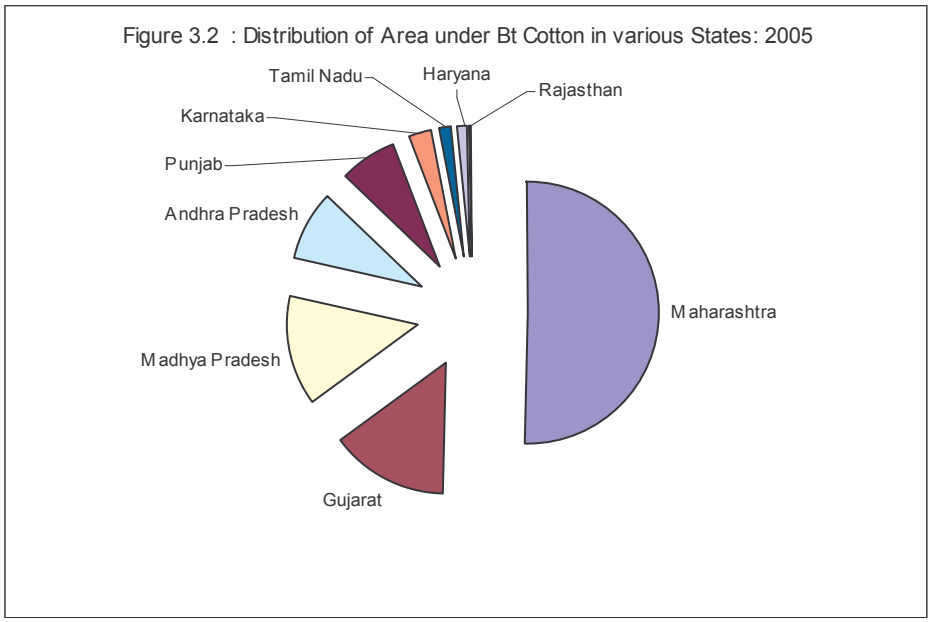
Gujarat and Maharashtra were the early adopters of Bt cotton in the country that commenced in 2002 followed by Andhra Pradesh and Karnataka (Table 2.4 and Figure 2.4). By official estimates, the area under Bt cotton in India was about 1 million hectare, or about 11 percent of the total area under cotton in the country in 2005. As of 2005, as per official statistics, the share of area under Bt cotton to total area under cotton was over 27 percent in Madhya Pradesh,

about18 percent in Maharashtra. These statistics do not include the substantial un-reported area in the state of Gujarat.

Table 3.3 : 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
Neg: Negligible or Nil Based on official statistics						

Table 3.4: Commercial cultivation of Bt cotton hybrids in India, 2002 (hectares)				
State	MECH-12	MECH-162	MECH-184	Total
Maharashtra	112	9300	5334	14746
Madhya Pradesh	60	404	1756	2220
Karnataka	0	3828	80	3908
Andhra Pradesh	44	5564	0	5608

Gujarat	76	4136	4642	8854
Tamil Nadu	0	2042	660	2702
Total	292	25274	12472	38038
Source: R.B. Barwale, V.R. Gadwal, Usha Zehr, and Brent Zehr, Prospects for Bt Cotton Technology in India, AgBioForum, Vol. 7, 2004				



3.3 A Brief Review of the Advantages of Bt Cotton over other Cotton Varieties

The reported potential advantages of Bt cotton 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 use of pesticides and effective yield superiority over non Bt cotton. Major environmental benefits

include reduction in number of insecticides spray, less insecticides in soils and aquifers, less exposure to pesticides for human beings and animals, and increase in the population of beneficial insects. These issues are reviewed below based on various studies conducted in India and elsewhere in the world.

3.3.1 Pesticide Use

A major agronomic attribute of Bt cotton over the conventional cotton is its high level of resistance to the bollworm complex. As a result, the need to use insecticides gets greatly reduced since the use of insecticides against bollworms is very high for the conventional cotton hybrids/ varieties. But there are conflicting views on these counts. Data based on field trials from a number of countries indicate that Bt cotton reduces the need of pesticides from seven sprays 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 in farmers using Bt cotton is four times less than farmers using conventional varieties (Pray, et al). Growers in the US are reported to have reduced insecticides use by 1.9 million pounds of active ingredient per year in 2001 (Gianessi, et al). It is reported that inChina the insecticide application was reduced by 67 per cent (Pray and Wang, 2002).

But the field level observations from various parts of India are mixed. Some observe that since Bt cotton does not offer protection against pink boll worm, it is essential to spray pesticides at almost the same level as for non-Bt. (Shai and Rahman, 2003). However, quite few studies have found that there was significant reduction in the use of pesticides on Bt cotton as compared to non-Bt

cotton (Sharma, 2002). A study carried out in four states of India during the first season of Bt cotton adoption shows that the Bt technology leads to significant pesticides reduction (Gopal Naik et al, 2005). Around 70 per cent of the farmers in Andhra Pradesh who have used Bt Cotton varieties responded favorably to it indicating that the variety is resistant to pests. The Indian Council of Agricultural Research (ICAR) indicates that about 65 per cent of the insecticide used in cotton production is to tackle the menace of bollworms, and if the genetically modified (GM) varieties are resistant to the pest, their cultivation must be encouraged (Statement of ICAR Director General quoted in Indian Express, 2003).

Others indicate that the variety 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. It found that farmers sprayed pesticides 4-6 times in Bt, and 5-7 times on non-Bt cotton. Bt farmer had to pay Rs.1,150 more towards the purchase of seed. Besides, the labour charges are stated to be about Rs. 150 more 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 are questioned. Bt cotton was also afflicted with the 'leaf curl virus' in the northern states of India. In Maharashtra, the Bt cotton crop in Vidarbha was 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). The above literature indicates that the opinions in the context of the resistance of Bt cotton to pests are divergent and require investigation.

3.3.2 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 it may not be so mainly due to high cost of Bt seed (Iyengar and Lalita, 2002). Besides, the use of yield increasing inputs is relatively high in Bt cotton and so the total cost of cultivation 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 even though the cost of seed was greater for Bt cotton, this was offset by a reduction in pesticides cost and a reduction in labour cost because Bt cotton farmers do not have to spend as much time spraying pesticides (Pray, 2002). The positive impact of Bt cotton on yield were 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 (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 (Naik, 2005). The net benefit from Bt cotton were 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 does have effective yield and profit superiority compared to non-Bt cotton.

3.3.3 Bt Cotton Seed Price

The prices of Bt seeds were almost three times that of non-Bt seeds and this has been a major issue in several parts of the country. The governments of Andhra Pradesh, Maharashtra and Gujarat, which constitute the cotton belt of India, have recently directed the sub-licensees of Monsanto not to charge more than Rs 750 per 450 gms packet of Bt cotton seed. After the Andhra Pradesh State Government referred the matter to the Monopoly Restricted Trade Practices Commission (MRTPC), the seed prices have been slashed to Rs. 750 per packet. The Mahyco-Monsanto Biotech India Limited (MMBL) after discussing with the seed companies brought down the trait value for Bt to Rs. 150 in Kharif 2006. The MMBL and seed companies decided to amend the relevant clauses of the agreement to avoid any issue vis-a-vis the MRTP Act. The intervention by the three states led to an injunction passed by MRTPC on

May 11, 2006 directing Monsanto to reduce its trait value of Rs 900 per 450 gms of Bt cotton seed to the level it charges in China, which works out to as little as Rs 40 for the same quantity. The price fixed by the states for the 2006-07 season was at least 50% less than the price at which the same seed was sold in the previous year - on account of the technology fee or "trait value" charged by Monsanto.

3.3.4 Environmental Considerations

Significant decrease in the number of insecticides sprays for the control of the major Lepidopteran insect pests – the bollworm – should substantially reduce the environmental hazards due to high toxicity of the insecticides. Lesser farmer exposure to insecticides would reduce health implications. The reduction in the use of insecticides will also 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.

Chapter 4

Data, Sampling and Methodology

4.1 Introduction

This study is based on the primary data collected from four states namely Andhra Pradesh, Gujarat, Maharashtra and Tamil Nadu. Effort was made to adopt similar methodology, content and survey instruments in all these states, as far as possible. On determining the farmer sample, a similar multi-stage stratified random sampling design was used. The first stage of sampling was the selection of districts, the second stage was the selection of villages in the selected district and the fourth stage was the selection of sample farmer households of different types (Bt-NonBt, farm sizes, irrigated-unirrigated) in the selected villages. Effort was made to have nearly an equal number of Bt and Non-Bt farmers in the sample. Effort was also made through stratification to cover both irrigated and unirrigated farms under Bt and non-Bt cotton, as well as small, medium and large farmers. The sampling methodology is discussed in greater details in the respective state studies. The primary data collected pertains to the agricultural year 2004-05.

4.2 Sample Size

The target sample size for each state was 180 cotton farmers comprising of 90 Bt and 90 Non-Bt farmers. Maharashtra proved to be an exception where the coverage was 85 Bt and 69 Non-Bt farmers (Tables 4.1 and 4.2). The Gujarat sample does not have unirrigated cotton as a sufficient number of such farmers were not available in the sample districts. The number of sample farmer

households under unirrigated Bt cotton was relatively less in Andhra Pradesh and Maharashtra, but were relatively more in Tamil Nadu. The study had an overall sample size of 694 farm households.

The average size of operational holding did not differ markedly between Bt and Non-Bt but was found to be marginally higher under Bt cotton compared to Non-Bt cotton in Andhra Pradesh, both irrigated and unirrigated (Table 4.3). The same was true for Gujarat and Tamil Nadu. In Maharashtra, the average operated area for both irrigated and unirrigated Bt cotton farmers was significantly greater than that of non-Bt farmers.

Table 4.1: Sample Size

Farm Size in Hectare	Bt Cotton			Non-Bt Cotton		
	Irrigated	Un-Irrigated	Total	Irrigated	Un-Irrigated	Total
Andhra Pradesh						
Small (Below 2 Ha)	24	18	42	24	18	42
Medium (2 to 4 Ha)	18	12	30	18	12	30
Large (Above 4 Ha)	12	6	18	12	6	18
Total	54	36	90	54	36	90
Gujarat						
Small (Below 2 Ha)	42	0	42	42	0	42
Medium (2 to 4 Ha)	30	0	30	30	0	30
Large (Above 4 Ha)	18	0	18	18	0	18
Total	90	0	90	90	0	90
Maharashtra						
Small (Below 2 Ha)	8	9	17	9	14	23
Medium (2 to 4 Ha)	14	9	23	5	13	18
Large (Above 4 Ha)	26	19	45	7	21	28
Total	48	37	85	21	48	69

Tamil Nadu						
Small (Below 2 Ha)	12	30	42	12	30	42
Medium (2 to 4 Ha)	11	19	30	11	19	30
Large (Above 4 Ha)	9	9	18	9	9	18
Total	32	58	90	32	58	90
Overall						
Small (Below 2 Ha)	86	57	143	87	62	149
Medium (2 to 4 Ha)	73	40	113	64	44	108
Large (Above 4 Ha)	65	34	99	46	36	82
Total	224	131	355	197	142	339
Grand Total						694

Table 4.2: Sample Farm Size Distribution (Percentage)						
Farm Size in Hectare	Bt Cotton			Non-Bt Cotton		
	Irrigated	Un-Irrigated	Total	Irrigated	Un-Irrigated	Total
Andhra Pradesh						
Small (Below 2 Ha)	44.44	50.00	46.67	44.44	50.00	46.67
Medium (2 to 4 Ha)	33.33	33.33	33.33	33.33	33.33	33.33
Large (Above 4 Ha)	22.22	16.67	20.00	22.22	16.67	20.00
Total	100	100	100	100	100	100
Gujarat						
Small (Below 2 Ha)	46.67		46.67	46.67		46.67
Medium (2 to 4 Ha)	33.33		33.33	33.33		33.33
Large (Above 4 Ha)	20.00		20.00	20.00		20.00
Total	100		100	100		100
Maharashtra						
Small (Below 2 Ha)	16.67	24.32	20.00	42.86	29.17	33.33
Medium (2 to 4 Ha)	29.17	24.32	27.06	23.81	27.08	26.09
Large (Above 4 Ha)	54.17	51.35	52.94	33.33	43.75	40.58
Total	100	100	100	100	100	100
Tamil Nadu						
Small (Below 2 Ha)	37.50	51.72	46.67	37.50	51.72	46.67
Medium (2 to 4 Ha)	34.38	32.76	33.33	34.38	32.76	33.33

Large (Above 4 Ha)	28.13	15.52	20.00	28.13	15.52	20.00
Total	100	100	100	100	100	100
Overall						
Small (Below 2 Ha)	38.39	43.51	40.28	44.16	43.66	43.95
Medium (2 to 4 Ha)	32.59	30.53	31.83	32.49	30.99	31.86
Large (Above 4 Ha)	29.02	25.95	27.89	23.35	25.35	24.19
Total	100	100	100	100	100	100

Table 4.3 : Average Operational Holding Size of Bt and Non-Bt Cotton Farmer Households

(Area in Hectares)

	Bt Cotton		Non-Bt.cotton	
	I	UI	I	UI
Andhra Pradesh				
Small	1.36	1.19	1.39	1.03
Medium	3.10	1.67	2.83	1.90
Large	6.52	3.88	5.13	4.27
Overall	2.92	2.59	2.62	2.49
Gujarat				
Small	1.58	0	1.28	0
Medium	3.15	0	3.09	0
Large	8.33	0	7.49	0
Overall	3.45	0	3.13	0
Maharashtra				
Small	1.38	0.64	1.62	0.52
Medium	3.45	2.13	3.40	0.72
Large	9.16	3.98	8.66	2.51
Overall	6.06	2.81	4.94	1.38

Tamil Nadu				
Small	1.15	0.65	0.99	0.44
Medium	2.83	1.74	2.69	1.12
Large	5.05	2.04	2.83	1.70
Overall	2.49	1.52	2.30	1.00

4.3 Methodology

Since the major objectives of the study is on the economics of Bt Cotton vis-à-vis Non-Bt cotton, a comparative study of between them on important parameters have been undertaken. Wherever possible the comparative performance of Bt and Non Bt farmer households under different farm size and irrigated and unirrigated conditions has been studied. Tabulation as well as basic statistical tools and regression analysis have been used to study the differences and impact of Bt cotton as compared to non-Bt cotton, measure some of the differences and check their statistical significance. The following chapters gives the results emerging from the study.

Chapter 5

Cotton Cultivation Practices and Patterns across the States

5.1 Introduction

In Andhra Pradesh, cotton is very important crop and stands at the third place in terms of area cultivated. Over the past two and half decades there had been a significant increase in the area under cotton in the state. Cotton has been grown under both irrigated and unirrigated conditions and the latter dominates. Many improved and hybrid varieties of cotton are used by the cultivators. Bt cotton was introduced in the state in 2002. The GEAC permitted Mahyco-Monsanto the commercial release of three Bt cotton varieties namely MECH-12, MECH-184 and RCH-20.

In Gujarat, cotton shares one of the two top position in terms of cropped area. The total area under cotton in Gujarat during 2005-06 was about 2.08 million hectares which is roughly about 23 percent of the total area under cotton in the country. Almost two-thirds of the area under cotton in the state under hybrid varieties .The Bt varieties has been spreading fast in the state, both approved and non-approved varieties of Bt cotton.

In Maharashtra, cotton is traditionally one of the most important crops. Area under cotton in Maharashtra is about 3 million hectares and the state accounts for about 30 percent of the cotton area in the country. As against its share in total area, the share in cotton production in the country was continued to be low due to its relatively low yields. Although cotton is not a major crop in

Tamil Nadu, it plays an important role in the economy of the selected districts in the state.

5.2 Cropping Pattern

The cropping pattern of the sample farm households during the survey year is given in Tables 5.1 to 5.4. The cropping pattern for the Bt and Non-Bt sample households was not collected separately in Andhra Pradesh. Among the sample households, cotton is the major crop followed by maize, chillies and paddy. In Gujarat cotton accounted for 50 percent of the cropped area for Bt cotton farmers and 45 percent for the non-Bt farmers. Groundnut was the other major crop grown by both Bt and Non-Bt sample households followed by wheat, sugarcane and pulses. In Maharashtra cotton is one of the most important crops in cropping pattern of the sample households. The other major crops grown by the sample households were jowar and pulses crops. There was no major difference in cropping pattern between Bt and non-Bt farmers. Although cotton is not a major crop in Tamil Nadu, cotton accounted for about 31 percent of the total cropped area for Bt farmers and 42.1 percent of the cropped area for non-Bt farmers. Cholam (jowar), maize and pulses were the othe major crops grown by the sample farm households.

Table 5.1 : Cropping Pattern Among Sample Households in Andhra Pradesh			
Sr.No.	Crop	Average Area in Hectares	Percentage to Total Cropped Area
1	Bt Cotton	0.69	26.14
2	Non-Bt Cotton	0.77	29.17
3	Paddy	0.27	10.23
4	Maize	0.35	13.26
5	Chillies	0.3	11.36
6	Tumeric	0.07	2.65
7	Others	0.19	7.20
	All Crops	2.64	100

Table 5.2: Cropping Patter Among Sample Households Gujarat					
Sr.No.	Crops	Area in Hectares		Percentage to total Cropped Area	
		Bt Cotton Farmers	Non-Bt Cotton Farmers	Bt Cotton Farmers	Non-Bt Cotton Farmers
1	Cotton-NC	1.02	0.07	26.43	1.89
2	Cotton-G	0.86	0.02	20.92	0.57
3	Cottton-Non Bt	0.11	1.65	2.62	42.21
4	Groundnut	0.62	0.76	15.11	19.96
5	Wheat	0.23	0.19	5.66	5.02
6	Sugarcane	0.22	0.21	5.32	5.60
7	Tur	0.21	0.21	5.17	5.62
8	Fodder	0.15	0.06	3.60	1.58
9	Fodder	0.12	0.03	2.98	0.70
10	Fodder	0.12	0.16	2.87	4.32
11	Vegetables	0.08	0.12	1.96	3.15
12	Garlic	0.06	0.17	1.54	4.60
13	Other	0.24	0.18	5.81	4.79
	Total Cropped Area	4.08	3.79	100	100

Table 5.3: Cropping Pattern among Sample Households: Maharashtra					
Sr. No	Crops	Area in Hectare		Percentage to total cropped area	
		Bt Cotton Farmers	Non-Bt Cotton Farmers	Bt Cotton Farmers	Non-Bt Cotton Farmers
1	Cotton	1.45	30.33	1.35	32.93
2	Jowar	0.59	12.36	0.51	12.54
3	Maize	0.20	4.15	0.20	4.94
4	Soyabean	0.25	5.16	0.24	5.82
5	Udad+Mung	0.35	7.28	0.37	9.08
6	Banana	0.22	4.66	0.28	6.91
7	Sugarcane	0.23	4.74	0.02	0.39
8	Tur	0.30	6.26	0.21	5.13
9	Chilli	0.17	3.64	0.20	4.84
10	Mango	0.13	2.62	0.02	0.49
11	Wheat	0.31	6.43	0.38	9.18
12	Gram	0.29	6.10	0.07	1.78
13	Sunflower	0.08	1.61	0.04	1.09
14	Jowar	0.18	3.73	0.13	3.16
15	Groundnut	0.02	0.51	0.03	0.79
16	Onion	0.02	0.51	0.04	0.89
	Total	4.78	100	4.10	100

Table 5.4: Cropping Pattern among Sample Households: Tamil Nadu					
		Area in Hectare		Percentage to total cropped Area	
	Crop	Bt Cotton	Non-Bt Cotton	Bt Cotton	Non-Bt Cotton
1	Cotton	0.86	1.10	30.71	42.15
2	Groundnut	0.37	0.37	13.21	14.18
3	Cholam	0.3	0.32	10.71	12.26
4	Paddy	0.3	0.18	10.71	6.90
5	Maize	0.25	0.06	8.93	2.30
6	Pulses	0.19	0.11	6.79	4.21
7	Cumbu	0.13	0.1	4.64	3.83
8	Sugarcane	0.11	0.02	3.93	0.77
9	Vegetables	0.11	0	3.93	0.00
10	Sunflower	0.07	0	2.50	0.00
11	Maize	0.04	0.33	1.43	12.64
12	Sunflower	0.04	0.01	1.43	0.38
13	Tapioca	0.02	0	0.71	0.00
14	Turmeric	0.01	0	0.36	0.00
15	Chillies	0	0.01	0.00	0.38
	Total Cropped Area	2.80	2.61	100	100

5.3 Area under Cotton

The cultivation of Bt cotton was found under both irrigated and unirrigated conditions among the sample households except in Gujarat where it was grown only under irrigated condition. But the Bt cotton area under irrigated conditions was more among the sample farmer households (Table 5.5). The average area under cotton among the sample households on a per farm basis was highest in Gujarat followed by Maharashtra and the least was in Andhra Pradesh.

Table 5.5 : Average Area Under Cotton among Sample Households (Hectares/per Farm)

	BT			Non-Bt		
	I	UI	Total	I	UI	Total
Andhra Pradesh						
Small	0.41	0.35	0.39	0.24	0.39	0.30
Medium	0.63	0.80	0.70	0.78	0.82	0.80
Large	1.34	1.64	1.47	1.22	1.42	1.28
Overall	0.65	0.76	0.69	0.62	0.74	0.66
Gujarat						
Small	1.03	0	1.03	0.87	0	0.87
Medium	2.05	0	2.05	1.59	0	1.59
Large	3.57	0	3.57	3.56	0	3.56
Overall	1.88	0	1.88	1.65	0	1.65
Maharashtra						
Small	0.86	0.63	0.74	0.85	1.07	0.92
Medium	1.55	1.21	1.42	1.38	1.18	1.24

Large	1.79	1.66	1.74	2.02	1.58	1.69
Overall	1.56	1.3	1.45	1.37	1.32	1.35
Tamil Nadu						
Small	0.63	0.37	0.45	0.86	0.63	0.70
Medium	1.56	0.71	1.02	1.58	1.21	1.35
Large	1.38	1.08	1.38	1.57	1.69	1.63
Overall	1.25	0.59	0.86	1.31	0.99	1.10

5.4 Cotton Varieties Used by the Sample Households

Many Bt and non Bt varieties were reported. The use of non-genuine Bt seeds was reported by both Gujarat and Andhra Pradesh sample households (Table 5.6). This accounted for 56 percent of the Bt sample in Gujarat and 20 percent in Andhra Pradesh. The Bt seeds that were used by the sample farmer households were of RCH and MAHYCO varieties in Andhra Pradesh and Gujarat besides the use of non-confirmed Bt seeds. While in Maharashtra both Mahyco and Rasi Bt seeds were used by the sample households, in Tamil Nadu only Rasi Bt seeds were used. A large number of non-Bt hybrid seeds were also reported among the sample households.

Table 5.6: Different Varieties of Cotton Used by the Sample Households

State	Cotton Type	Varieties
Andhra Pradesh	BT	Rasi (RCH), MECH, Other Non-confirmed
	Non-BT	Bunny, Super Bunny, Brahma, Satya, Attara, JK, Tagore, Bindu, Others
Gujarat	BT	Rasi (RCH), Mahyco, Other Non-confirmed
	Non-BT	Sankar, Vikram, Navbharat Deshi, Other deshi

Maharashtra	BT	MECH 184, MECH 12, MECH 162, Rashi 2, MECH + Rashi
	Non-BT	Ankur, Banny, Ajit, Others
Tamil Nadu	BT	RCH-2 BT
	Non-BT	RCH-2 Non-BT

The use of non-confirmed Bt cotton was found in 20 percent of the Bt cotton sample households in Andhra Pradesh (Table 5.7). Among the genuine Bt seeds, Rasi seeds was more popular among the sample farmers (58.9 percent). A large number of non-Bt varieties have been used by the sample farmers in the state.

Table 5.7: Brand/Variety-wise Use of Cotton Seeds by Sample Farmers: Andhra Pradesh

		Number	Percentage
Bt	Rasi	53	58.89
	MCH	19	21.11
	Non-Confirmed	18	20.00
	Total Bt	90	100
Non-Bt	Bonny	34	37.78
	Super Bonn	20	22.22
	Brahma	5	5.56
	JK	6	6.67
	Satya	4	4.44

	Attara	3	3.33
	Others	18	20.00
	Total Non-Bt	90	100

In Gujarat the use of non-confirmed Bt cotton seeds was very common accounting for over 57 percent of the sample farmers. The two most popular varieties among the Bt sample farmers were Navbharat and Dhanlaxmi (Table 5.8). The two confirmed Bt varieties used were RCH and MAHYCO. Under non-Bt seeds, a large number of hybrids and non-hybrids were in use during the survey year.

Table 5.8: Brand/Variety-wise Use of Cotton Seeds by Sample Farmers: Gujarat

		Number	Percentage
Bt-G	RCH	20	22.22
	Mahyco	19	21.11
Bt-NC	Navbharat	32	35.56
	Dhanlaxmi	19	21.11
	Total Bt	90	100
Non-Bt	Sankar(H)	15	16.67
	Vikram(H)	33	36.67
	Navbharat Deshi(Non-H)	25	27.78
	Other deshi(Non-H)	17	18.89
	Total Non-Bt	90	100

In Maharashtra two Bt varieties have been used by the sample farmers namely MECH and Rasi (Table 5.9) and among them MECH was more popular among the farmers. Among the non-Bt farmers, the prominent varieties were Ankur and Ajit.

Table 5.9: Brand/Variety-wise Use of Cotton Seeds by Sample Farmers : Maharashtra

	Variety	Number	Percentage
Bt Cotton	MECH 184 - 1	25	29.41
	MECH 12 - 2	19	22.35
	MECH 162 - 3	6	7.06
	Rashi 2 - 4	12	14.12
	2 MECH - 5	20	23.53
	MECH + Rashi - 6	3	3.53
	All Varieties	85	100
Non-Bt Cotton	Ankur	14	20.29
	Banny	11	15.94
	Ajit	19	27.54
	Others	25	36.23
	All Varieties	69	100

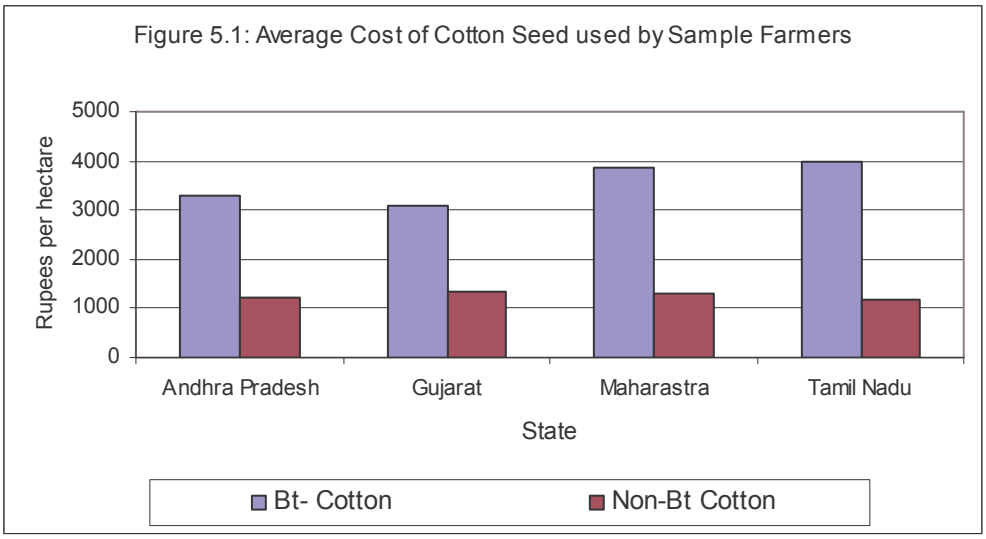
In Tamil Nadu the Bt farmers used only RCH-2 Bt and the non-Bt sample farmers used only RCH-2 Non.Bt (Table 5.10)

Table 5.10: Brand/Variety-wise Use of Cotton Seeds by Sample Farmers: Tamil Nadu			
		Number	Percentage
Bt	RCH-2	90	100
Non-Bt	RCH-2	90	100

5.5 Average Cost of Seeds Used

The average cost of Bt Cotton seeds used per hectare by the sample households varied substantially across the states. The cost of Bt seeds was the least in Gujarat at Rs 3079 per hectare followed by Andhra Pradesh with Rs. 3313 (Table 5.11). This could be because the use of non-confirmed Bt seeds was very common in these states and the cost such seeds are reported to be lower than the confirmed Bt seeds. On an average the cost of Bt seeds per hectare was more than double than the non-Bt seeds in all the four states.

Table 5.11 : Average Cost of Seed Used by the Sample Households (Rs/Hectare)				
Particulars	Andhra Pradesh	Gujarat	Maharashtra	Tamil Nadu
Bt- Cotton	3313	3079	3857	3977
Non-Bt Cotton	1213	1324	1319	1180
Bt-Cotton over Non-Bt Cotton	2100	1756	2538	2797



5.6 Application of Pesticides

The average number pesticides sprays as well as its cost per hectare was relatively higher on non-Bt cotton in all the selected states (Tables 5.12 to 5.15). But the difference across states was very high. For example, average number of spray on non-Bt Cotton in Gujarat was 0.52, but it was as high as 3.84 in Andhra Pradesh. Similarly the cost of pesticides was higher on non-Bt cotton by Rs. 436 per hectare in Gujarat, and Rs.2749 in Andhra Pradesh. Thus the average number of pesticides spray as well as its cost was higher on non-Bt cotton in all the selected states.

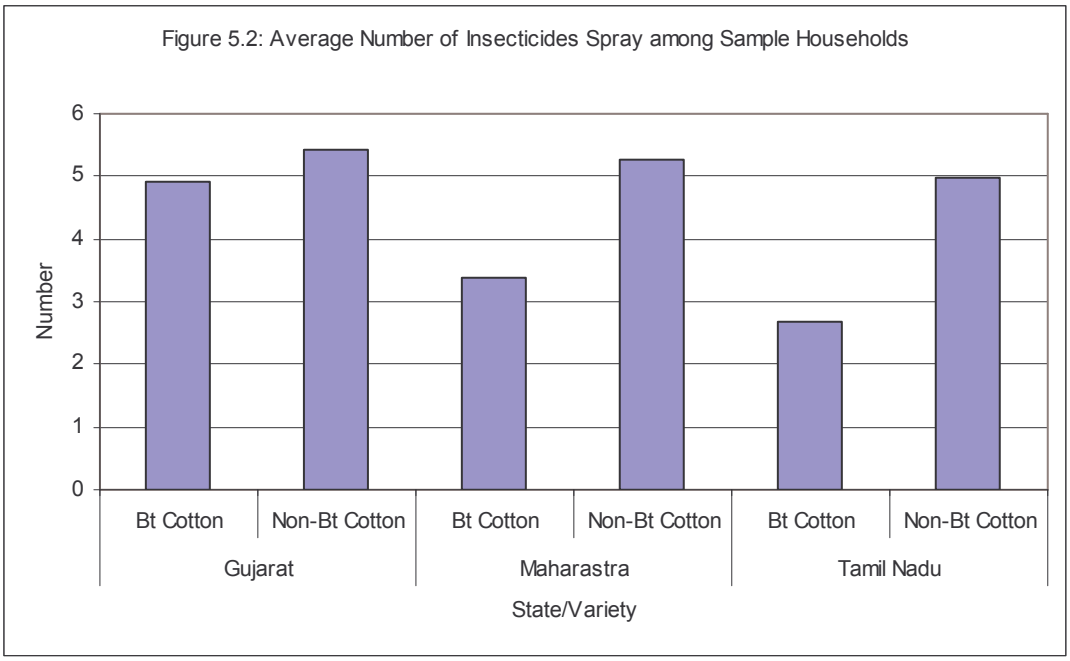
Table 5.12: Practice Followed by Sample Farmers in Pesticides Spraying: AP

		Bt Cotton	Non-Bt Cotton	Difference
1	Average Number of Spray	4.27	8.11	3.84
2	Total Quantity Sprayed (litre/ha)	5.22	6.93	1.71
3	Cost of Pesticides (Rs/ha)	7926	10675	2749

Table 5.13: Practice Followed by Sample Farmers in Pesticides Spraying: Gujarat				
		Bt Cotton	Non-Bt Cotton	Difference
1	Average Number of Spray	4.92	5.44	0.52
2	Total Quantity Sprayed (litre/ha)	2.53	3.90	1.37
3	Cost of Pesticides (Rs/ha)	2732	3168	436

Table 5.14: Practice Followed by Sample Farmers in Pesticides Spraying: Maharashtra				
		Bt Cotton	Non-Bt Cotton	Difference
1	Average Number of Spray	3.37	5.28	1.91
2	Cost of Pesticides (Rs/ha)	3242	4120	878

Table 5.15: Practice Followed by Sample Farmers in Pesticides Spraying: Tamil Nadu				
		Bt Cotton	Non-Bt Cotton	Difference
1	Average Number of Spray	2.67	4.98	2.31
2	Cost of Pesticides (Rs/ha)	1901	4196	2295



5,7 Average Bt and Non-Bt Cotton Yields

The average yields observed of Bt and non-Bt cotton under irrigated and unirrigated conditions among different size of farming households are given in Table 5.16 and Figure 5.1. In Andhra Pradesh the Bt yields were higher but the difference in the yield levels under irrigated and unirrigated was not consistent. The yield of Bt cotton irrigated was significantly higher in Maharashtra and Tamil Nadu. There was no consistent yield difference across farm sizes. The average yield of Bt cotton over non-Bt cotton was higher in all the states in the study and it was higher by 18.2 percent in Andhra Pradesh, 28.4 percent in Gujarat, 46.4 percent in Maharashtra and 28.5 percent in Tamil Nadu.

Table 5.16 :Average Cotton Yield among Sample Households(Quintal/Ha)									
Farm Size	Bt Cotton			Non-Bt Cotton			Difference between Bt Cotton and Non-Bt Cotton (Percentage)		
	I	UI	Total	I	UI	Total	I	UI	Total
Andhra Pradesh									
Small	30.16	25.00	27.96	26.40	23.74	24.81	14.24	5.29	12.51
Medium	31.20	32.34	31.83	26.27	20.77	23.39	18.76	55.66	36.84
Large	27.48	29.50	28.60	30.73	23.30	26.74	-10.59	26.57	6.96
Overall	29.73	29.51	29.44	28.06	22.34	24.90	4.68	32.03	18.19
Gujarat									
Small	29.24		29.24	21.07		21.07	38.78		38.78
Medium	34.34		34.34	25.61		25.61	34.09		34.09
Large	32.13		32.13	26.95		26.95	19.22		19.22
Overall	32.20		32.20	25.07		25.07	28.44		28.44
Maharastra									
Small	24.65	21.46	23.0	18.66	16.09	17.10	32.10	33.37	34.31
Medium	26.81	24.49	25.90	17.42	17.39	17.40	53.90	40.83	48.88
Large	28.85	25.17	27.30	19.24	18.44	18.64	49.95	36.50	46.44
Overall	27.56	24.10	26.05	18.56	17.47	17.80	48.49	37.95	46.36
Tamil Nadu									
Small	24.24	12.85	17.47	10.32	18.99	29.31	134.88	-32.33	-20.01
Medium	23.84	13.47	19.26	16.78	13.15	14.71	42.07	2.43	30.93
Large	23.40	13.76	19.64	16.94	13.12	14.96	38.13	4.88	31.28
Overall	23.75	13.35	18.93	16.97	12.10	14.73	39.95	10.33	28.51

Figure 5.1: Average Yiled per Hectare of Bt and Non-Bt Cotton under Irrigated Condition

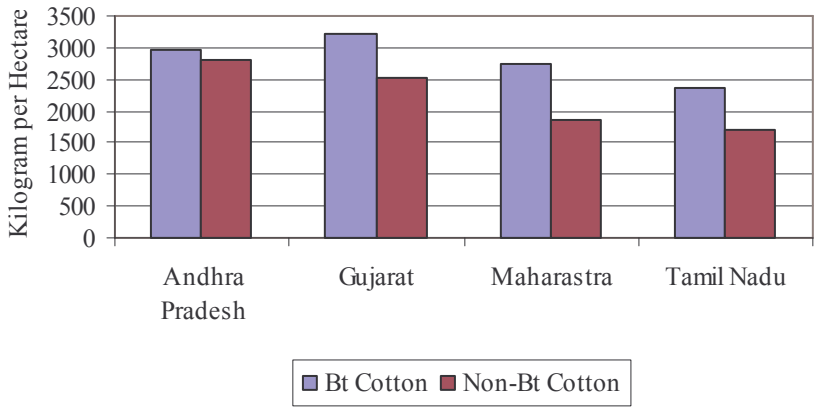


Figure 5.2: Average Yield of Bt and Non-Bt Cotton under Unirrigated Conditin

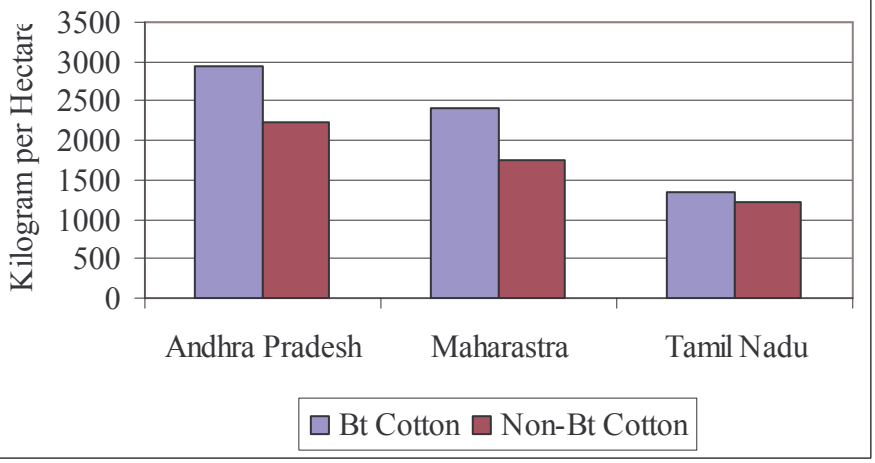
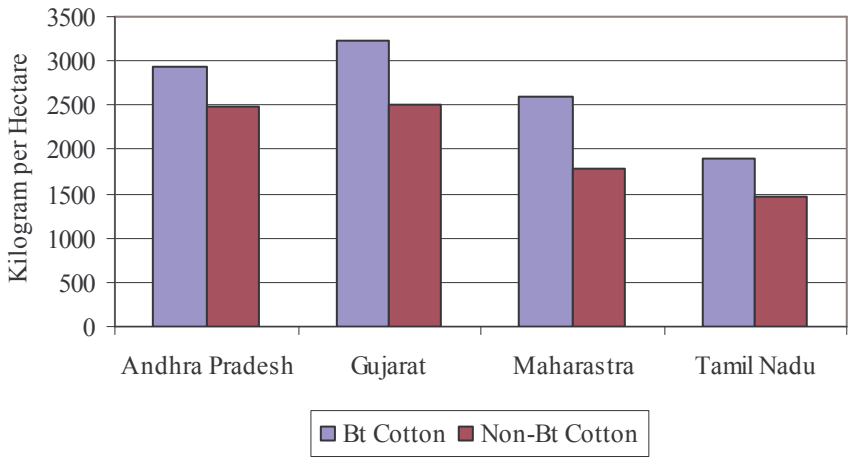


Figure 5.3: Average Yield per Hectare of Bt and Non-Bt Cotton



Chapter 6

Economics of Bt and Non-Bt Cotton Cultivation

6.1 Introduction

In this chapter we examine the cost of cultivation, various input costs, the value of output, and the profitability of Bt and Non-Bt cotton under irrigated and unirrigated conditions. These aspects have also been examined for different farm size and these results are given at the end of the report in Exhibit Tables.

6.2 Cost of Production, Cost Structure, Value of Output and Profit

The total cost of cultivation under irrigated condition was in general higher than under unirrigated conditions both for Bt and Non-Bt cotton. Comparing the input costs and value of output of Bt and Non-Bt cotton overall - without making distinction between irrigated and unirrigated, the following major observations can be made (Tables 6.1 to 6.6 and Figures 6.1 to 6.7)

1 The cost of cultivation per hectare of Bt cotton exceeded that of non-Bt cotton in all the states and the difference was the highest in Maharashtra exceeding Rs.8250

2 The cost of irrigation for both Bt and non-Bt was relatively much higher in Maharashtra and Gujarat. This may be because of the dependence on tubewell irrigation as against canal irrigation in Andhra Pradesh and Tamil Nadu

3 The average per hectare cost seed for Bt cotton was higher compared to non-Bt cotton and the difference ranged from Rs. 1600 per ha in Gujarat to over Rs. 2700 per ha in Tamil Nadu. The relatively low cost

of Bt cotton seeds in Gujarat and Andhra Pradesh as opposed to Maharashtra and Tamil Nadu could be due to non-genuine Bt seeds used whose price (as well as quality) was comparatively lower than genuine Bt cotton seeds

4 While the share of seed cost of Bt seeds in total cost of production was in the range of 10 to 17 percent in the selected states, whereas it varied from 4 to 6 percent for non-Bt cotton seeds

5 The per hectare cost of pesticides under Bt cotton varied from Rs. 2732 in Gujarat to Rs. 7806 in Andhra Pradesh. This is as against the per hectare cost of pesticides at Rs. 3168 in Gujarat to Rs. 10878 in Andhra Pradesh for Non-Bt.

6 While the share of cost of pesticides in total cost of cultivation was in range of 8.29 percent in Tamil Nadu to 24.29 percent in Andhra Pradesh for Bt cotton, it varied from 11.96 per cent in Gujarat to 35.73 per ccent in Andhra Pradesh for non-Bt.

7 The value of output of Bt cotton per hectare exceeded that of non-Bt cotton by 30.843 percent in Gujarat, 42.1 per cent in Andhra Pradesh, 44.74 percent in Maharashtra and 47.06 percent in Tamil Nadu.

8 The net profit per hectare from Bt cotton ranged from Rs.15242 in Tamil Nadu to Rs. 34199 in Gujarat as opposed to Rs. 5772 in Tamil Nadu to Rs. 21880 in Gujarat for non-Bt cotton.

9 The Benefit-Cost Ratio of Bt cotton ranges from 1.586 in AP to 2.150 in Gujarat and is higher than that of non-Bt cotton in almost every case.

Table 6.1: Cost of Production in Rupees per Hectare: Irrigated Cotton								
Item	Bt - Cotton				Non-Bt - Cotton			
	AP	GJ	MR.	TN	AP	GJ	MR.	TN
1. Seed	3495	3079	3776	4005	1234	1324	1240	1194
2.Human Labour	9140	10827	11801	11073	8786	9587	8920	8250
3. Bullock Labour	2146	2468	2004		2056	2527	2606	
4. Tractor	1800	1042	1037	2464	1685	848	856	1854
5. Farm Yard Manure	2252	1488		2553	2109	1429		1575
6. Fertilizer	5888	3247	7193	2936	4605	3292	3984	3423
7. Pesticides	8116	2732	2936	1887	11972	3168	4224	5316
8. Irrigation	642	3818	2011	103	328	3872	1556	122
9.Other Operational Costs	0	467	340	0	0	450	235	0
10.Total Operational Cost	33478	29167	31098	25021	32775	26497	23621	21734
11. Total Marketing Cost	276	576	1271	651	233	496	830	339
12. Total Cost	33754	29743	32368	25672	33008	26993	24102	22073
Value of Output	49437	63942	57262	45599	48810	48873	38973	29307
Net Profit	15683	34199	24894	19927	15802	21880	14871	7234
Benefit-Cost Ratio	1.465	2.150	1.769	1.776	1.479	1.811	1.617	1.328
Value of Output of Bt Cotton over Non-Bt Cotton (%)	1.28	30.83	46.93	55.59				
Net Profit of Bt Cotton over Non-Bt Cotton (%)	-0.75	56.07	67.40	175.46				

Table 6.2: Share of Various Costs in Total Cost and Value of Production: Irrigated Cotton								
Item	Bt – Cotton				Non-Bt – Cotton			
	AP	GJ	MR.	TN	AP	GJ	MR.	TN
	Percentage Share of Various Inputs in total Cost							
1. Seed	10.35	10.41	11.67	15.60	3.74	5.00	5.07	5.41
2.Farm Power	38.77	48.23	45.85	52.73	37.95	48.02	50.64	45.78
3.Manure	24.11	15.56	22.22	21.38	20.34	16.88	16.29	22.64
4. Pesticides	24.04	8.66	9.07	7.35	36.27	11.99	17.28	24.08
5. Other Inputs	2.72	17.15	11.19	2.94	1.70	18.10	10.72	2.09
6. Total Cost	100	100	100	100	100	100	100	100
	Costs as percentage of Value of Output							
1. Seed	7.07	5.02	6.59	8.78	2.53	2.95	3.18	4.07
2.Farm Power	26.47	23.26	25.92	29.69	25.66	28.34	31.77	34.48
3.Manure	16.47	7.51	12.56	12.04	13.76	9.97	10.22	17.05
4. Pesticides	16.42	4.17	5.13	4.14	24.53	7.08	10.84	18.14
5. Other Costs	1.86	8.27	6.33	1.65	1.15	10.69	6.73	1.57
6. Total Cost	68.28	48.23	56.53	56.30	67.63	59.03	62.74	75.32
7. Value of Output	100	100	100	100	100	100	100	100

Table 6.3: Cost of Production in Rupees per Hectare: Unirrigated Cotton								
Item	Bt - Cotton				Non-Bt - Cotton			
	AP	GJ	MR.	TN	AP	GJ	MR.	TN
1. Seed	3137		3963	3945	1215		1354	1167
2.Human Labour	10378		11694	6791	7846		9251	7177
3. Bullock Labour	1982		1794		2029		1915	
4. Tractor	1611		989	2267	1642		701	1613
5. Farm Yard Manure	1955			1852	1928			1075
6. Fertilizer	3752		7017	2905	3631		4131	4057
7. Pesticides	7509		3638	1934	10004		4074	3074
8. Irrigation	0		0		0		0	
9.Other Operational Costs	0		321	0	0		72	0
10.Total Operational Cost	30323		29416	19694	28295		21498	12163
11. Total Marketing Cost	139		1369	297	167		1334	291
12. Total Cost	30463		30785	19991	28462		22815	18454
Value of Output	52847		50487	29797	28372		36890	23632
Net Profit	22384		19702	9806	-90		14075	5178
Benefit-Cost Ratio	1.735		1.640	1.491	0.997		1.617	1.281
Value of Output of Bt Cotton over Non-Bt Cotton (%)	86.26		36.86	26.09				
Net Profit of Bt Cotton over Non-Bt Cotton (%)			39.98	89.38				

Table 6.4: Share of Various Costs in Total Cost and Value of Production: Unirrigated Cotton								
Item	Bt – Cotton				Non-Bt – Cotton			
	AP	GJ	MR.	TN	AP	GJ	MR.	TN
	Percentage Share of Various Inputs in total Cost							
1. Seed	10.30		12.87	19.73	4.27		5.93	6.32
2.Farm Power	45.86		47.03	45.31	40.46		51.98	47.63
3.Manure	18.73		22.79	23.80	19.53		18.09	27.81
4. Pesticides	24.65		11.82	9.67	35.15		17.84	16.66
5. Other Inputs	0.46		5.49	1.49	0.59		6.16	1.58
6. Total Cost	100		100	100	100		100	100
	Costs as percentage of Value of Output							
1. Seed	5.94		7.85	13.24	4.28		3.67	4.94
2.Farm Power	26.44		28.67	30.40	40.59		32.17	37.20
3.Manure	10.80		13.90	15.96	19.59		11.20	21.72
4. Pesticides	14.21		7.21	6.49	35.26		11.04	13.01
5. Other Costs	0.26		3.35	1.00	0.59		3.81	1.23
6. Total Cost	57.64		60.98	67.09	100.32		61.89	78.09
7. Value of Output	100		100	100	100		100	100

Table 6.5: Cost of Production in Rupees per Hectare: Overall								
Item	Bt - Cotton				Non-Bt – Cotton			
	AP	GJ	MR.	TN	AP	GJ	MR.	TN
1. Seed	3313	3079	3857	3977	1213	1324	1319	1180
2.Human Labour	9818	10827	11754	9089	8249	9587	9150	7714
3. Bullock Labour	2062	2468	1913		2024	2527	2125	
4. Tractor	1705	1042	1016	2373	1648	848	748	1734
5. Farm Yard Manure	2103	1488	0	2228	2000	1429	0	1325
6. Fertilizer	4804	3247	7116	2922	4078	3292	4086	3740
7. Pesticides	7806	2732	3242	1909	10878	3168	4120	4195
8. Irrigation	319	3818	1136	55	163	3872	474	60
9.Other Operational Costs	0	467	332	0	0	450	122	0
10.Total Operational Cost	31930	29167	30366	22553	30252	26497	22144	19948
11. Total Marketing Cost	210	576	1314	487	192	496	1181	312
12. Total Cost	32139	29743	31679	23040	30444	26993	23207	20260
Value of Output	50970	63942	54313	38282	35870	48873	37524	26032
Net Profit	18831	34199	22634	15242	5426	21880	14317	5772
Benefit-Cost Ratio	1.586	2.150	1.714	1.662	1.178	1.811	1.617	1.285
Value of Output of Bt Cotton over Non-Bt Cotton (%)	42.10	30.83	44.74	47.06				
Net Profit of Bt Cotton over Non-Bt Cotton (%)	247.05	56.07	58.09	164.07				

Table 6.6: Share of Various Costs in Total Cost and Value of Production: Overall								
Item	Bt – Cotton				Non-Bt – Cotton			
	AP	GJ	MR.	TN	AP	GJ	MR.	TN
	Percentage Share of Various Inputs in total Cost							
1. Seed	10.31	10.56	12.17	17.26	3.98	5.00	5.65	5.82
2.Farm Power	42.27	49.15	46.35	49.75	39.16	48.92	51.55	46.63
3.Manure	21.49	16.23	22.46	22.35	19.96	17.82	17.52	25.00
4. Pesticides	24.29	9.37	10.23	8.29	35.73	11.96	17.66	20.71
5. Other Inputs	1.65	14.69	8.78	2.35	1.17	16.31	7.62	1.84
6. Total Cost	100	100	100	100	100	100	100	100
	Costs as percentage of Value of Output							
1. Seed	6.50	4.82	7.10	10.39	3.38	2.71	3.52	4.53
2.Farm Power	26.65	22.42	27.03	29.94	33.23	26.52	32.04	36.29
3.Manure	13.55	7.41	13.10	13.45	16.94	9.66	10.89	19.46
4. Pesticides	15.31	4.27	5.97	4.99	30.33	6.48	10.98	16.11
5. Other Costs	1.04	6.70	5.12	1.42	0.99	8.89	4.74	1.43
6. Total Cost	63.06	46.61	58.33	60.18	84.88	54.22	62.16	77.83
7. Value of Output	100	100	100	100	100	100	100	100

Figure 6.1: Average Operating Cost (Rs./Hectare): Andhra Pradesh

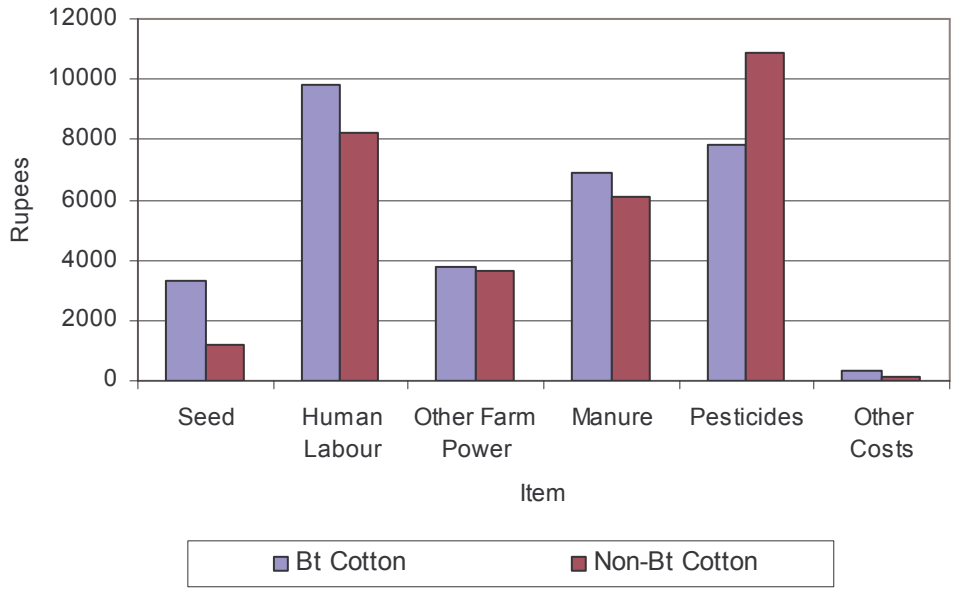


Figure 6.1: Average Operating Cost (Rs./Hectare): Andhra Pradesh

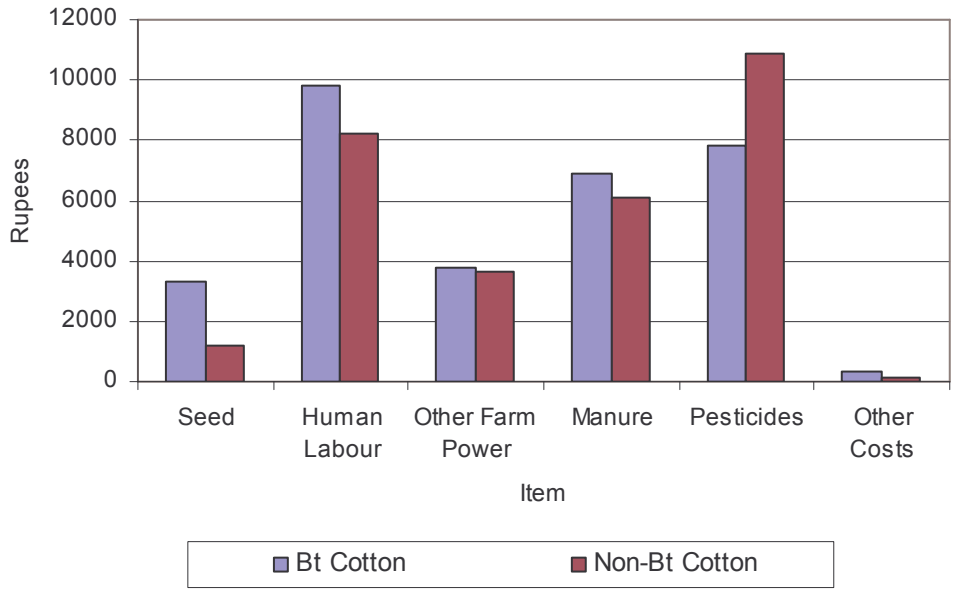


Figure 6.2: Average Operating Cost (Rs./Hectare): Gujarat

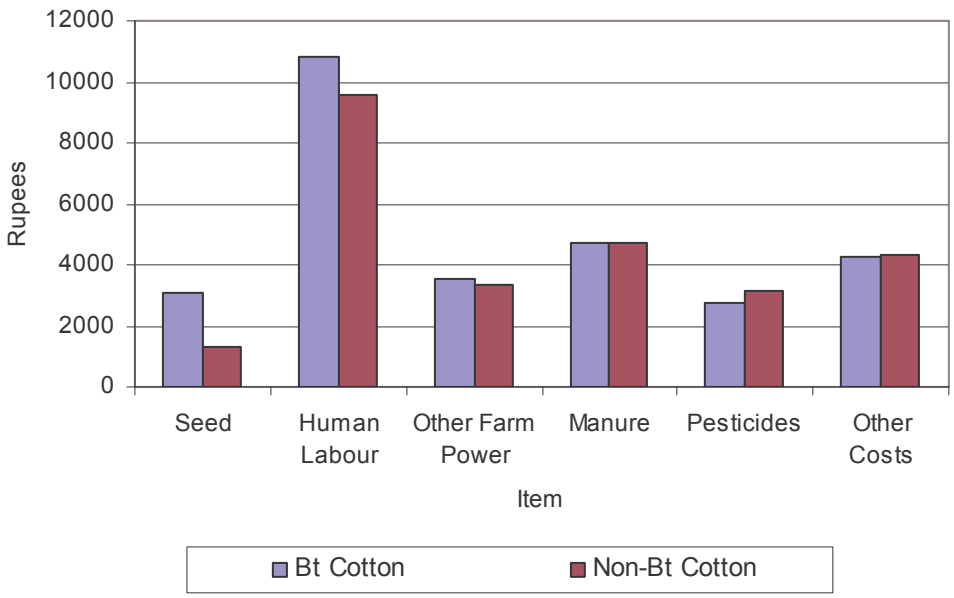
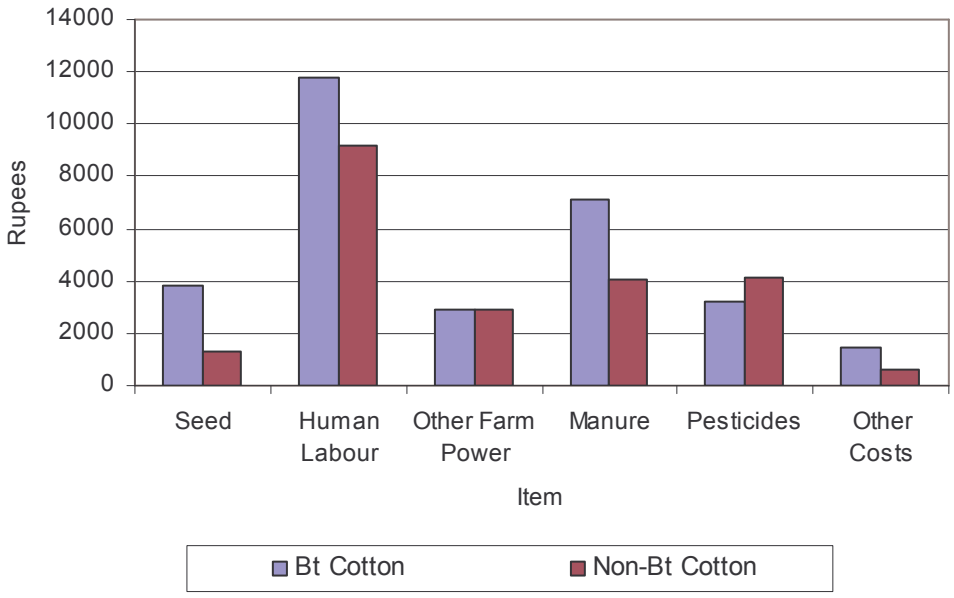


Figure 6.3 : Average Operating Cost(Rs./Hectare): Maharastra



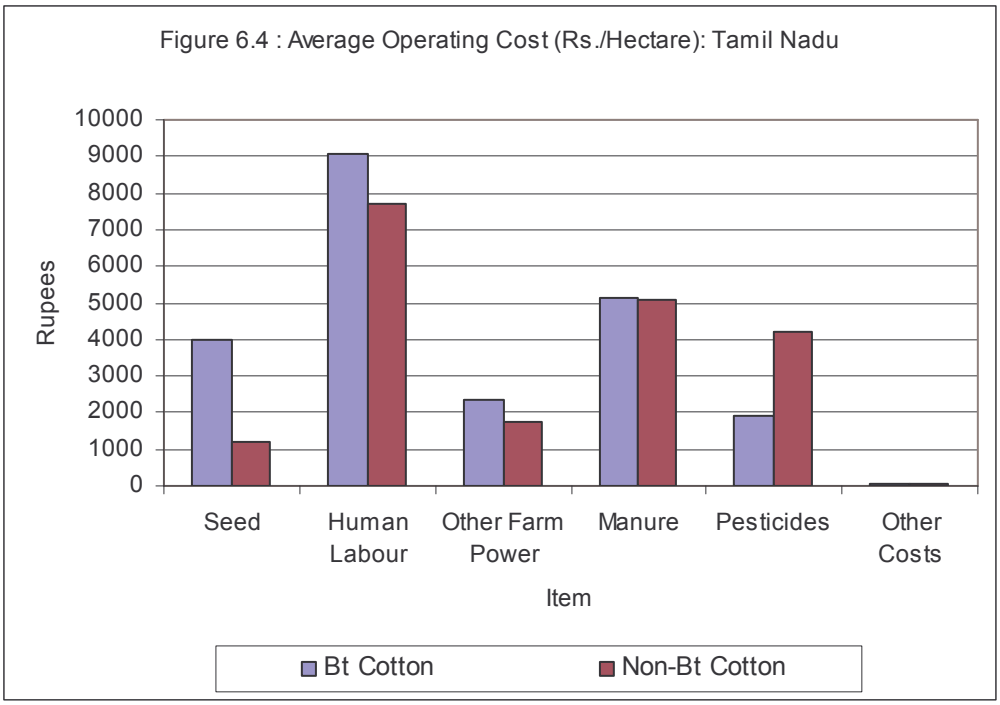


Table 6.7: Average Yield, Value of Output and Net Profit of Bt and non_Bt cotton among Sample Households

	Bt Cotton				Non-Bt Cotton				Bt over Non-Bt Cotton			
	AP	GUJ	Mah	TN	AP	GUJ	Mah	TN	AP	GUJ	Mah	TN
Yield (Kg/ha)	2944	3220	2605	1893	2490	2507	1780	1473	18.2	28.4	46.4	28.5
Value of Output (Rs/ha)	50970	63942	54313	38282	35870	48873	37524	26032	42.1	30.8	44.7	47.1
Net Profit (Rs/ha)	18831	34199	22634	15242	5426	21880	14317	5772	217.1	53.1	58.1	164.1

Figure 6.5: Average Cost of Seed per Hectare under Bt and Non-Bt Cotton

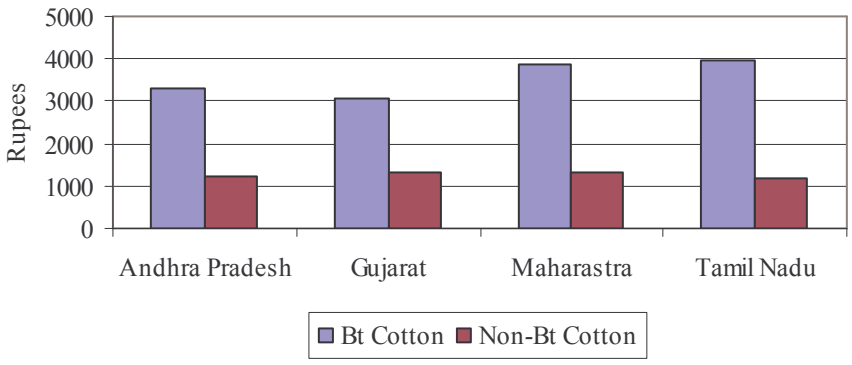


Figure 6.6: Average Cost of Pesticides Used per Hectare under Bt and Non-Bt Cotton

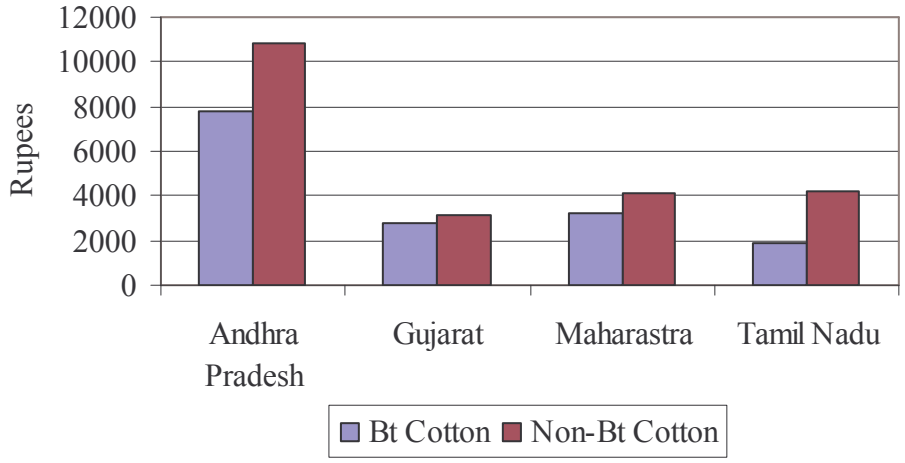


Figure 6.7: Average Cost of Cultivation per Hectare for Bt and Non-Bt Cotton

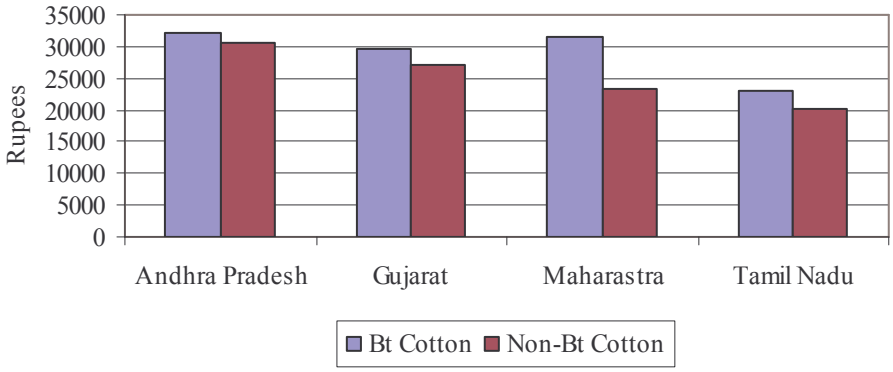
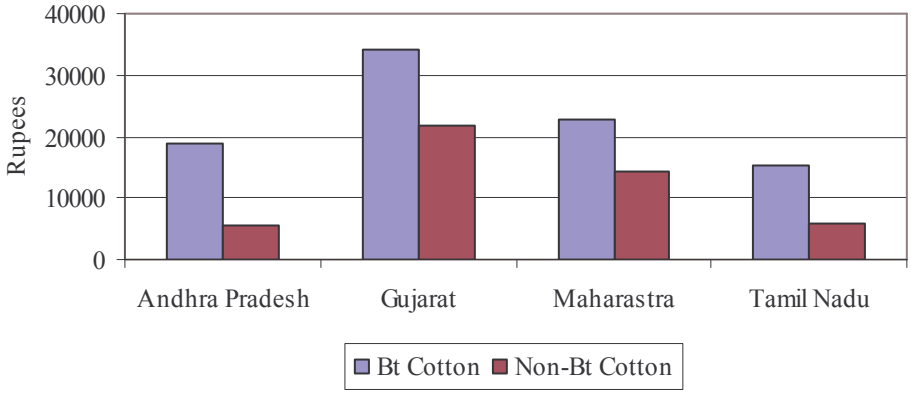


Figure 6.8: Average Net Revenue per Hectare under Bt and Non-Bt Cotton



6.3 Econometric Analysis of the Performance of Bt Cotton vs Non-Bt Cotton

Whereas many differences between Bt and non-Bt cotton have been indicated above, it is important to examine whether the differences are statistically significant, and for this purpose, econometrics analysis has been carried out. This has been first examined through a regression approach relating yield and other variables with a dummy variable of Bt cotton, which is 1 for Bt cotton and 0 for Non-Bt cotton. The results of this would be identical to that of Analysis of Variance (ANOVA). The results in Table 6.7 below indicate that Bt cotton clearly has a statistically significant impact on the yield, significant at the 99 percent level. The estimates indicate that Bt cotton yields are 30.71 percent higher. The impact of the value of output is also highly significant and estimates show that this is boosted by 33.35 percent. However, the cost also rises significantly, and this rise is estimated to be 6.69 percent. The pesticide cost is reduced by 23.98 percent, but the seed cost rises by 168.77 percent. The difference in the output price between Bt and Non-Bt cotton is positive but not statistically significant. The results indicate that the profit rise is highly significant and the increase is estimated to be 87.58 percent. The results explain the popularity of Bt cotton, at the same time, the opposition to the high seed cost.

Table 6.7 : Regression Results: Impact of Bt Cotton				
		Independent Variables		N=515
Dependent Variable		Constant	Bt	Percent Impact of Bt
Yield	Coefficient	2212.25	679.45	30.71
	t-stat	47.05	10.37	
	Signifi.	***	***	
Value of Output	Coefficient	41861	13960	33.35
	t-stat	45.2	10.81	
	Signifi.	***	***	
Total Cost	Coefficient	28066	1878.56	6.69
	t-Stat	71.5	3.43	
	Signifi.	***	***	
Pesticide Cost	Coefficient	7387.95	-1771.47	-23.98
	t-Stat	33.01	-5.68	
	Signifi.	***	***	
Seed Cost	Coefficient	1296.12	2187.41	168.77
	t-Stat	28.71	34.76	
	Signifi.	***	***	
Price	Coefficient	19.04	0.28679	1.51
	t-Stat	140.45	1.52	
	Signifi.	***	NS	
Profit	Coefficient	13795	12081	87.58
	t-Stat	16.1	10.11	
	Signifi.	***	***	
Note: *** = significant at 99 percent, ** = significant at 95 percent, * = significant at 90 percent, NS = not significant				

The performance of Bt cotton varies from state to state. The results given below indicate that in Gujarat, the positive impact on yield and value of output is greater than the combined results, but the cost increase is also greater. The reduction in the pesticide cost is somewhat lower, but the increase in the seed cost is also lower. The pesticide cost as such is considerably lower than the combined case as shown by the value of the coefficient of the constant. The price increase is statistically significant but small, and the profit increase is 73.81 percent.

Table 6.8: Regression Results: Impact of Bt Cotton - Gujarat				
		Independent Variables		N=181
Dependent Variable		Constant	Bt	Percent Impact of Bt
Yield	Coefficient	2345.25	830.89	35.43
	t-stat	28.45	7.11	
	Signifi.	***	***	
Value of Output	Coefficient	44720	17128	38.30
	t-stat	26.27	7.09	
	Signifi.	***	***	
Total Cost	Coefficient	26318	3544.30	13.47
	t-Stat	38.26	3.63	
	Signifi.	***	***	
Pesticide Cost	Coefficient	3146.69	-568.64	-18.07
	t-Stat	16.99	-2.17	
	Signifi.	***	**	
Seed Cost	Coefficient	1346	1723.95	128.08
	t-Stat	13.36	12.07	
	Signifi.	***	***	
Price	Coefficient	18.96	0.4713	2.48
	t-Stat	114.7	2.01	
	Signifi.	***	**	
Profit	Coefficient	18402	13583	73.81
	t-Stat	14.33	7.46	
	Signifi.	***	***	
Note: *** = significant at 99 percent, ** = significant at 95 percent, * = significant at 90 percent, NS = not significant				

In the case of Maharashtra, the results given below indicate that the impact on the yield and the value of output at 42.67 and 42.79 percent respectively is the highest among the three states, and the impact on the total cost is relatively low at 5.18 percent. Pesticide cost is reduced by 22.38 percent, and the profit increase is the highest at 120.08 percent. This indicates that the technology appears to be highly profitable in Maharashtra.

Table 6.9 : Regression Results: Impact of Bt Cotton - Maharashtra				
		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				

In the case of Andhra Pradesh, the impact on the yields as well as the value of outputs is the lowest at about 21.33 percent, but the rise in total cost is also lower. The fall in the pesticide cost is the highest in Andhra Pradesh at -28.17 percent, but the rise in the seed cost is also the highest at 192.53 percent. This is supportive of the fact why opposition to the seed prices may be the highest in Andhra Pradesh. The rise in the profits is statistically highly significant and amounts to a 78.18 percent, which is in between Gujarat and Maharashtra. The absolute level of profitability of cotton in Andhra Pradesh is lowest amongst the three states. Note that similar analysis could not be carried out for Tamil Nadu since observation-wise data was not available from the AERC there.

Table 6.10: Regression Results: Impact of Bt Cotton – Andhra Pradesh

		Independent Variables		N=180
Dependent Variable		Constant	Bt	Percent Impact of Bt
Yield	Coefficient	2377.73	506.89	21.32
	t-stat	29.75	4.48	
	Signifi.	***	***	
Value of Output	Coefficient	41207	8789.63	21.33
	t-stat	30	4.52	
	Signifi.	***	***	
Total Cost	Coefficient	31266	1017.42	3.25
	t-Stat	80.09	1.84	
	Signifi.	***	*	
Pesticide Cost	Coefficient	11022	-3104.41	-28.17
	t-Stat	83.45	-16.62	
	Signifi.	***	***	
Seed Cost	Coefficient	1227.94	2364.18	192.53
	t-Stat	20.47	27.87	
	Signifi.	***	***	

Price	Coefficient	17.35	0	0
	t-Stat	2975.13	0	
	Signifi.	***	NS	
Profit	Coefficient	9940.99	7772.21	78.18
	t-Stat	7.42	4.1	
	Signifi.	***	***	
Note: *** = significant at 99 percent, ** = significant at 95 percent, * = significant at 90 percent, NS = not significant				

Even though Bt appears to have a dominant effect, perhaps also pulling in other inputs to its potential to boost the profitability, the performance could be considered a function of other inputs as well. The model below relates the performance of the dependent variables to various inputs/factors including Bt, pesticide, seed, fertilizer, irrigation, and state of location, together. These results would be affected to some extent by the multicollinearity across the explanatory variables – since the inputs are associated and complementary. The results indicate that Bt alone is still statistically highly significant as a determinant of the yield, value of output and profitability. The impact on yield is estimated to be about 22 percent and the impact on profitability about 35 percent. Profit is negatively related to pesticide cost and positively related to seed cost (reflecting use of Bt seeds) and irrigation. The adverse relationship with fertilizer cost is perhaps a result of multicollinearity. The state dummies indicate that whereas profits are significantly higher in Maharashtra as compared to Gujarat, there is no statistically significant difference in the profitability between Gujarat and Andhra Pradesh.

Table 6.11: Regression Results: Impact of Bt Cotton and Other Determinants									
		Independent Variables (N=515)							
Dependent Variable		Constant	Bt	Pesticide Cost	Seed Cost	Fertilizer Cost	Irrigation Status	Maha Dummy	AP Dummy
Yield	Coefficient	1912.78	428.03	0.0318	0.1469	-0.0819	475.07	-333.41	-37.70
	t-stat	16.36	3.78	2.27	3.44	-4.43	6.22	-2.94	-0.3
	Signifi.	***	***	**	***	***	***	**	NS
Value of Output	Coefficient	35854	7568.29	0.6136	3.3843	-1.2864	8440.21	-2875.29	-6810.50
	t-stat	15.08	3.28	2.16	3.9	-3.42	5.43	-1.25	-2.67
	Signifi.	***	***	**	***	***	***	NS	***
Total Cost	Coefficient	15637	392.30	1.2683	1.6172	1.2548	1117.76	-9105.81	-6689.49
	t-stat	20.7	0.54	14.03	5.86	10.49	2.26	-12.43	-8.25
	Signifi.	***	NS	***	***	***	**	***	***
Profit	Coefficient	20217	7175.99	-0.6547	1.7671	-2.5412	7322.45	6230.52	-121.014
	t-stat	9.85	3.61	-2.67	2.36	-7.82	5.46	3.13	-0.05
	Signifi.	***	***	***	**	***	***	***	NS
Note: *** = significant at 99 percent, ** = significant at 95 percent, * = significant at 90 percent, NS = not significant									

Chapter 7

General Observations of Farmers on Different Features of Bt Cotton

This chapter is devoted to examining the general observations and perceptions of the sample farmer households growing Bt cotton on various aspects such as pest incidence, economic benefits, availability of Bt seeds, extension and information sources, environmental impact, and other features. The Bt cotton farmers were asked questions on various aspects such as input use, seed availability and quality, various farm operations, marketing of cotton fibre, and other related aspects. Since the exact format with which the opinions of the farmer households were collected was not uniform across the states, this depend on the availability of such information, and have been presented separately for each states.

7.1 Observations of Farmer Households in Andhra Pradesh

As expressed by the sample farmer households in Andhra Pradesh, the major advantages of Bt cotton over non-Bt cotton varieties were lesser need for pesticides, better yields and profits (Table 7.1). No major differences were expressed in terms of the use of inputs other than pesticides, and price of cotton. Two major disadvantages expressed by the sample households were the availability of Bt seeds and its high price.

Table 7.1: Advantages or disadvantages of Bt cotton-G *vis-à-vis* non-Bt Cotton Reported by Bt Growers in Andhra Pradesh : Percentages						
Sl.No	Particulars	Strong Advantage	Advantage	No Difference	Disadvantage	Strong Disadvantage
1	Availability of seeds	0.0	17.8	8.8	71.4	2.0
2	Seed cost/price	3.4	16.6	12.5	40.3	28.0
3	Quality of avail. Seeds	15.4	75.8	8.8	0.0	0.0
4	Pest Incidence/problem	19.0	56.7	21.3	3.5	0.0
5	Pesticide need/cost	37.0	54.4	7.6	1.0	0.0
6	Fertilizer need/cost	10.0	32.2	58.1	0.0	0.0
7	Labour need/cost	7.8	48.6	43.6	0.0	0.0
8	Machine need/cost	2.2	19.8	78.0	0.0	0.0
9	Irrigation need/cost	1.0	45.5	53.5	0.0	0.0
10	Harvesting cost	4.2	49.1	46.7	0.0	0.0
11	Cotton quality	38.0	52.2	9.8	0.0	0.0
12	Market preference	12.0	23.3	64.2	0.0	0.0
13	Staple length	19.8	74.2	4.5	1.0	0.0
14	Fibre colour	25.5	67.9	5.6	1.0	0.0
15	Cotton price	5.4	23.3	70.8	0.0	0.0
16	Easy marketing	2.2	27.6	70.2	0.0	0.0
17	By-product output	1.2	18.8	80.0	0.0	0.0
18	Yield	19.1	68.7	5.6	0.0	0.0
19	Profit	29.0	57.8	4.1	3.5	0.0
20	Livestock feeding	0.0	22.1	77.9	0.0	0.0
21	Water saving	2.2	27.8	70.0	0.0	0.0
22	Suitable for early sowing	2.2	23.3	74.5	0.0	0.0
23	Suitable for late sowing	2.2	21.2	76.6	0.0	0.0

About 57.6 percent of the sample households reported that the seed rate for Bt cotton was reduced by about 25 percent, because the seeds are very expensive. More than three-fourth of the households reported that the Bt cotton flowers earlier by 1 to 10 days that non-Bt cotton. Other major features observed were shorter plant size of Bt cotton, bigger boll size, and lesser number of pickings as compared to non-Bt cotton (Table 7.2). 96 percent of the sample households reported that Bt cotton has more resistance to boll worm attack. Over 90 percent of the sample households expressed their willingness to continue with Bt seeds considering better yields and profitability. About 10 per of the sample households expressed their unwillingness to continue with Bt cultivation due to high cost of seeds and its suitability to their land.

Table 7.2: Sample Households Opinion of Seed Rate, Flowering Date, Plant Size, Boll Size, Date of Picking etc in Andhra Pradesh (Percent Response)	
Sample Households Opinion on Seed Rate	
Seed Rate Reduced 25%	57.60
Sample Households Opinion on Flowering	
1 to 10 days early flowering	75.54
No change	24.46
Sample Households Opinion on Plant Size	
Plant Size Shorter	74.90
Plant Size Same	25.10
Sample Households Opinion on Boll Size	
Bigger Boll Size	74.80
Smaller Boll ize	11.00

Same Boll Size	14.20
Sample Households Opinion on Picking:	
No. of picking More	0.00
No. of picking less	88.70
No of picking same	11.30
Resistance of Bt Cotton to Pests	
Percentage of Households Reporting more Resistance to Boll Worm	96.80
Resistance Level Reported	
Resistance Beloq 25%	61.20
Resistance 25 to 50%	38.80
Willingness to Continue Bt Cotton Cultivations:	
Percentage of Households Reporting Willingness to continue Bt Cultivation	90.00
Why to Continue Bt Cultivation?	
Resistance to Boll Worm and Better Yield	90.00
Why not to Continue Bt Cultivation?	
High Seed Cost	10.00
Poor Performance	6.00
Bt not suitable to the area	6.00

7.2 Observations of Farmer Households in Gujarat

The sample farmer households in Gujarat expressed that the major advantages of Bt cotton over non-Bt cotton varieties were lesser need for better yields and profits, less pest incidence and pesticides cost, and suitability for early sowing (Table 7.3). No major differences were expressed in terms of the use of

inputs other than pesticides, and price of cotton. Two major disadvantages expressed by the sample households were high seed price and the availability of Bt seeds.

Table 7.3: Advantages/Disadvantages of Bt Cotton vis-à-vis Non Bt Cotton in Gujarat: Percentage of Bt Cotton Growers Reporting

Particulars	Strong Advantage	Advantage	No Difference	Disadvantage	Strong Disadvantage
1. Seed Availability	16.67	24.44	38.89	20.00	0.0
2. Seed Price	0.0	0.0	4.44	40.00	55.56
3. Pest Incidence	4.44	86.67	8.89	0.0	0.0
4. Pesticide Cost	5.56	88.89	5.56	0.0	0.0
5. Fertilizer Cost	1.11	12.22	80.00	5.56	1.11
6. Irrigation Cost	0.0	4.44	91.12	3.33	1.11
7. Labour Cost	0.0	5.56	84.44	10.00	0.0
8. Harvesting Cost	0.0	0.0	68.89	0.0	31.11
9. Fibre Quality	13.33	52.22	34.44	0.0	0.0
10. Cotton Price	15.56	24.44	58.89	1.11	0.0
11. Yield	54.44	38.89	6.67	0.0	0.0
12. Profit	52.22	42.22	5.56	0.0	0.0
13. Suitability of early sowing	21.11	68.89	10.00	0.0	0.0
14. Market Preference	17.78	18.89	63.33	0.0	0.0
15. Improvement in Village economy	8.88	88.89	2.22	0.0	0.0

7.3 Observations of Farmer Households in Maharashtra

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. Observations on the pest incidence on the crops was available from Maharashtra farmers. Table 7.4 below reports this for Maharashtra for Bt growers. For boll worms, including American, pink and spotted boll worms, no infestation is indicated by over 70 percent on Bt cotton, whereas no infestation is reported by only 2-30 percent on non-Bt cotton. Only about 4-6 percent report of moderate to heavy infestation on Bt, whereas this number is as high as 20-60 percent on non-Bt. Surprisingly, there is also a difference in the infestation by sucking and foliage feeding pests, for which the incidence is none to light in the case of Bt, whereas it is moderate to heavy in the case of non-Bt. Thus Bt cotton seems to provide considerable resistance to boll worms, and even shows resistance to other pests. A small number of farmers indicate incidence of boll worms on Bt, particularly other kinds of boll worms.

Table 7.4: 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

Other responses indicate that Bt cotton growers were not approached or pressured by private sales agents for the promotion of Bt cotton (Table 7.5). As regards the 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 7.5 : 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

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 agents/ dealers (Table 7.6). 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 from the agents was about its

superiority in terms of better profits and lesser amount of pesticides sprays, more bolls per plant, no bolls shedding etc (Table 7.7).

Table 7.6 : 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 7.7 : 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 7.8). This indicates an adjustment to the high price of seeds and their more efficient use.

Table 7.8 : 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

All the sample farmer households reported early flowering of Bt cotton compared to non-Bt cotton. About 50.6 percent 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 7.9).

Table 7.9 : 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 7.10). 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 7.10 : 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

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

7.11). 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 7.11 : 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

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 7.12). 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 7.12 : Advantages or disadvantages of Bt cotton-G vis-à-vis non-Bt Cotton Reported by Bt Cotton-Growers: Percentage - Maharashtra

		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

7.4 Observations of Sample Farmer Households from Tamil Nadu

Majority of the sample farmers households from Tamil Nadu said that the plant size of Bt cotton is shorter than non-Bt cotton but the boll size of Bt cotton is bigger. (Table 7.13). 92 percent of the sample farmers indicated that the number of pickings is same for Bt and non-Bt cotton.

Table 7.13: Attributes of Bt Cotton compared to Non-Bt Cotton: Response of Sample Households(%): Tamil Nadu	
Plant Size	
Shorter	93.4
Taller	2.2
Same	4.4
Boll Size	
Bigger	87.8
Smaller	10.0
Same	2.2
Number of Picking	
More	3.3
Less	4.4
Same	92.3

The sample farmer households were unanimous in terms of the reasons behind the adoption of Bt cotton: less boll worm attack and the crop being more remunerative compared to other crops (Table 7.14).

Table 7.14: Reason for Cultivation Bt Cotton (%): Tamil Nadu	
Less Boll Worm and less pesticides Use	100
More remunerative compared to other crops	100

Majority of the sample households did not observe any major difference in terms of the flowering time between Bt and non-Bt cotton either under irrigated or unirrigated conditions (Table 7.15). As of now, none of the sample framers had observed any adverse impact on the environment caused by the cultivation of Bt cotton (Table 7.16).

Table 7.15: Flowering of Bt Cotton as compared to Non-Bt Cotton: Farmers' Response (%):Tamil Nadu			
	Irrigated	Unirrigated	Overall
Early	6.3	8.6	7.8
No Difference	93.7	91.4	92.2

Table 7.16: Impact of Bt cotton on Environment: Tamil Nadu			
		Bt	Non-Bt
Adverse Impact on Environment observed (%)	Yes	0	0
	No	100	100

Major measures suggested by the sample households to help Bt cultivation are reduction in the seed price, guidance from extension agencies, and prevention of the sale of spurious Bt cotton seeds (Table 7.15).

Table 7.15: Measures Suggested by Farmers to Help Bt Cotton Cultivation: Tamil Nadu

	Percentage
Reduce the Price of Seed	100
Field Visit and Guidance by Extension Agencies	88
Traders should not sell spurious seeds	100

Chapter 8
Summary and Conclusions

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

8.1 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 of this. 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 over 6 million hectares in 2004 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.

8.2 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 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 after 2002-03 in the wake of Bt cotton. The estimated

production of cotton in 2004-05 was a record in the history of cotton cultivation in the country at 21.3 million bales (1 bale = 170 kilogram), and this has further risen to 22.9 million bales by 2007/08. The cotton yield from 1990-91 to 2000-01 shows an annual growth of merely 1.45 percent, but taken between 1990-91 and 2007-08, it is more than double at 3.01 percent per annum.

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.

8.3 Cotton in the Study States

Based on cotton production during the recent triennium ending 2007-08, Gujarat ranks at the top with a share of 36 percent, followed by Maharashtra with 17.8 percent and Andhra Pradesh with 13.2 percent. Tamil Nadu has a share of only 1.86 percent in the national production. Together, Gujarat, Maharashtra, Andhra Pradesh and Tamil Nadu accounted for 69 percent of the cotton production in India, in the triennium ending 2007-08. In terms of area under cotton, Maharashtra occupies the top position with a share of 33.2 percent in the

9.2 million hectares of area under cotton cultivation in the country, followed by Gujarat with 25.36 percent and Andhra Pradesh with 11.3 percent during triennium ending 2007-08. However, the average yield of cotton is among the lowest in Maharashtra at 273 Kg per hectare as against 514 kg per hectare for the country as a whole.

8.4 Data and Sampling

This study is based on the primary data collected from four states namely Andhra Pradesh, Gujarat, Maharashtra and Tamil Nadu. Effort was made to adopt similar methodology, content and survey instruments in all these states, as far as possible. Effort was made to have nearly an equal number of Bt and Non-Bt farmers in the sample. Effort was also made through stratification to cover both irrigated and unirrigated farms under Bt and non-Bt cotton, as well as small, medium and large farmers. The primary data collected pertains to the agricultural year 2004-05.

The target sample size for each state was 180 cotton farmers with 90 Bt and 90 Non-Bt farmers. Maharashtra was an exception where the coverage was 85 Bt and 69 Non-Bt farmers. The Gujarat sample did not have unirrigated cotton as a sufficient number of such farmers were not available in the sample districts. The number of sample farmer households under unirrigated Bt cotton was relatively less in Andhra Pradesh and Maharashtra, but were relatively more in Tamil Nadu. The study had an overall sample size of 694 farm households.

8.5 Varieties Grown

Many Bt and non Bt varieties were reported. The use of non-genuine Bt seeds was reported by both Gujarat and Andhra Pradesh sample households. This accounted for 56 percent of the Bt sample in Gujarat and 20 percent in Andhra Pradesh. The genuine Bt seeds that were used by the sample farmer households were of RCH and MAHYCO varieties - MECH 184, MECH 12, MECH 162, and Rasi (RCH) 2, in Andhra Pradesh and Gujarat besides the use of non-confirmed Bt seeds. While in Maharashtra both Mahyco and Rasi Bt seeds were used by the sample households, in Tamil Nadu only Rasi Bt seeds were used. A large number of non-Bt hybrid seeds were also reported among the sample households such as Bunny, Super Bunny, Brahma, Satya, Attara, JK, Tagore, Bindu, Sankar, Vikram, Navbharat-Deshi Ankur, Banny, and Ajit.

8.6 Cost of Seeds

The average cost per hectare of Bt Cotton seeds used by the sample households varied substantially across the states. It was the least in Gujarat at Rs 3079 per hectare followed by Andhra Pradesh with Rs. 3313. On an average the cost of Bt seeds per hectare was more than double than the non-Bt seeds in all the four states.

8.7 Application of Pesticides

The average number pesticides sprays as well as its cost per hectare was higher on non-Bt cotton in all the states. But the difference across states was very high. The average number of spray on non-Bt Cotton in Gujarat was 0.52, but it was as high as 3.84 in Andhra Pradesh. Similarly the cost of pesticides was

higher on non-Bt cotton by Rs. 436 per hectare in Gujarat, and Rs.2749 in Andhra Pradesh.

8.8 Yields of Bt and Non-Bt Cotton

In Andhra Pradesh the Bt yields were higher but the difference in the yield levels under irrigated and unirrigated was not consistent. The yield of Bt cotton irrigated was significantly higher in Maharashtra and Tamil Nadu. There was no consistent yield difference across farm sizes. The average yield of Bt cotton over non-Bt cotton was higher in all the states in the study and it was higher by 18.2 percent in Andhra Pradesh, 28.4 percent in Gujarat, 46.4 percent in Maharashtra and 28.5 percent in Tamil Nadu.

8.9 Cost of Production, Value of Output and Profit

The total cost of cultivation under irrigated condition was in general higher than under unirrigated conditions both for Bt and Non-Bt cotton. The cost of cultivation per hectare of Bt cotton exceeded that of non-Bt cotton in all the states and the difference was the highest in Maharashtra exceeding Rs.8250.

The average per hectare seed cost for Bt cotton was higher compared to non-Bt cotton and the difference ranged from Rs. 1600 per ha in Gujarat to over Rs. 2700 per ha in Tamil Nadu. The lower cost of Bt cotton seeds in Gujarat and Andhra Pradesh as opposed to Maharashtra and Tamil Nadu could be due to use of non-genuine Bt seeds in Gujarat and Andhra Pradesh. The share of seed cost of Bt seeds in total cost of production was about 10 to 17 percent in the selected states, whereas it varied from 4 to 6 percent for non-Bt cotton seeds

The per hectare cost of pesticides under Bt cotton varied from Rs. 2732 in Gujarat to Rs. 7806 in Andhra Pradesh. This is as against Rs. 3168 in Gujarat to Rs. 10878 in Andhra Pradesh for Non-Bt. While the share of pesticide cost in total cost of cultivation ranged from 8.29 percent in Tamil Nadu to 24.29 percent in Andhra Pradesh for Bt cotton, it varied from 11.96 per cent in Gujarat to 35.73 percent in Andhra Pradesh for non-Bt.

The value of output of Bt cotton per hectare exceeded that of non-Bt cotton by 30.84 percent in Gujarat, 42.1 per cent in Andhra Pradesh, 44.74 percent in Maharashtra and 47.06 percent in Tamil Nadu. The net profit per hectare from Bt cotton ranged from Rs.15242 in Tamil Nadu to Rs. 34199 in Gujarat as opposed to Rs. 5772 in Tamil Nadu to Rs. 21880 in Gujarat for non-Bt cotton. The Benefit-Cost Ratios of Bt cotton are higher than that of non-Bt cotton.

8.10 Results of Econometric Analysis

The results of statistical/ econometric analysis of the whole sample indicate that the positive impact of Bt cotton on the yields has strong statistically significance . It is significant at the 99 percent level and the estimates indicate that Bt cotton yields are 30.71 percent higher. The impact of the value of output is also highly significant and estimates show that this is boosted by 33.35 percent. However, the cost also rises significantly, and this rise is estimated to be 6.69 percent. The pesticide cost is reduced by 23.98 percent, but the seed cost rises by 168.77 percent. The difference in the output price between Bt and Non-Bt cotton is positive but not statistically significant. The results indicate that the profit rise is also highly significant and the increase is estimated to be 87.58

percent. The results explain the popularity of Bt cotton, at the same time, the opposition to the high seed cost.

The performance varies from state to state. The results for Gujarat indicate that the positive impact on yield and value of output is greater than the combined results, but the cost increase is also greater. The reduction in the pesticide cost is somewhat lower, but the increase in the seed cost is also lower. The price increase is statistically significant but small, and the profit increase is 73.81 percent. In the case of Maharashtra indicate that the impact on the yield and the value of output at 42.67 and 42.79 percent respectively are the highest among the three states, and the impact on the total cost is relatively low at 5.18 percent. Pesticide cost is reduced by 22.38 percent, and the profit increase is the highest at 120.08 percent.

In the case of Andhra Pradesh, the impact on the yields as well as the value of outputs is the lowest at about 21.33 percent, but the rise in total cost is also lower. The fall in the pesticide cost is the highest in Andhra Pradesh at -28.17 percent, but the rise in the seed cost is also the highest at 192.53 percent. This is supports the great opposition to the seed prices in Andhra Pradesh. The rise in the profits is statistically highly significant and amounts to a 78.18 percent, which is in between Gujarat and Maharashtra. The absolute level of profitability of cotton in Andhra Pradesh is lowest amongst the three states.

The model relating the performance to all the covered inputs/factors including Bt, pesticide, seed, fertilizer, irrigation, and state of location together, though affected by multicollinearity, indicates that Bt alone is still statistically

highly significant as a determinant of the yield, value of output and profitability. Its exclusive impact on yield is estimated to be about 22 percent and the impact on profitability about 35 percent. Profit is negatively related to pesticide cost and positively related to seed cost (reflecting use of Bt seeds) and irrigation. The results also indicate that whereas profits are significantly higher in Maharashtra as compared to Gujarat, there is no statistically significant difference in the profitability between Gujarat and Andhra Pradesh.

8.11 General Observations of Farmers

The sample farmer households of Andhra Pradesh expressed that the major advantages of Bt cotton over non-Bt cotton varieties were lesser need for pesticides, better yields, and profits. No major differences were expressed in terms of the use of inputs other than pesticides, and price of cotton. Two major disadvantages expressed by the sample households were the availability of Bt seeds and its high price. About 57.6 percent of the sample households reported that the seed rate for Bt cotton was reduced by about 25 percent, because the seeds are very expensive. Other major features observed were shorter plant size of Bt cotton, bigger boll size, and lesser number of pickings as compared to non-Bt cotton. 96 percent of the sample households reported that Bt cotton has more resistance to boll worm attack. Over 90 percent of the sample households expressed their willingness to continue with Bt seeds considering better yields and profitability. About 10 per of the sample households expressed their unwillingness to continue with Bt cultivation due to high cost of seeds and its unsuitability to their land.

The sample farmer households in Gujarat expressed that the major advantages of Bt cotton over non-Bt cotton varieties were better yields and profits, less pest incidence and pesticides cost, and suitability for early sowing . No major differences were expressed in terms of the use of inputs other than pesticides, and price of cotton. Two major disadvantages expressed by the sample households were high seed price and the availability of Bt seeds.

Observations on the pest incidence are available from the Maharashtra Bt growers. They indicate that for boll worms, including American, pink and spotted boll worms, no infestation on Bt cotton is indicated by over 70 percent of growers, whereas no infestation is reported by only 2-30 percent on non-Bt cotton. Only about 4-6 percent report moderate to heavy infestation on Bt, whereas this number is as high as 20-60 percent on non-Bt. Surprisingly, there is also a difference in the infestation by sucking and foliage feeding pests, for which the incidence is none to light in the case of Bt, whereas it is moderate to heavy in the case of non-Bt. Thus, Bt cotton appears to provide considerable resistance to boll worms, and even shows resistance for other pests.

Over 50.6 percent of the Maharashtra sample households adopted Bt seeds with the recommendation of fellow farmers, and the next major sources of information was seed company agents/ dealers. 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. The main communication from the agents was about its superiority in terms of better profits and lesser amount of pesticides sprays, more bolls per plant, no bolls shedding etc.

Other responses from Maharashtra Bt cotton growers indicate that 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. None of the Bt growers indicate having observed any adverse environmental impact as a result of the cultivation of Bt cotton. They also do not indicate any increase in the pest attack on other crops as a result of the cultivation of Bt cotton. 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.

The major advantages of Bt cotton that are expressed by majority of the Maharashtra sample farmer households were yield superiority, more profit, lesser need of pesticides, better quality, and its suitability for early sowing. On the other hand a common disadvantage expressed was the high cost of seed. Other differences expressed include higher fertilizer and irrigation cost, and higher harvest cost. No major differences were observed in other matters.

To improve the improve the use of Bt technology, the most frequent suggestion given by the Maharashtra farmers was to reduce the cost of Bt cotton seed. Other suggestions were: arranging field demonstrations, seed packages with smaller quantities, and assurance of seed quality.

Majority of the sample farmers households from Tamil Nadu said that the plant size of Bt cotton is shorter than non-Bt cotton but the boll size of Bt cotton is bigger. 92 percent of the sample farmers indicated that the number of pickings is

same for Bt and non-Bt cotton. Majority of the sample households did not observe any major difference in terms of the flowering time between Bt and non-Bt cotton either under irrigated or unirrigated conditions. None of the sample framers had observed any adverse impact on the environment caused by the cultivation of Bt cotton. Major measures suggested by the Tamil Nadu sample households to help Bt cultivation are reduction in the seed price, guidance from extension agencies, and prevention of the sale of spurious Bt cotton seeds.

Appendix

Exhibit 1: Cost of Production in Rupees per Hectare: Small Farm (I)								
Item	Bt – Cotton				Non-Bt - Cotton			
	AP	GJ	MR.	TN	AP	GJ	MR.	TN
1. Seed	3762	2875	3631	4167	1246	1229	1222	1181
2.Human Labour	9186	10348	8515	11592	8461	8802	7098	8392
3. Bullock Labour	2175	2895	2427	0	2082	2679	2433	0
4. Tractor	1796	752	958	2555	1727	611	536	1876
5. Farm Yard Manure	2242	1209	0	2819	2177	1145	0	1266
6. Fertilizer	5963	3197	5535	2568	4966	2826	2893	2673
7. Pesticides	8163	2377	2859	1991	11880	3009	4471	5279
8. Irrigation	601	4434	1520	178	429	3933	1400	151
9.Other Operational Costs	0	0	247	0	0	0	55	0
10.Total Operational Cost	33888	28087	25692	25870	32968	24234	20108	20518
11. Total Marketing Cost	224	651	572	721	212	686	645	318
12. Total Cost	34112	28738	26264	26591	33181	24920	20753	20836
Value of Output	53309	58463	49210	46324	45815	39165	36276	28713
Net Profit	19197	29725	22946	19733	12634	14245	15523	7877
Benefit-Cost Ratio	1.563	2.034	1.874	1.742	1.381	1.572	1.748	1.378
Value of Output of Bt Cotton over Non-Bt Cotton (%)	16.36	49.27	35.65	61.33				
Net Profit of Bt Cotton over Non-Bt Cotton (%)	51.95	108.67	47.82	150.51				

Exhibit 2: Cost of Production in Rupees per Hectare: Small Farm (UI)								
Item	Bt – Cotton				Non-Bt - Cotton			
	AP	GJ	MR.	TN	AP	GJ	MR.	TN
1. Seed	3362		3656	3908	1217		1299	1144
2.Human Labour	9462		9429	6905	8236		8540	7385
3. Bullock Labour	2020		1344	0	2045		1906	0
4. Tractor	1646		988	1472	1618		582	1974
5. Farm Yard Manure	1975		0	2545	1921		0	1742
6. Fertilizer	4022		6789	2428	3499		3469	910
7. Pesticides	7617		3920	2122	9617		3459	3967
8. Irrigation	0		0	0	0		0	0
9.Other Operational Costs	0		380	0	0		71	0
10.Total Operational Cost	30103		26506	20323	28153		19326	17092
11. Total Marketing Cost	134		1245	255	43		1200	294
12. Total Cost	30237		27750	20578	28196		20528	17386
Value of Output	47382		42206	25259	39543		32118	23374
Net Profit	17145		14456	4681	11347		11590	5988
Benefit-Cost Ratio	1.567		1.521	1.227	1.402		1.565	1.344
Value of Output of Bt Cotton over Non-Bt Cotton (%)	19.82		31.41	8.06				
Net Profit of Bt Cotton over Non-Bt Cotton (%)	51.10		24.73	-21.83				

Exhibit 3: Cost of Production in Rupees per Hectare: Small Farm (I+UI)								
Item	Bt - Cotton				Non-Bt - Cotton			
	AP	GJ	MR.	TN	AP	GJ	MR.	TN
1. Seed	3592	2875	3644	4013	1228	1229	1269	1160
2.Human Labour	9305	10348	8999	8802	8336	8802	7976	7828
3. Bullock Labour	2109	2895	1854	0	2061	2679	2112	0
4. Tractor	1732	752	974	2506	1664	611	564	1931
5. Farm Yard Manure	2127	1209	0	2623	2029	1145	0	1532
6. Fertilizer	5129	3197	6199	2782	4126	2826	3244	1790
7. Pesticides	7932	2377	3421	2069	10555	3009	3855	4608
8. Irrigation	341	4434	715	72	185	3933	548	69
9.Other Operational Costs	0	0	317	0	0	0	65	0
10.Total Operational Cost	32265	28087	26123	22867	30183	24234	19632	18915
11. Total Marketing Cost	186	651	928	444	111	686	983	305
12. Total Cost	32451	28738	27051	23311	30294	24920	20616	19220
Value of Output	50872	58463	45502	33791	41930	39165	33745	25254
Net Profit	18421	29725	18451	10480	11636	14245	13129	6034
Benefit-Cost Ratio	1.568	2.034	1.682	1.450	1.384	1.572	1.637	1.314
Value of Output of Bt Cotton over Non-Bt Cotton (%)	21.33	49.27	34.84	33.80				
Net Profit of Bt Cotton over Non-Bt Cotton (%)	58.31	108.67	40.54	73.68				

Exhibit 4: Cost of Production in Rupees per Hectare: Medium Farm (I)								
Item	Bt - Cotton				Non-Bt - Cotton			
	AP	GJ	MR.	TN	AP	GJ	MR.	TN
1. Seed	3440	3437	3800	4041	1221	1360	1200	1219
2.Human Labour	9384	11532	10998	10910	8787	9856	9513	8359
3. Bullock Labour	2124	2503	1752		2065	2457	2506	
4. Tractor	1799	1202	1183	2477	1689	844	1597	1936
5. Farm Yard Manure	2210	1570		2595	2107	1803		1307
6. Fertilizer	5594	3464	7122	3248	4560	3315	4095	4823
7. Pesticides	8071	2565	2626	1913	11883	3194	4074	5439
8. Irrigation	572	4716	1935	104	315	4175	1620	96
9.Other Operational Costs	0	0	300		0	0	346	
10.Total Operational Cost	33193	30989	29716	25288	32626	27004	24951	23179
11. Total Marketing Cost	333	644	1245	890	111	493	841	441
12. Total Cost	33526	31634	30959	26178	32738	27498	25791	23620
Value of Output	55344	66859	56160	46207	46620	48305	39158	29120
Net Profit	21818	35225	25201	20029	13882	20807	13367	5500
Benefit-Cost Ratio	1.651	2.114	1.814	1.765	1.424	1.757	1.518	1.233
Value of Output of Bt Cotton over Non-Bt Cotton (%)	18.71	38.41	43.42	58.68				
Net Profit of Bt Cotton over Non-Bt Cotton (%)	57.17	69.29	88.53	264.16				

Exhibit 5: Cost of Production in Rupees per Hectare: Medium Farm (UI)								
Item	Bt - Cotton				Non-Bt - Cotton			
	AP	GJ	MR.	TN	AP	GJ	MR.	TN
1. Seed	3344		4338	3998	1221	1360	1200	1219
2.Human Labour	10663		11810	6975	8787	9856	9513	8359
3. Bullock Labour	1965		2158		2065	2457	2506	
4. Tractor	1614		1019	2146	1689	844	1597	1936
5. Farm Yard Manure	1956			1668	2107	1803		1307
6. Fertilizer	3623		6589	2815	4560	3315	4095	4823
7. Pesticides	7522		3637	1880	11883	3194	4074	5439
8. Irrigation	0		0	0	315	4175	1620	96
9.Other Operational Costs	0		310		0	0	346	
10.Total Operational Cost	30688		29861	19482	32626	27004	24951	23179
11. Total Marketing Cost	122		1282	278	111	493	841	441
12. Total Cost	30809		31142	19760	32738	27498	25791	23620
Value of Output	57736		47955	35915	46620	48305	39158	29120
Net Profit	26927		16813	16155	13882	20807	13367	5500
Benefit-Cost Ratio	1.874		1.540	1.818	1.424	1.757	1.518	1.233
Value of Output of Bt Cotton over Non-Bt Cotton (%)	55.73		29.29	50.81				
Net Profit of Bt Cotton over Non-Bt Cotton (%)	194.28		22.94	179.98				

Exhibit 6: Cost of Production in Rupees per Hectare: Medium Farm (I+UI)								
Item	Bt - Cotton				Non-Bt - Cotton			
	AP	GJ	MR.	TN	AP	GJ	MR.	TN
1. Seed	3387	3437	4011	4022	1217	1360	1319	1137
2.Human Labour	10053	11532	11316	9173	7973	9856	9234	7666
3. Bullock Labour	2034	2503	1911		2052	2457	2344	
4. Tractor	1695	1202	1119	2331	1683	844	828	1540
5. Farm Yard Manure	2064	1570	0	2186	2015	1803	0	1220
6. Fertilizer	4482	3464	6913	3057	4139	3315	4570	4242
7. Pesticides	7754	2565	3022	1898	10784	3194	3998	4226
8. Irrigation	245	4716	1178	58	156	4175	450	48
9.Other Operational Costs	0	0	304		0	0	137	
10.Total Operational Cost	31715	30989	29773	22725	30019	27004	22880	20079
11. Total Marketing Cost	194	644	1259	619	210	493	1194	412
12. Total Cost	31909	31634	31031	23344	30229	27498	24074	20491
Value of Output	56314	66859	52949	41664	41547	48305	37664	26098
Net Profit	24405	35225	21918	18320	11318	20807	13590	5607
Benefit-Cost Ratio	1.765	2.114	1.706	1.785	1.374	1.757	1.565	1.274
Value of Output of Bt Cotton over Non-Bt Cotton (%)	35.54	38.41	40.58	59.64				
Net Profit of Bt Cotton over Non-Bt Cotton (%)	115.63	69.29	61.28	226.73				

Exhibit 7: Cost of Production in Rupees per Hectare: Large Farm (I)								
Item	Bt - Cotton				Non-Bt - Cotton			
	AP	GJ	MR.	TN	AP	GJ	MR.	TN
1. Seed	3334	3119	3808	3883	1244	1437	1293	1203
2.Human Labour	8936	10553	13244	10995	8943	9620	10840	8292
3. Bullock Labour	2132	2348	2010		2035	2496	2900	
4. Tractor	1813	1091	984	2404	1662	851	738	1779
5. Farm Yard Manure	2288	1537		2372	2078	1444		2224
6. Fertilizer	6054	3037	7741	2768	4476	2953	4259	3077
7. Pesticides	8140	3108	3127	1807	12053	3420	4014	5214
8. Irrigation	724	4278	2203	164	293	4759	1710	120
9.Other Operational Costs	0	0	390	0	0	0	388	0
10.Total Operational Cost	33422	29071	33507	24393	32785	26980	26142	21909
11. Total Marketing Cost	312		1141	36	375		741	78
12. Total Cost	33734	29610	35006	24742	33160	27459	27200	22171
Value of Output	42473	61870	60333	44551	50437	50761	42309	29971
Net Profit	8739	32260	25327	19809	17277	23302	15109	7800
Benefit-Cost Ratio	1.259	2.089	1.724	1.801	1.521	1.849	1.555	1.352
Value of Output of Bt Cotton over Non-Bt Cotton (%)	-15.79	21.88	42.60	48.65				
Net Profit of Bt Cotton over Non-Bt Cotton (%)	-49.42	38.44	67.63	153.96				

Exhibit 8: Cost of Production in Rupees per Hectare: Large Farm (UI)								
Item	Bt - Cotton				Non-Bt - Cotton			
	AP	GJ	MR.	TN	AP	GJ	MR.	TN
1. Seed	2896		3932	3915	1217		1383	1235
2.Human Labour	10596		12712	6404	8270		9801	6592
3. Bullock Labour	1964		1835		1997		1694	
4. Tractor	1587		975	2200	1618		885	1674
5. Farm Yard Manure	1939			1379	1931			1177
6. Fertilizer	3732		7327	3004	3612		4150	4573
7. Pesticides	7452		3504	1795	10516		4548	2283
8. Irrigation	0		0		0		0	
9.Other Operational Costs	0		299	0	0		82	0
10.Total Operational Cost	30165		30584	18697	29161		22543	17534
11. Total Marketing Cost	198		1131	163	130		1059	56
12. Total Cost	30364		32053	19068	29291		23969	17742
Value of Output	50878		55609	26494	42831		39948	23679
Net Profit	20514		23556	7426	13540		15979	5937
Benefit-Cost Ratio	1.676		1.735	1.389	1.462		1.667	1.335
Value of Output of Bt Cotton over Non-Bt Cotton (%)	18.79		39.20	11.89				
Net Profit of Bt Cotton over Non-Bt Cotton (%)	51.51		47.42	25.08				

Exhibit 9: Cost of Production in Rupees per Hectare: Large Farm (I+UI)								
Item	Bt - Cotton				Non-Bt - Cotton			
	AP	GJ	MR.	TN	AP	GJ	MR.	TN
1. Seed	3100	3119	3860	3896	1209	1437	1361	1223
2.Human Labour	9967	10553	13019	9203	8509	9620	10061	7402
3. Bullock Labour	2044	2348	1936		1978	2496	1996	
4. Tractor	1700	1091	980	2324	1608	851	848	1711
5. Farm Yard Manure	2122	1537	0	1984	1969	1444	0	1700
6. Fertilizer	4884	3037	7566	2860	3960	2953	4177	3820
7. Pesticides	7782	3108	3286	1802	11123	3420	4415	3748
8. Irrigation	378	4278	1273	100	143	4759	428	65
9.Other Operational Costs	0	0	352	0	0	0	159	0
10.Total Operational Cost	31976	29071	32273	22169	30498	26980	23443	19669
11. Total Marketing Cost	251		1137	86	240		980	69
12. Total Cost	32227	29610	33759	22527	30738	27459	24777	19907
Value of Output	46103	61870	58338	37502	46136	50761	40538	26717
Net Profit	13876	32260	24579	14975	15398	23302	15761	6810
Benefit-Cost Ratio	1.431	2.089	1.728	1.665	1.501	1.849	1.636	1.342
Value of Output of Bt Cotton over Non-Bt Cotton (%)	-0.07	21.88	43.91	40.37				
Net Profit of Bt Cotton over Non-Bt Cotton (%)	-9.88	38.44	55.95	119.90				

Exhibit 10: Share of Various Costs in Total Cost and Value of Production: Small Farm (I)								
Item	Bt – Cotton				Non-Bt - Cotton			
	AP	GJ	MR.	TN	AP	GJ	MR.	TN
	Percentage Share of Various Inputs in total Cost							
1. Seed	11.03	10.00	13.83	15.67	3.76	4.93	5.89	5.59
2.Farm Power	38.57	48.70	45.31	53.20	36.98	48.52	48.51	48.58
3.Manure	24.05	15.33	21.07	20.26	21.53	15.93	13.94	18.64
4. Pesticides	23.93	8.27	10.89	7.49	35.80	12.07	21.54	24.98
5. Other Inputs	2.42	17.69	8.91	3.38	1.93	18.54	10.12	2.22
6. Total Cost	100	100	100	100	100	100	100	100
	Costs as percentage of Value of Output							
1. Seed	7.06	4.92	7.38	9.00	2.72	3.14	3.37	4.11
2.Farm Power	24.68	23.94	24.18	30.54	26.78	30.87	27.75	35.76
3.Manure	15.39	7.54	11.25	11.63	15.59	10.14	7.97	13.72
4. Pesticides	15.31	4.07	5.81	4.30	25.93	7.68	12.32	18.39
5. Other Costs	1.55	8.70	4.75	1.94	1.40	11.79	5.79	1.63
6. Total Cost	63.99	49.16	53.37	57.40	72.42	63.63	57.21	73.61
7. Value of Output	100	100	100	100	100	100	100	100

Exhibit 11: Share of Various Costs in Total Cost and Value of Production: Small Farm (UI)								
Item	Bt – Cotton				Non-Bt – Cotton			
	AP	GJ	MR.	TN	AP	GJ	MR.	TN
	Percentage Share of Various Inputs in total Cost							
1. Seed	11.12		13.17	19.90	4.32		6.33	6.57
2.Farm Power	43.42		42.38	42.66	42.20		53.73	53.74
3.Manure	19.83		24.46	25.33	19.22		16.90	15.23
4. Pesticides	25.19		14.13	10.81	34.11		16.85	22.78
5. Other Inputs	0.44		5.86	1.30	0.15		6.19	1.69
6. Total Cost	100		100	100	100		100	100
	Costs as percentage of Value of Output							
1. Seed	7.10		8.66	15.47	3.08		4.04	4.89
2.Farm Power	27.71		27.87	33.16	30.09		34.34	40.04
3.Manure	12.66		16.09	19.69	13.71		10.80	11.35
4. Pesticides	16.08		9.29	8.40	24.32		10.77	16.97
5. Other Costs	0.28		3.85	1.01	0.11		3.96	1.26
6. Total Cost	63.82		65.75	77.73	71.30		63.91	74.51
7. Value of Output	100		100	100	100		100	100

Exhibit 12: Share of Various Costs in Total Cost and Value of Production: Small Farm (I+UI)								
Item	Bt – Cotton				Non-Bt – Cotton			
	AP	GJ	MR.	TN	AP	GJ	MR.	TN
	Percentage Share of Various Inputs in total Cost							
1. Seed	11.07	10.00	13.47	17.22	4.05	4.93	6.16	6.03
2.Farm Power	40.51	48.70	43.72	48.51	39.81	48.52	51.67	50.77
3.Manure	22.36	15.33	22.92	23.19	20.32	15.93	15.74	17.28
4. Pesticides	24.44	8.27	12.65	8.88	34.84	12.07	18.70	23.97
5. Other Inputs	1.62	17.69	7.25	2.21	0.98	18.54	7.74	1.95
6. Total Cost	100	100	100	100	100	100	100	100
	Costs as percentage of Value of Output							
1. Seed	7.06	4.92	8.01	11.88	2.93	3.14	3.76	4.59
2.Farm Power	25.84	23.94	25.99	33.46	28.76	30.87	31.57	38.64
3.Manure	14.26	7.54	13.62	16.00	14.68	10.14	9.61	13.15
4. Pesticides	15.59	4.07	7.52	6.12	25.17	7.68	11.42	18.25
5. Other Costs	1.04	8.70	4.31	1.53	0.71	11.79	4.73	1.48
6. Total Cost	63.79	49.16	59.45	68.99	72.25	63.63	61.09	76.12
7. Value of Output	100	100	100	100	100	100	100	100

Exhibit 13: Share of Various Costs in Total Cost and Value of Production: Medium Farm (I)								
Item	Bt – Cotton				Non-Bt - Cotton			
	AP	GJ	MR.	TN	AP	GJ	MR.	TN
	Percentage Share of Various Inputs in total Cost							
1. Seed	10.26	10.87	12.27	15.44	3.73	4.95	4.65	5.16
2.Farm Power	39.69	48.17	45.00	51.14	38.31	47.85	52.79	43.59
3.Manure	23.28	15.91	23.00	22.32	20.36	18.61	15.88	25.95
4. Pesticides	24.07	8.11	8.48	7.31	36.30	11.62	15.80	23.03
5. Other Inputs	2.70	16.94	11.24	3.80	1.30	16.98	10.88	2.27
6. Total Cost	100	100	100	100	100	100	100	100
	Costs as percentage of Value of Output							
1. Seed	6.22	5.14	6.77	8.75	2.62	2.82	3.06	4.19
2.Farm Power	24.04	22.79	24.81	28.97	26.90	27.24	34.77	35.35
3.Manure	14.10	7.53	12.68	12.65	14.30	10.60	10.46	21.05
4. Pesticides	14.58	3.84	4.68	4.14	25.49	6.61	10.40	18.68
5. Other Costs	1.64	8.02	6.20	2.15	0.91	9.66	7.17	1.84
6. Total Cost	60.58	47.31	55.13	56.65	70.22	56.92	65.87	81.11
7. Value of Output	100	100	100	100	100	100	100	100

Exhibit 14: Share of Various Costs in Total Cost and Value of Production: Medium Farm (UI)								
Item	Bt – Cotton				Non-Bt - Cotton			
	AP	GJ	MR.	TN	AP	GJ	MR.	TN
	Percentage Share of Various Inputs in total Cost							
1. Seed	10.85		13.93	20.23	4.34		5.83	6.58
2.Farm Power	46.23		48.12	46.16	39.33		50.99	51.21
3.Manure	18.11		21.16	22.69	20.23		20.30	22.22
4. Pesticides	24.41		11.68	9.51	35.06		16.95	17.59
5. Other Inputs	0.40		5.11	1.41	1.03		5.92	2.41
6. Total Cost	100		100	100	100		100	100
	Costs as percentage of Value of Output							
1. Seed	5.79		9.05	11.13	3.27		3.68	4.72
2.Farm Power	24.67		31.25	25.40	29.62		32.19	36.71
3.Manure	9.66		13.74	12.48	15.24		12.81	15.93
4. Pesticides	13.03		7.58	5.23	26.41		10.70	12.61
5. Other Costs	0.21		3.32	0.77	0.77		3.74	1.73
6. Total Cost	53.36		64.94	55.02	75.31		63.12	71.70
7. Value of Output	100		100	100	100		100	100

Exhibit15: Share of Various Costs in Total Cost and Value of Production: Medium Farm (I+UI)								
Item	Bt – Cotton				Non-Bt – Cotton			
	AP	GJ	MR.	TN	AP	GJ	MR.	TN
	Percentage Share of Various Inputs in total Cost							
1. Seed	10.61	10.87	12.92	17.23	4.03	4.95	5.48	5.55
2.Farm Power	43.19	48.17	46.23	49.28	38.73	47.85	51.53	44.93
3.Manure	20.52	15.91	22.28	22.46	20.36	18.61	18.98	26.66
4. Pesticides	24.30	8.11	9.74	8.13	35.67	11.62	16.61	20.62
5. Other Inputs	1.38	16.94	8.83	2.90	1.21	16.98	7.40	2.24
6. Total Cost	100	100	100	100	100	100	100	100
	Costs as percentage of Value of Output							
1. Seed	6.01	5.14	7.58	9.65	2.93	2.82	3.50	4.36
2.Farm Power	24.47	22.79	27.09	27.61	28.18	27.24	32.94	35.27
3.Manure	11.62	7.53	13.06	12.58	14.81	10.60	12.13	20.93
4. Pesticides	13.77	3.84	5.71	4.56	25.96	6.61	10.61	16.19
5. Other Costs	0.78	8.02	5.18	1.62	0.88	9.66	4.73	1.76
6. Total Cost	56.66	47.31	58.61	56.03	72.76	56.92	63.92	78.52
7. Value of Output	100	100	100	100	100	100	100	100

Exhibit 16: Share of Various Costs in Total Cost and Value of Production: Large Farm (I)								
Item	Bt – Cotton				Non-Bt – Cotton			
	AP	GJ	MR.	TN	AP	GJ	MR.	TN
	Percentage Share of Various Inputs in total Cost							
1. Seed	9.88	10.73	10.99	15.90	3.75	5.33	4.81	5.47
2.Farm Power	38.19	48.13	46.87	54.85	38.12	48.06	53.86	45.80
3.Manure	24.73	15.73	22.34	21.04	19.77	16.30	15.84	24.11
4. Pesticides	24.13	10.69	9.03	7.40	36.35	12.68	14.93	23.71
5. Other Inputs	3.07	14.72	10.78	0.82	2.01	17.64	10.56	0.90
6. Total Cost	100	100	100	100	100	100	100	100
	Costs as percentage of Value of Output							
1. Seed	7.85	5.04	6.31	8.72	2.47	2.83	3.06	4.01
2.Farm Power	30.33	22.62	26.91	30.08	25.06	25.55	34.22	33.60
3.Manure	19.64	7.39	12.83	11.54	12.99	8.66	10.07	17.69
4. Pesticides	19.17	5.02	5.18	4.06	23.90	6.74	9.49	17.40
5. Other Costs	2.44	6.91	6.19	0.45	1.32	9.38	6.71	0.66
6. Total Cost	79.42	46.99	57.43	54.83	65.74	53.15	63.54	73.36
7. Value of Output	100	100	100	100	100	100	100	100

Exhibit 17 Share of Various Costs in Total Cost and Value of Production: Large Farm (UI)								
Item	Bt – Cotton				Non-Bt – Cotton			
	AP	GJ	MR.	TN	AP	GJ	MR.	TN
	Percentage Share of Various Inputs in total Cost							
1. Seed	9.54		12.40	20.76	4.15		5.86	7.02
2.Farm Power	46.59		48.94	45.62	40.58		52.45	46.99
3.Manure	18.68		23.10	23.24	18.92		17.58	32.69
4. Pesticides	24.54		11.05	9.52	35.90		19.27	12.98
5. Other Inputs	0.65		4.51	0.86	0.44		4.83	0.32
6. Total Cost	100		100	100	100		100	100
	Costs as percentage of Value of Output							
1. Seed	5.69		7.07	14.78	2.84		3.46	5.22
2.Farm Power	27.81		27.91	32.48	27.75		30.99	34.91
3.Manure	11.15		13.18	16.54	12.94		10.39	24.28
4. Pesticides	14.65		6.30	6.78	24.55		11.38	9.64
5. Other Costs	0.39		2.57	0.62	0.30		2.86	0.24
6. Total Cost	59.68		57.03	71.19	68.39		59.08	74.29
7. Value of Output	100		100	100	100		100	100

Exhibit 18: Share of Various Costs in Total Cost and Value of Production: Large Farm (I+UI)								
Item	Bt – Cotton				Non-Bt – Cotton			
	AP	GJ	MR.	TN	AP	GJ	MR.	TN
	Percentage Share of Various Inputs in total Cost							
1. Seed	9.62	10.73	11.55	17.51	3.93	5.33	5.57	6.20
2.Farm Power	42.54	48.13	47.70	51.80	39.35	48.06	52.84	46.17
3.Manure	21.74	15.73	22.65	21.77	19.29	16.30	17.10	27.97
4. Pesticides	24.15	10.69	9.84	8.10	36.19	12.68	18.08	18.99
5. Other Inputs	1.95	14.72	8.27	0.84	1.25	17.64	6.42	0.68
6. Total Cost	100	100	100	100	100	100	100	100
	Costs as percentage of Value of Output							
1. Seed	6.72	5.04	6.62	10.39	2.62	2.83	3.36	4.58
2.Farm Power	29.74	22.62	27.31	30.74	26.22	25.55	31.83	34.11
3.Manure	15.20	7.39	12.97	12.92	12.85	8.66	10.30	20.66
4. Pesticides	16.88	5.02	5.63	4.81	24.11	6.74	10.89	14.03
5. Other Costs	1.36	6.91	4.73	0.50	0.83	9.38	3.87	0.50
6. Total Cost	69.90	46.99	57.27	59.34	66.63	53.15	60.25	73.88
7. Value of Output	100	100	100	100	100	100	100	100

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Annexure I & II

Action Taken and Response to the Reviewer's Comments on the Report "Economics of Bt Cotton vis-à-vis Non-Bt Cotton in India: A Study Across Four Major Cotton Growing States"

Comment	Action Taken/ Response
1. Though Bt cotton is being cultivated in India now for more than 10 years, controversies related to Bt cotton continue. These controversies are not essentially on the issue of bio-safety and similar environment related concerns that are subjective in nature. Often the basic premises of Bt technology like its potential to increase the yield and reduce the cost of pesticide, are contested. In order to answer few of these questions studies have been undertaken in the states of Andhra Pradesh, Gujarat, Maharasthra, and Tamil Nadu by the respective AERCs. The report under review is a synthesis of above studies.	Noted.
2. In order to analyze comparative economics of Bt and non-Bt cotton the present study adopts with and without approach. The study is based on primary data collected from farmers in the states of Andhra Pradesh, Gujarat, Maharashtra and Tamil Nadu. The multi-stage stratified random sampling method to select farmers takes not of important factors that influence economics of cotton. Survey period for the above study was 2004-05. Regression analysis was conducted to assess effect of Bt cotton on productivity, costs, price and profitability of cotton. This also attempts to segregate the influence of states on above parameters. Though methodology adopted are sufficient to meet the objectives of the present study. The researcher may compute Benefit-cost ratios in alternate technologies (Bt and non-Bt) since cost of production and return to farmers is reported to have been increasing simultaneously with the adoption of Bt cotton.	Noted. Benefit-Cost Ratios have been calculated and have been added in all the relevant Tables in the report, and reference to the Benefit-Cost Ratios has been added in the text, the conclusions and the executive summary.

Comment	Action Taken/ Response
3. The study under review is a synthesis of results on comparative profitability of Bt and non-Bt cotton in Andhra Pradesh, Gujarat, Maharashtra and Tamil Nadu. The findings from these studies provide sufficient evidences on different questions related to cultivation of Bt and non-Bt cotton in India. The study also provides some evidences on environment related concerns of the Bt cotton.	Noted.
4. The study under review is acceptable in the existing form.	Noted.