Comparative Analysis of the Economics of Bt and Non-Bt Cotton Production

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Comparative Analysis of the Economics of Bt and Non-Bt Cotton Production

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List of Abbreviations

AP	Andhra Pradesh
APAARI	Asia-Pacific Association of Agricultural Research Institutions
APMC	Agricultural Production and Market Committee
Bt	Bacillus thuringensis
EU	European Union
DBT	Department of Biotechnology
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GEAC	Genetic Engineering Approval Committee
ICAC	International Cotton Advisory Committee
ICAR	Indian Committee for Agricultural Research
INR	Indian Rupee
IPCS	International Programme on Chemical Safety
IPM	Integrated Pest Management
MAHYCO	Maharashtra Hybrid Seeds Company
NBRI	National Botanical Research Institute
Non - Bt	Non-Bt Cotton
NGO	Non Governmental Organization
ToF	Training of Facilitators
UAS	University of Agricultural Science Dharwad

Conversion Table

1 Hectare (ha)	= 2.47 Acre
1 Quintal	= 100 kg
1 Bale	= 170 kg
1 US Dollar (US$)	= 47 Rupees (INR)

Preface

Biotechnology has rapidly and overwhelmingly entered agriculture in the USA and some other countries. Most biotechnology applications that are today in farmers' fields are in the area of crop protection, expressing herbicide tolerance and insect resistance. In developing countries, Bt cotton was introduced in China in the mid nineties and since then the area planted with transgenic cotton has rapidly expanded. Initial economic analysis indicated considerable economic benefits from this technology. Studies that compared adopters of Bt cotton varieties with non-adopters found higher yields and lower pesticide use. The results have raised great expectations regarding the contribution of biotechnology to rural poverty reduction. In India, the government was initially reluctant to approve the commercial use of Bt varieties because civil society organisations raised concerns about possible negative environmental effects of Bt cotton. Nevertheless, commercial planting was approved in the 2002/2003 season.

While the debate on the environmental risks of the Bt technology continues, the question of economic benefits has received less attention. No ex-ante economic analysis was conducted in India prior to the commercialisation of Bt varieties. In an article published in *Science* in 2003, Matin Qaim and David Zilberman presented an analysis that investigated yield and pesticide use effects of Bt cotton on the basis of experimental data. Their conclusions were highly optimistic. Economic calculations based on these data predicted a very rapid uptake of Bt cotton in India. It was expected that by 2005 already 70 % of the cotton area in India would be planted with Bt varieties.

The rationale for this study was to assess the actual technology adoption process based on data from farmers´ fields. Input and output information was collected from farmers who had purchased the new cotton varieties and farmers who continued to use conventional ones. This study by Jana Orphal is thus most useful for providing researchers and regulators with valuable information about institutional conditions, the technology transfer process, the expectations and the actual performance of the new technology given farmers' constraints in terms of physical, financial and human resources.

The results ultimately tend to support the observation that whenever a new technology is introduced, not only is there a tendency to exaggerate its risks and therefore its external costs, but the same may also be true for its benefits. Therefore economists should continue to study and identify the conditions under which agro-biotechnology can be of maximum benefit to producers, consumers and future generations.

Hannover and Bangkok, January 2005 Hermann Waibel

Gerd Walter-Echols

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Jana Orphal

January 2005

Summar y

This study on the economics of Bt cotton in the state of Karnataka was conducted during the first year of commercial introduction of Bt cotton in India. It is based on a survey of 100 farmers in the 2002/2003 cropping season that included farmers that had purchased Bt cotton and others who planted conventional, non-transgenic varieties. Simple statistical and economic analyses have been carried out in order to derive baseline information for an early impact assessment of Bt crops in developing countries. Comparisons were made across farms for farmers who planted Bt and those who planted non-Bt cotton varieties. In addition, pair wise on-farm comparisons were made of farmers who had planted both types of cotton.

Although the sample size was small and in this very early phase the access to Bt seed was still limited, a number of important observations can be made. Firstly, there seemed to have been a lack of knowledge regarding the true biological characteristics of Bt cotton among farmers and extension agents. Many farmers simply assumed that Bt cotton was a high yielding variety that would not need any pesticides. Secondly, farmers listed the high costs of seed as a major disadvantage. Seed company agents, which were found to be the major source of information justified high Bt seed costs with high yield promises. Thirdly, the economic analysis showed that the economic advantage of Bt cotton depends on the agronomic conditions. While the gross margin for Bt was higher although not statistically significant if farmers had good access to irrigation the opposite was true for cotton production under rain fed conditions. Fourthly, pesticide costs were not the major cost item and the difference in seed cost between Bt and non-Bt was higher than the difference in pesticide cost. Hence, during years with low bollworm attack planting of Bt varieties can be a costly prophylactic pest control treatment that can reduce farmer's ability to cope with different pests later in the season.

The conclusion of the study is that Bt is an additional option of cotton pest management also for developing countries. The benefits of the technology depend on the institutional and ecological conditions of the adopters. While some prospects seem to exist for irrigated areas, under rain fed conditions, which is about two thirds of the cotton area in India, Bt can be an expensive and inflexible pest management tool. Given the constraints that were found in the state of Karnataka one should perhaps not be too optimistic on the potential of Bt crops to sustainably solve pest management problems in cotton especially in developing countries. Yield differences do not always translate into differences in profit and the actual reduction in pesticide

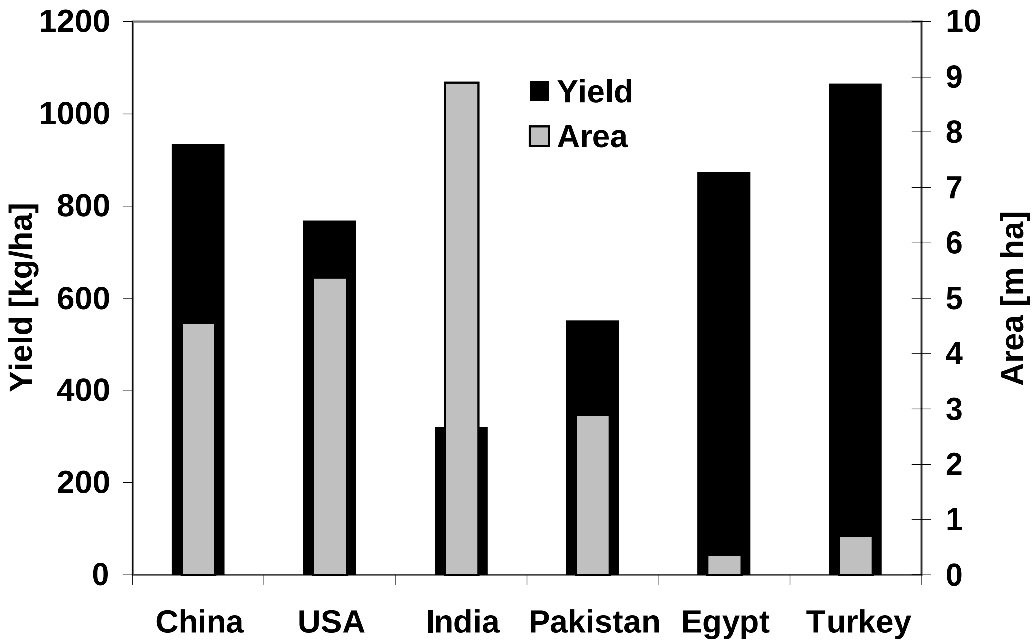
use by farmers depends on many other conditions. There is a need to repeat the study at some later point in time in order to obtain a better understanding of the performance of Bt cotton in the long run.

1 Introduction

1.1 Background

Cotton is one of the most important commercial crops in India contributing to over 30 per cent of foreign exchange earnings of the country. India accounts for approximately 21 per cent of the world cotton area but the average productivity of cotton is markedly low at about 293 kg lint cotton/ha compared to 600 kg/ha world average per year (Sen, 2003). The low productivity of cotton is caused by some serious constraints. Lack of irrigation, limited supplies of quality seeds, poor management practices, high costs of cultivation (particularly of plant protection measures) and serious pest outbreaks have been the major limiting factors in the past (Mohanty et al., 2002). Figure 1 illustrates the big gap between size of cotton area and productivity of cotton in India when compared to other cotton producing countries like Turkey or China.

Figure 1.1: International comparison of yield and area under cotton



Source: adopted from Choudhary, 2001

In 2002, the government of India approved the commercial use of Bt cotton despite concerns and discussions regarding possible environmental effects (Corpwatch, 2002). The transgenic variety is resistant against lepidopteran insect pests. It is promoted as an alternative to pesticide use, as a possibility to reduce high input costs and to prevent crop losses. Mahyco/Monsanto Company is at present the only company in India with production authorisation for Bt cotton.

Bt cotton was first commercially planted in India in the 2002/2003 season.

1.2 Cotton in India

Agriculture represents an important sector of the Indian economy providing employment for about 64 per cent of India's population. The annual growth rate of the agricultural GDP was 8.6 per cent in 2001/2002 (Agricultural Statistics, 2002). The major cultivated crops are food grains, pulses and oilseeds (see Annex A-11).

Cotton is one of the most important commercial crops and has a long history in India (see production details in Table 1.1).

Table 1.1: Selected statistics of cotton production in India[1] from crop years 1970/1971 to 2001/2002

Crop Year	Area (mill. ha)	Production (mill. bales)	Yield* (kg/ha)	% Coverage under Irrigation
1970-71	7.61	4.76	106	17.3
1975-76	7.35	5.95	138	23.5
1980-81	7.82	7.01	152	27.3
1985-86	7.53	8.73	197	30.2
1990-91	7.44	9.84	225	32.9
1995-96	9.04	12.86	242	35.0
2000-01	8.58	9.65	191	NA
2001-02	8.75	11.30	220	NA

*Note: lint cotton, about 1/3 of seed cotton

Source: Agricultural Statistics 2002

The total area under cotton in India is about 9 million ha with a production of 1,9 million tonnes of lint cotton. India ranks third in global cotton production after China and the United States.

[1] See Appendix for state-wise production of cotton in India.

Cotton is grown in three distinct agro ecological zones of India which are characterised by different soils:

- Northern zone of sandy loam soils were cotton is grown almost entirely under irrigation,
- Central zone of black soils where cotton is mostly grown under rainfed conditions and
- Southern zone of red soils where cotton is predominantly rainfed (Basu, Paroda, 1995)

At present 125 cotton varieties and hybrids have been released so far in India (Khadi, 2002). All four species of cotton (i.e. G. hirsutum, G. barbadense, G. arboreum and G. herbaceum) are grown in the different geographical zones. In addition, hybrid cotton varieties have a big share on the total cotton area (around 36 per cent, Annex A-16) and are mostly grown in the central and southern zones of India.

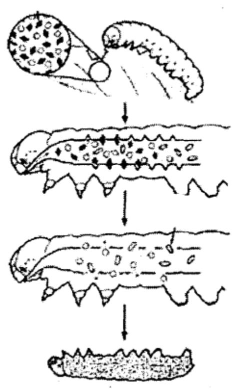
Although cotton accounts for only 5 per cent of the arable land in India, it consumes more than 50 per cent of chemical pesticides (FAO, 2002). The largest proportion of cotton pesticides is used to protect cotton plants against losses due to bollworm pests.

Cultivating cotton is a high-risk business constrained by pests and unfavourable climatic conditions. Farmers, especially marginal and small-scale farmers who are dependent on regular season income, often shift to other less risky crops.

1.3 Bt cotton in India

"*Bacillus thuringiensis* (Bt) is a naturally-occurring soil bacterium that produces a protein that is toxic to Lepidopteran insect pests" (Choudhary, Laroia, 2001). Bt cotton is an insect-protected variety of cotton in which the gene of the Bt bacterium has been introduced. According to Choudhary and Laroia (2001) bollworm infestation has to be controlled in the early stages of plant growth to be effective. The Bt gene works inside the plants and replaces an insecticide that is sprayed on the crop. It can be compared with systemic insecticides. The Bt toxin mechanism of action is demonstrated below (Box 1.1).

Box 1.1: Bt toxin mechanism of action



- Caterpillar consumes foliage with Bt protein
- Protein binds to receptors in the gut wall
- Gut wall breaks down, leading to leaching of ingested material
- Caterpillar dies in 1-2 days

Source: adopted from Venugopal et al., 2002

Two types of transgenic cotton are existent on the world's cotton market; one conferring resistance to bollworm (Bollgard® Cotton), the other conferring resistance to herbicides (RoundupReady Cotton) (Khadi et al., 2002).

The Department of Biotechnology (DBT) has been the primary institution funding research on transgenic plants in India (Choudhary, 2001). Indian Research began in 1994 with a multi-network project funded by DBT located in Lucknow (NBRI), but ended in 1998 with no obvious success (Choudhary, 2001).

In 2000/2001, transgenic cotton comprised 12 per cent of the total transgenic crop-area in the world (ICAC, 2002). The share of Bt cotton on the global cotton area increased steadily over the last years. Today the Bt cotton area reaches 2.2 Mill ha (ISAAA, 2002), which are about 10 per cent of the total world cotton area, since other main cotton producing countries gave commercial approval for insect-resistant Bt cotton (China 1997, India 2002).

According to Khadi et al. (2002), in India, efforts were made on breeding cotton varieties resistant or tolerant to insects. But these efforts have never resulted in a cultivar that exhibited sufficient resistance to bollworm.

In 1998, the Maharashtra Hybrid Seeds Company (Mahyco) conducted multi-location field trials (in seven states of India) on Bt cotton under the supervision of the Indian Council for Agriculture (ICA), DBT and agricultural universities. (Liberty Institute, 2002).

The attempts of the Indian government and Mahyco were accompanied by objections from various Non Governmental Organisations (NGO's) like Greenpeace or Gene Campaign who reproached the Indian government for a lack of serious evaluating and monitoring of the new technology. The debate on Bt cotton has been simmering since 1998. The argument between the parties reached a peak in 2001 when instigated farmers burned Bt cotton trial fields. Nevertheless, the government proceeded in promoting the new varieties.

Based on approval given by the Genetic Engineering Approval Committee (GEAC) the government declared Mahyco’s three transgenic cotton hybrids Mech 12, Mech 162 and Mech 184 as free for commercial use in Central and South India in March 2002. The decision was based on unpublished data of Mahyco Company and co-operating Indian research institutions.

The season 2002/03 was the first season in which Bt cotton was grown under farmer field conditions. According to a report in New Zuericher Newspaper (NZZ) (02/03) about 55,000 farmers in India cultivated Mahyco´s transgenic cotton varieties on 40,000 ha land in 2002.

The box below contains the chronology of the Bt cotton approval in India documented by Corpwatch (2002):

Box 1.2: Chronology of Bt cotton in India

1995 (March 10): Department of Biotechnology (DBT) of the government of India permits import of 100 gm of transgenic Cocker-312 variety of cottonseed cultivated in the United States by Monsanto. This variety contained the Cry1 Ac gene from the bacterium *Bacillus thuringiensis.*

1998 (April): Mahyco is given permission for small trials of Bt cotton 100 g seed per trail by DBT.

1998 (Nov 28): Thousands of farmers occupy and burn down Bt cotton trial fields in Karnataka as part of "Operation Cremate Monsanto".[2]

1999 (Jan 6): Vandana Shiva's Research Foundation for Science, Technology and Ecology goes to the Supreme Court challenging the "legality" of the field trials authorised by the DBT.

2000 (July): Mahyco is allowed to conduct large-scale field trials including seed production at 40 sites in six states of India. The permission was granted based on the "totally confidential" data from the small trials that allowed regulators to infer that Bt Cotton was "safe".[3] The DBT sets up a Committee to "independently" monitor and evaluate large-scale field trials.

2001 (June 18): An open dialogue has been held between Monsanto and Greenpeace to discuss Bt cotton with scientists, Ministry of Environment representatives and farmers. No data on field trials was presented, though farmers vociferously demanded Bt cotton to be commercialised. Technical questions and concerns raised by Greenpeace remained unanswered.

2001 (June 19): Genetic Engineering Approval Committee (GEAC) extends field trials of Bt Cotton by another year. Mahyco conducts large-scale trials on 100 hectares in seven states.

2001 (Oct): Mahyco discovers commercial Bt cotton farming over several thousand hectares in Gujarat. Source of the cotton is traced back to Navbharat Seeds Pvt Ltd.

2001 (Oct): GEAC orders Bt cotton fields in Gujarat to be burnt. No action was taken after farmers' protest order.

2001 (Nov 20): Gene Campaign files a case in the Delhi High Court charging the Government with negligence in allowing large-scale field trials to be conducted without appropriate monitoring, regulation and safety precautions.

2002 (Jan 23): Dr Manju Sharma, secretary of DBT, declares that the latest round of Bt cotton trials was satisfactory. He gives over the decision on approval to the GEAC and the Ministry of Environment.

2002 (Feb 20): The Indian Council of Agricultural Research (ICAR) submits a positive report to the Ministry of Environment on the field trials of Bt cotton.

2002 (March 26): The official approval for commercial use of Bt cotton is given by the Genetic Engineering and Approval Committee (GEAC) of the environment ministry.

Source: Corpwatch, 2002

2 "Operation Cremate Monsanto" launched against Monsanto Field Trials meant to destroy all existing Monsanto/Mahyco field trials all over India.

3 This data has not been published so far.

1.4 Objectives of this study

The overall objective of this study was to compare the economic performance of Bt cotton and non-Bt cotton in farmers' fields in selected areas in Karnataka, South India.

These results are accompanied by an overview of cotton production and the current status of Bt cotton production in India. Finally, this report will give a first assessment on the performance of Bt cotton during its first commercial season in Karnataka.

The specific objectives were:

1. Assessment of the traits of cotton production in South India.
2. The economic evaluation of Bt varieties under the specific conditions of South India.
3. Development of recommendations for further studies.

Another study that looked at yield effects of Bt versus conventional cotton varieties in India was carried out by Quaim and Zilberman (2003). The authors used data of Mahyco / Monsanto on-farm trials with Bt cotton, a non-Bt counterpart and conventional cotton. They concluded that crop loss and pesticide use can be much reduced if farmers plant Bt cotton. However, the authors did not perform any economic analysis by calculating gross margins.

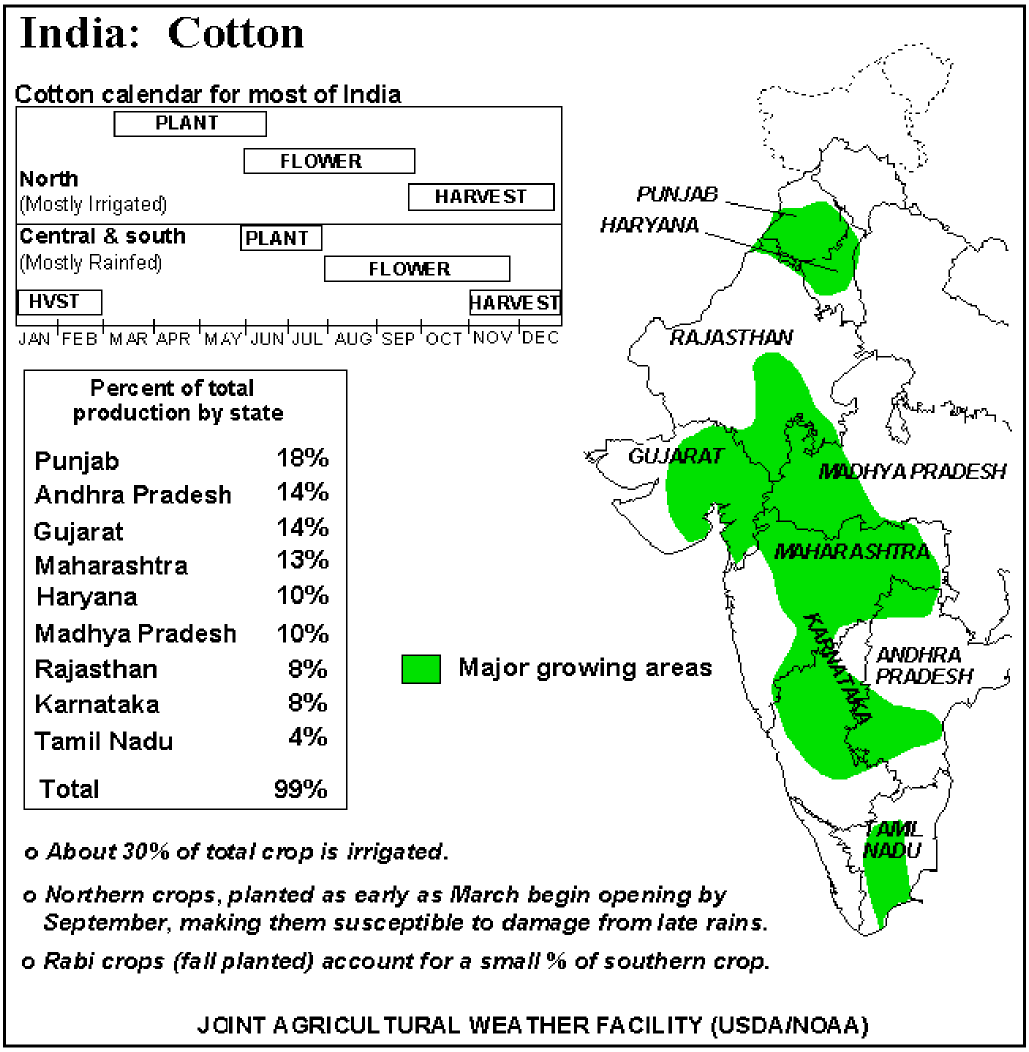
Hence, there is a need to conduct an economic analysis before concluding on the net benefits of Bt cotton to farmers.

2 Study area

The state of Karnataka is located in the south-west of the Indian peninsular between the Bay of Bengal to the west and Andhra Pradesh to the east. The state has an equable climate with temperatures ranging between 18 to 35°C. The two most important rivers are Krishna in the north and Cavery in the south. Both rivers merge into the Bay of Bengal. The state is the eighth largest of India in both area and population.

Karnataka State has 27 districts with 49 revenue subdivisions and 1075 taluks (FAO, 2002). Dharwad and Belgaum district are located in the North of Karnataka State.

Figure 2.1: Cotton map of India



Source: Maps of India, 2002

Karnataka is predominantly rural and agrarian and more than 71 per cent of the population[4] is engaged in agriculture. Hence, agriculture plays an important role in the state's economy and contributes about 28 per cent to the domestic product (Karnataka State Department, 2000). The total geographical area of Karnataka is 19 million hectares and 64 per cent is used for agriculture of which less than one fourth is irrigated.

Cotton is grown as one of the major cash crops but the production has been constrained by especially low rainfall during the last three years (see Figure 2.2). Only 35 per cent of cotton is grown with supplementary irrigation.

Figure 2.2 shows average yields of lint cotton in five-year intervals between 1955 and 1999.

Figure 2.2: Area and yield[5] of cotton in Karnataka

Source: Karnataka State Department 2000

The cotton area decreased over the last ten years since farmers shifted to other crops like maize and sugarcane. The cotton yield of 212 kg lint

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[4] See Appendix for districtwise population and area.

[5] Fiber Cotton (about 1/3 of Seed Cotton)

cotton/ha is low as compared to world average with about 600 kg lint cotton/ha (High Power Committee, 2003).

Hybrid varieties are commonly used in South India. In 1994, nearly 80 per cent of the total cotton area in Karnataka was covered with hybrid varieties (Table 2.1).

Table 2.1: Area and production of hybrids in Karnataka relative to other states

State	Total Area	Hybrids Area	% of Total Area	Total Production	Hybrids Production	% of Total Production
	(mill ha)	(mill ha)	%	(mill tons)	(mill tons)	%
Central Zone						
Maharashtra	2.48	0.10	4.03	0.30	0.15	50.0
Gujarat	1.15	0.55	47.80	0.34	0.20	59.5
Madhya Pradesh	0.48	0.20	41.70	0.06	0.02	39.0
Southern Zone						
Andhra Pradesh	0.80	0.50	62.50	0.20	0.12	60.0
Karnataka	**0.61**	**0.42**	**68.80**	**0.17**	**0.13**	**79.6**
Tamil Nadu	0.27	0.03	11.00	0.08	0.02	25.5
Total (Central & South)	5.79	1.80		1.16	0.66	

Source: adopted from Basu, Paroda, 1995

The average size of land holdings in the state was 1.95 ha according to 1995/1996 agricultural census.

Karnataka introduced Bt cotton immediately after commercial approval in March 2002.

3 Methodology

A total of 100 farmers were selected from a list of farmers who have received Bt cotton seeds. The majority of farmers were found to grow both Bt cotton and non-Bt cotton, while a smaller proportion was no longer growing conventional cotton (Table 3.1). A further general grouping criteria was access to irrigation, which was believed to determine productivity.

Table 3.1: Number of respondents by type

	Bt cotton	Cotton (both)	
		Bt-plots	Non-Bt plots
Irrigated	9	25	11
Non-Irrigated	14	52	66
Total	23	77	77

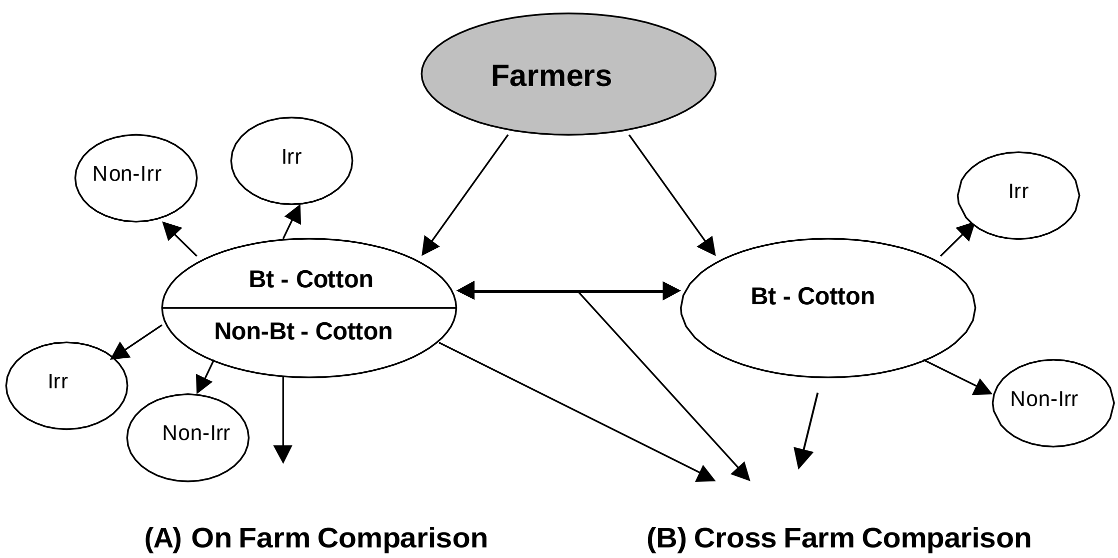
Source: Field Survey, 2002

The sampling design allows two types of analysis to be performed:

(a) On farm comparison between Bt and non-Bt cotton in one production system (pair-wise),

(b) Across-farm comparison between Bt cotton and non-Bt cotton and Only-Bt cotton.

Figure 3.1: Sampling design



The survey was mainly carried out in Dharwad district because a reasonable quantity of Bt cotton seed-packages has been sold in this district as documented in Table 3.2.

Table 3.2: Bt cotton sale in Karnataka

District	2002 Bt cotton-Sales (in packages @ 450g)
Dharwad*	3722
Gadag	30
Bellary	279
Koppal	80
Gulbarga	990
Raichur	520
Davangere	140
Bijepur	530
Belgaum	491
Mysore	-
Total	6782

*Note: including Haveri District

Source: ISAAA, 2002

3.1 Sampling procedure

Due to widely dispersed Bt cotton cultivation in Karnataka, it was difficult to identify a representative sample. Only a few farmers per village were supplied with Bt seeds for cultivation. Most of these farmers planted only part of their cotton area with Bt cotton because the available amount of Bt cottonseed was limited to two packages per farmer. A Bt-seed sales list of Mahyco / Monsanto Company was used to identify farmers. Finally, 100 farmers in 50 villages were selected[6] (compare Annex A-1).

3.2 Data collection

Before starting regular farmer interviews, field visits provided an insight on field conditions. The questionnaire was pre-tested in different areas. In addition to the interviews, farmers' fields were examined in order to get a better impression on state of the cotton plots.

[6] See Appendix for list of villages.

A questionnaire with mainly closed questions was used for farmer interviews during the season 2002/2003 (Dec. 2002). The survey was carried out in three talukas[7] of Dharwad district (Hubli, Dharwad, Kalghatagi) and one taluka of Belgaum district (Bailhongal) in Karnataka. These areas were chosen to ensure comparability of data, as they are all located in the same agro-ecological zone.

3.3 Indicators / data obtained by questionnaire

3.3.1 Land holding and cropping pattern

The variable included was the total area of land, both owned and rented. Based on the extent of land holding farmers were categorised in five categories:

- Below 1 ha — Marginal Farmers
- 1-2 ha — Small Farmers
- 2.1-4 ha — Semi-Medium Farmers
- 4.1-10 ha — Medium Farmers
- above 10 ha — Large Farmers

Moreover, information about land usage in *Kharif* (late summer) and *Rabi*[8] season was compiled. The extent of crops grown by the farmers was obtained including the seasons 2001/2002 and 2002/2003.

3.3.2 Cotton production data

a) Cost of cultivation

In order to estimate the cost of cultivation, cost of labour (including land preparation, hire-charges for bullocks and farm machinery), cost of seeds, fertilizer, pesticides and irrigation were recorded.

The costs were calculated as following:

- labour costs based on wage rates of hired labour.
- seed costs based on quantity per hectare
- pesticides, fertilizer, irrigation costs: US$/ha

b) Seed-cotton yield

[7] Taluka is an administrative unit comprising a group of villages within the district.

[8] Kharif: Late Summer Season, Rabi: Winter Season (in India three seasons occur over the year, the third season is summer)

Cotton yields were calculated by taking the amount of picked seed-cotton.

3.3.3 Pesticide use

Type and quantity of pesticides used were recorded. The chemical pesticides were categorised into WHO toxicity groups (IPCS, 2002):

- Class 1a extremely hazardous
- Class 1b highly hazardous
- Class 2 moderately hazardous
- Class 3 slightly hazardous
- Class 4 unlikely to present acute hazard

To check possible changes in pesticide use during the past years, the number of pesticide applications in the 2002/2003 season and the previous three years was collected.

3.3.4 Bt cotton and farmers' attitude

To assess the impact of Bt cotton in the first year, the farmers' opinion of advantages and disadvantages of Bt cotton and of other problems related to cotton production were collected. The farmers could give multiple answers on particular "open" questions.

3.4 Methodology of data analysis

For across- and on-farm comparison of conventional non-Bt and Bt cotton simple statistical analytical tools have been used.

a) Descriptive statistics:

Means and standard deviations were calculated to allow the comparison of different variables like yields, pesticide use (quantity, number of applications), cost and gross margins of cotton production, market prices etc.

b) Statistical tests:

Statistical tests (t-test) were used to verify results calculated before. To truly compare results and to identify possible differences between cotton production systems it is necessary to test if the results are statistically significant different.

4 Results and discussion

This chapter presents the results of the farm survey.

First, details on the land holding pattern are summarised in order to show which farmer group, i.e. smaller or larger farmers grew Bt cotton during its first year of commercialisation.

Farmers' attitude concerning Bt cotton is presented since the opinions and perceptions regarding this new technology ultimately affect its success. These data are summarised in section 4.3. Afterwards, the characteristics of pesticide use in both Bt and non-Bt cotton production are presented. Costs of cotton production and productivity aspects are summarised at the end of the chapter.

In section 4.5 (productivity of cotton production) and 4.6 (economics of cotton production), the results are presented for across-farm and on-farm comparison between Bt and non-Bt cotton as well as for irrigated and rain-fed conditions.

4.1 Land holding

Seventy-five per cent of the respondents were medium or large-scale farmers. Mainly the large-scale farmers adopted Bt cotton, however, the majority of farmers in Karnataka are marginal or small farmers (see Annex A-6). Only one marginal farmer was found to grow Bt cotton. For that reason this group is not represented in the table below.

Table 4.1 below provides details on the distribution of respondents according to their farm size.

Table 4.1: Farm size categories [ha] of respondents

Category	Percentage of Farmers [%]	Total Land	Bt-Area	Non - Bt-Area	Cotton % of Total Land
Small	7	1.6	0.6	0.2	37.5
Semi	17	3.0	0.4	0.6	35.7
Medium	28	6.4	0.8	1.2	31.3
Large	47	14.3	0.6	1.8	16.5

Source: Field Survey, 2002

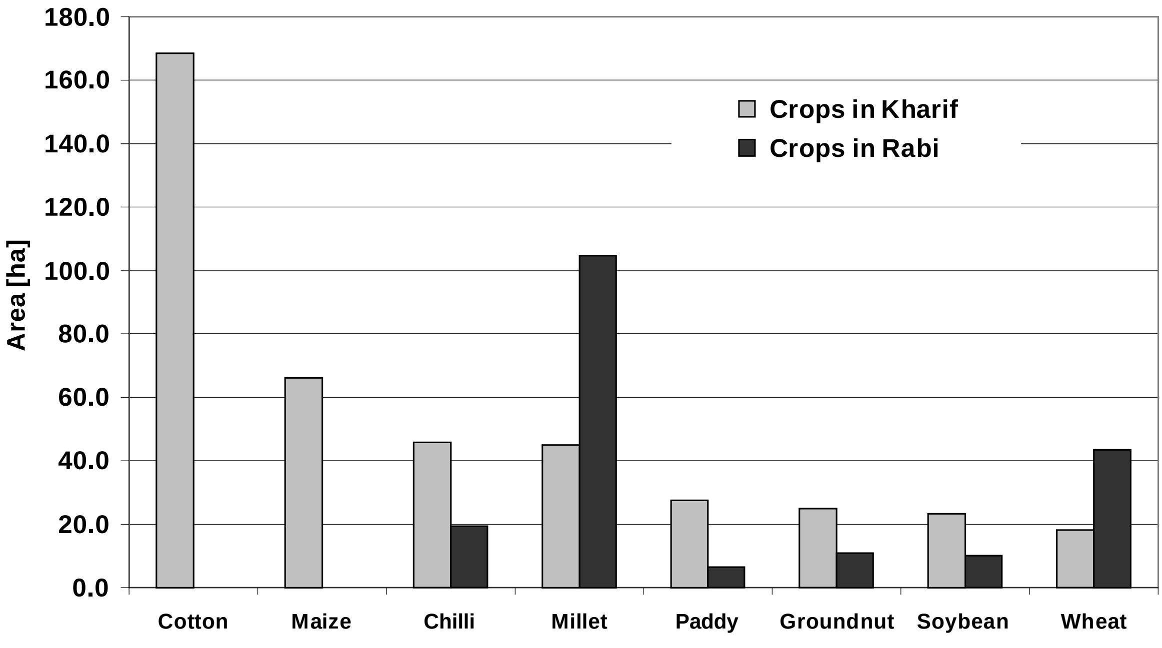
Small farmers grew cotton on around 40 per cent of their total land, while large farmers covered only 17 per cent of their land with cotton crop. However, the average size of Bt cotton area was the same in all categories since all farmers were given the same amount of seeds.

4.2 Cropping pattern

Cotton was one of the principal crops grown by the respondents during 2002. Other major crops were maize and chilli (Figure 4.1). In the rabi season wheat and millet were the most important crops.

Only two farmers planted cotton for the late season 2002/2003 (sowing in fall). For the other farmers, the main reason for not growing cotton in the winter was the shortage of water due to low monsoon rains. The lack of rain already limited cotton production in the previous season.

Figure 4.1: Cropping pattern in the season 2002/2003



Source: Field Survey, 2003

4.3 Farmers' attitude and assessment of Bt cotton

Farmers' knowledge, attitude and perceptions of Bt cotton are important as they can provide some indication for farmers' production decisions.

Table 4.2 lists the farmers´ sources of information about the traits of this new variety. Forty-eight per cent of the interviewed farmers received information about Bt cotton from their seed dealers. Company promotion (Mahyco) reached another 18 per cent.

Table 4.2: Source of farmers' knowledge concerning Bt cotton

Information Bt Cotton	Percentage of Farmers
Seed dealer	48
Company promotion	18
Other farmers	6
Media (radio, newspaper)	5
Agricultural department	1

Source: Field Survey, 2002

Informal interviews revealed that extension staff often had no knowledge about the new technology.

Bt cotton was promoted, by companies and dealers as a high yielding variety that would not need any pesticides because of its resistance to pests. Farmers purchased Bt cotton seed despite its high price which was about four times the price of conventional cotton. Seed agents explained the high seed prices with their high yield potential.

Table 4.3: Farmers' reason(s) for adopting Bt cotton, 2002

Reasons expressed by farmers	Percentage of Farmers
High yield	43
New variety	16
Less pesticide costs	15
Less expenses	7
Less pests	5

Source: Field Survey, 2002

Farmers' reasons for adopting Bt cotton reflect widely reported expectations about the Bt hybrid. Nearly half of the respondents said that the expectation of high yields was their main reason for adoption (see Table 4.3). The second reason, where farmers simply stated "new varieties" may in fact refer to the same point.

Farmer's ex-post evaluation after growing it for the first time, i.e. what they thought about the new variety, showed that about one third saw their advantage in the lower pest pressure but only 10 per cent reported lower pesticide costs (Table 4.4). In contrast to their reasons for adoption one fourth of the respondents could actually observe a yield advantage.

About one third of the Bt cotton farmers saw no advantage of the Bt variety at all. Interestingly however, farmers also observed advantages that do not correspond with the biological characteristics of Bt varieties such as quality and drought resistance.

Table 4.4: Advantages of Bt cotton reported by farmers, 2002

Advantages of Bt Cotton reported by Farmers	Percentage of Farmers
Low pest (bollworm) attack	32
High yield	24
Good quality	20
Low pesticide costs	10
Low labour costs	5
Drought resistance	4
Less costs	4
New variety	4
No advantages	31

Source: Field Survey, 2002

Table 4.5 summarizes farmers´ assessment of the problems encountered with Bt cotton. Nearly 50 per cent of the farmers felt that extraordinary high seed costs and lower market prices for seed cotton were the major problems. The fact that Mech 162 (Bt cotton) is a medium staple variety, which commands lower prices, was of major concern to the farmers.

Low yield of Bt cotton was also mentioned as disadvantage. However, 2002 was not a good cotton year and both Bt and non-Bt cotton did not perform well. Farmers generally blamed climatic conditions and especially the low rainfall as the major constraint to cotton production.

Table 4.5: Disadvantages of Bt cotton reported by farmers

Problem	Percentage of Farmers
High seed costs	45
Low market price	42
Medium staple variety	25
Bad quality (colour, smoothness)	14
Low yield	13
No market structure	8
Pests occurrence	4
No problems	9

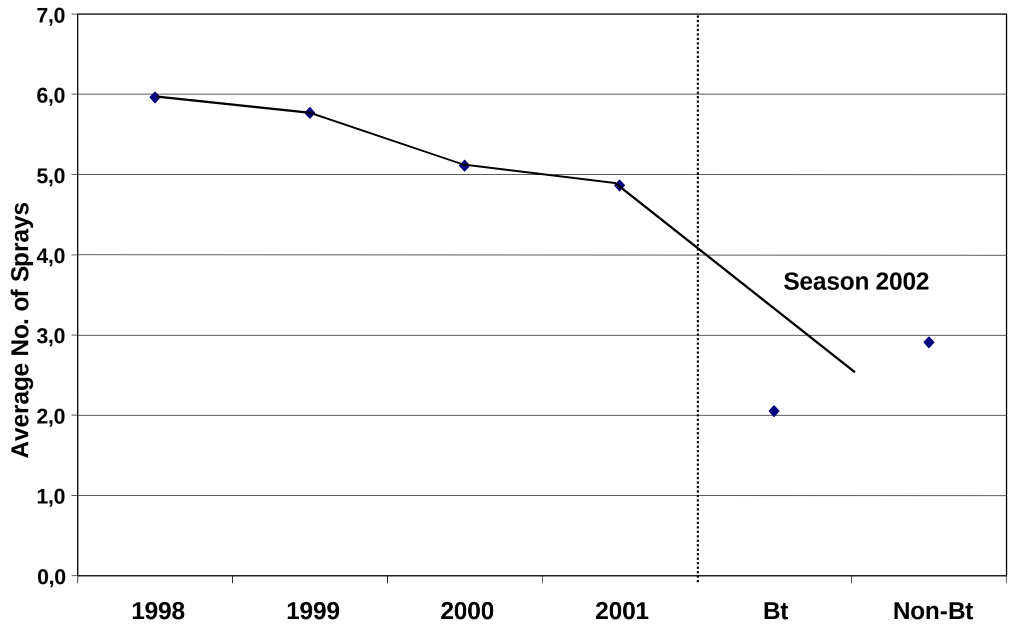
Source: Field Survey, 2002

These results show that the expectations of farmers for higher yields, which were nurtured by the information given by seed dealers, could not be met by the actual performance of the crop during the 2002/2003 season. This has led to some disappointment among farmers as almost one third could not see any advantage of Bt at all. However, farmers generally recognize the pest control properties of Bt crops.

4.4 Pesticide use

According to Khadi et al. (2002), pesticides account for 80 per cent of total production costs. Detailed information on pesticide use in cotton production in the present study is given in this section. The number of pesticide applications was comparatively low (Figure 4.2). This was mainly due to two factors: shortage of water and a low bollworm infestation.

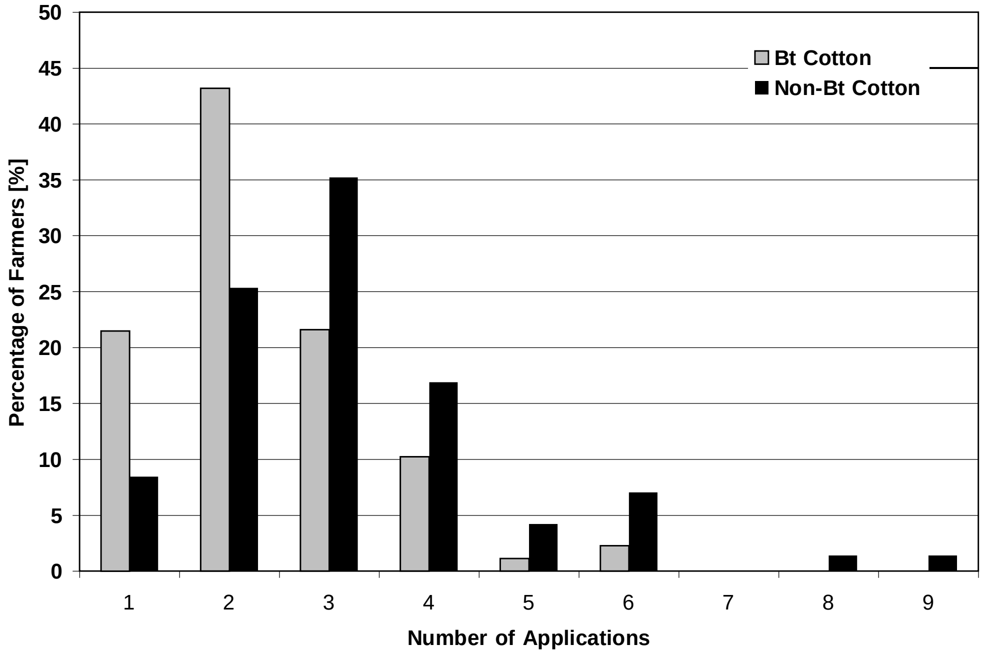
Figure 4.2: Average number of pesticide applications 1998-2002



Source: Field Survey, 2002

Figure 4.2 shows the average number of pesticide applications from 1998 to 2002, which decreased from six applications in 1998 to three in 2002. These numbers are low as compared to other regions of India or most of the cotton areas in China, where the frequency of application is between 10 to 15 times. Surprisingly there was only a marginal difference between irrigated and non-irrigated cotton (about 16 per cent increase for irrigated cotton).

Figure 4.3: Frequency of pesticide applications, 2002



Source: Field Survey, 2002

Figure 4.3 shows the absolute frequency of pesticide applications in 2002. Nearly 90 per cent of all farmers made fewer than four pesticide applications on either non-Bt or Bt cotton.

Table 4.6 presents the quantity and number of pesticide applications for different pests.

Table 4.6: Number and quantity of pesticide applications

Pesticide	Pest	Total Number of Applications [Number of Farmers]		Av. Quantity per Application [l/ha]	
		Non-Bt	Bt	Non-Bt	Bt
Profenofos	Bollworm	12 (9)	13 (10)	1.25	1.45
Endosulfan		25 (24)	19 (19)	2.50	2.45
Acephate		5 (5)	5 (5)	1.70	1.30
Quinalphos		14 (11)	6 (6)	1.70	1.00
Fenvalerate		5 (5)	4 (4)	1.25	1.62
Cypermethrin		13 (10)	7 (7)	1.75	1.70
Chlorpyrifos		2 (2)	-*	1.33	-*
Decamethrin		3 (3)	2 (2)	1.05	1.05
Indoxacarb		5 (5)	3 (3)	1.87	1.30
Total Bollworm		86 (73)	59 (56)	14.40	11.8
Endosulfan		21 (19)	20 (10)	1.20	1.07
Carbendazim		1	-*	2.25	-*
Imidachloprid		4 (4)	9 (7)	2.12	1.07
Buprofezin		1	3 (2)	1.25	1.37
Dimethoate		25 (23)	29 (24)	1.45	1.25
Acephate		1	1	0.75	0.75
Metasystox		1	1	0.75	0.75
Total Sucking Pests		112 (95)	120 (91)	11.52	7.71
Total		198	179	26.92	19.51

*not used, The values in brackets is the number of farmers that used the pesticide.

Source: Own Calculation, 2003

Farmers applied pesticide more often against sucking pests (Tables 4.7 and 4.8). Due to drought conditions, the incidence of sucking pests was higher. Especially whitefly and thrips were serious problems. The number of pesticide applications against bollworm pests was less than against sucking pests but the total quantity of pesticides sprayed against bollworms was significantly higher (Table 4.7).

Table 4.7: Average number of pesticide applications per pest and farmer

	Average number of pesticide applications against sucking pests [appl./farmer]	Average number of pesticide applications against bollworm pests [appl./farmer]
Non-Bt cotton	1.45	1.10
Bt cotton	1.20	0.59

Source: Own Calculation, 2002

Table 4.8 presents the average number of pesticide applications for bollworm and sucking pests

Table 4.8: Classification of pesticides

Common Name	Chemical	Class
Endosulfan	Organochlorine	2
Dimethoate	Organophosphate	2
Quinalphos	Organophosphate	2
Cypermethrin	Pyrethroid	2
Profenofos	Organophosphate	2

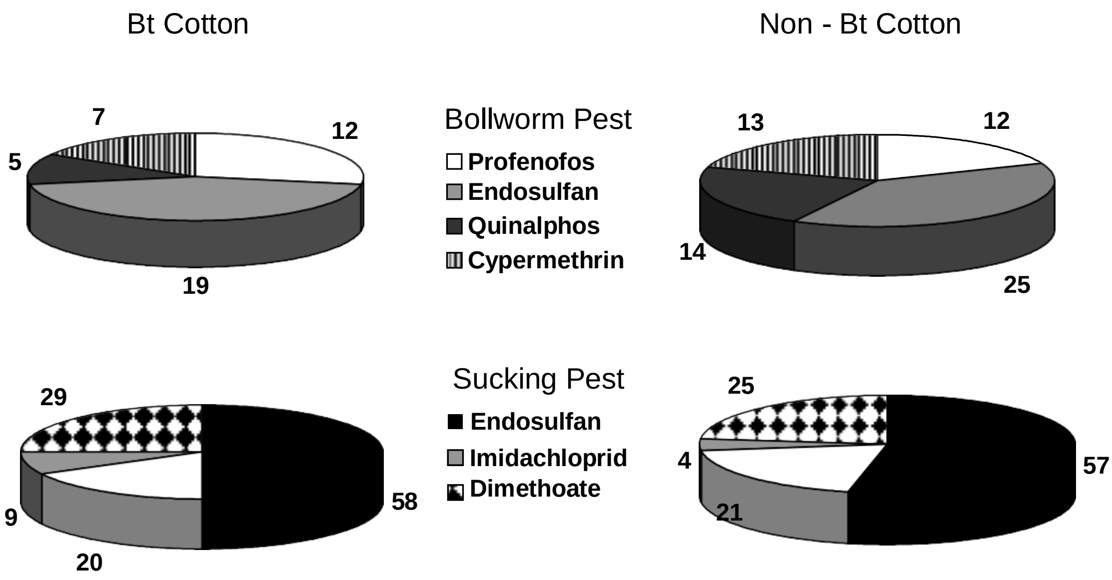
Note: WHO Classification of Pesticides: 1a: extremely hazardous, 1b: highly hazardous, 2: moderately hazardous

Source: WHO, 2003

The most frequently used pesticides on both Bt and non-Bt cotton for sucking pests were , endosulfan and dimethoate (Figure 4.4). For bollworm, the most frequently applied pesticides were profenofos and endosulfan. As given in Table 4.8 these pesticides belong to the WHO classes 1b or 2. The remaining compounds were of lesser relevance in the study area.

Figure 4.4 presents the different pesticides applied against sucking and bollworm pests.

Figure 4.4: Pesticides used on Bollworm and Sucking Pests, 2002 (based on number of applications)



Source: Field Survey, 2002

Many of the pesticides used pose potential health hazards. Especially and endosulfan are linked to specific symptoms (Hayat, 1993):

- causes hepatic damage, anorexia, convulsion and acidosis.
- Endosulfan causes abdominal pains, diarrhoea and insomnia.

Nearly 36 per cent of the farmers mentioned health problems like headache, vomiting and skin irritation which could be signs for health problems related to pesticide exposures during the 2002 season. This is remarkable given the low intensity of pesticide use.

With two applications on average, farmers' pesticide use on Bt cotton was only marginally less than on conventional cotton. Many farmers tended to overdose pesticides instead of increase the number of applications (see Table 4.9).

Table 4.9: Number of pesticide applications and percent overdose for Bollworm and Sucking Pests, 2002

	Non-Bt Cotton		Bt Cotton	
Pest	**Number of Applications**	**Overdosed Applications [%]**	**Number of Applications**	**Overdosed Applications [%]**
Bollworm Pest	86	43.0	59	45.7
Sucking Pest	112	34.8	120	13.3

Source: Field Survey, 2002

Nearly half of all applications against bollworm pests were overdosed for both Bt and non-Bt cotton. However, in Bt cotton overdosing was less frequent for sucking pests.

4.5 Productivity of Non-Bt and Bt Cotton

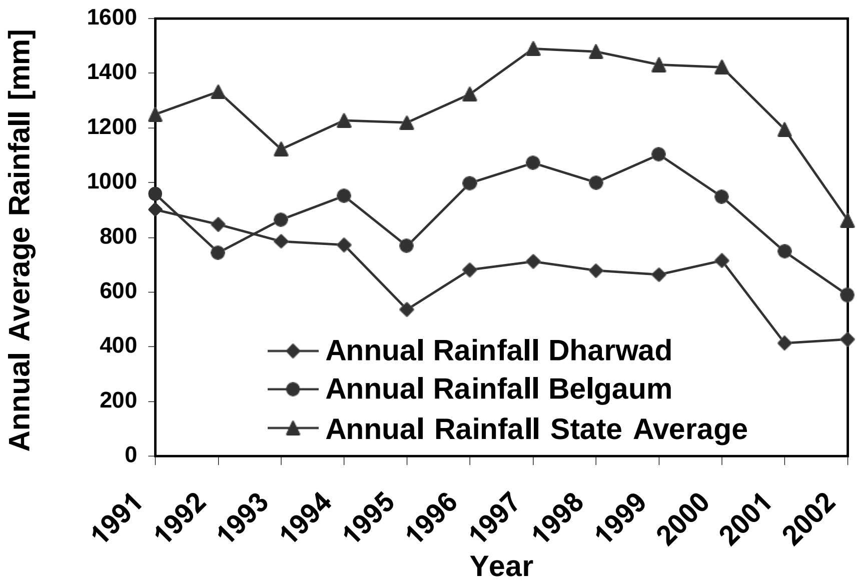
According to Choudhary (2001) the main three factors determining the yield of cotton are:

- genetic make-up and optimisation of gene technology
- agronomic practices and agricultural technologies
- biotic and abiotic stress-related factors

During the cropping season investigated, the most important constraint for cotton yield was water stress caused by decreased monsoon rains during the past three years.

Karnataka, like Andhra Pradesh and Maharashtra experienced an exceptionally long drought (see Figure 4.5). Cotton requires about 37.5 to 40 mm water per week. Due to limited rainfalls from 40 to 100 mm per month (Karnataka State Department, 2003), the water supply was not sufficient for proper cotton cultivation under rain-fed conditions.

Figure 4.5: Annual rainfall 1991-2002 (Karnataka State)



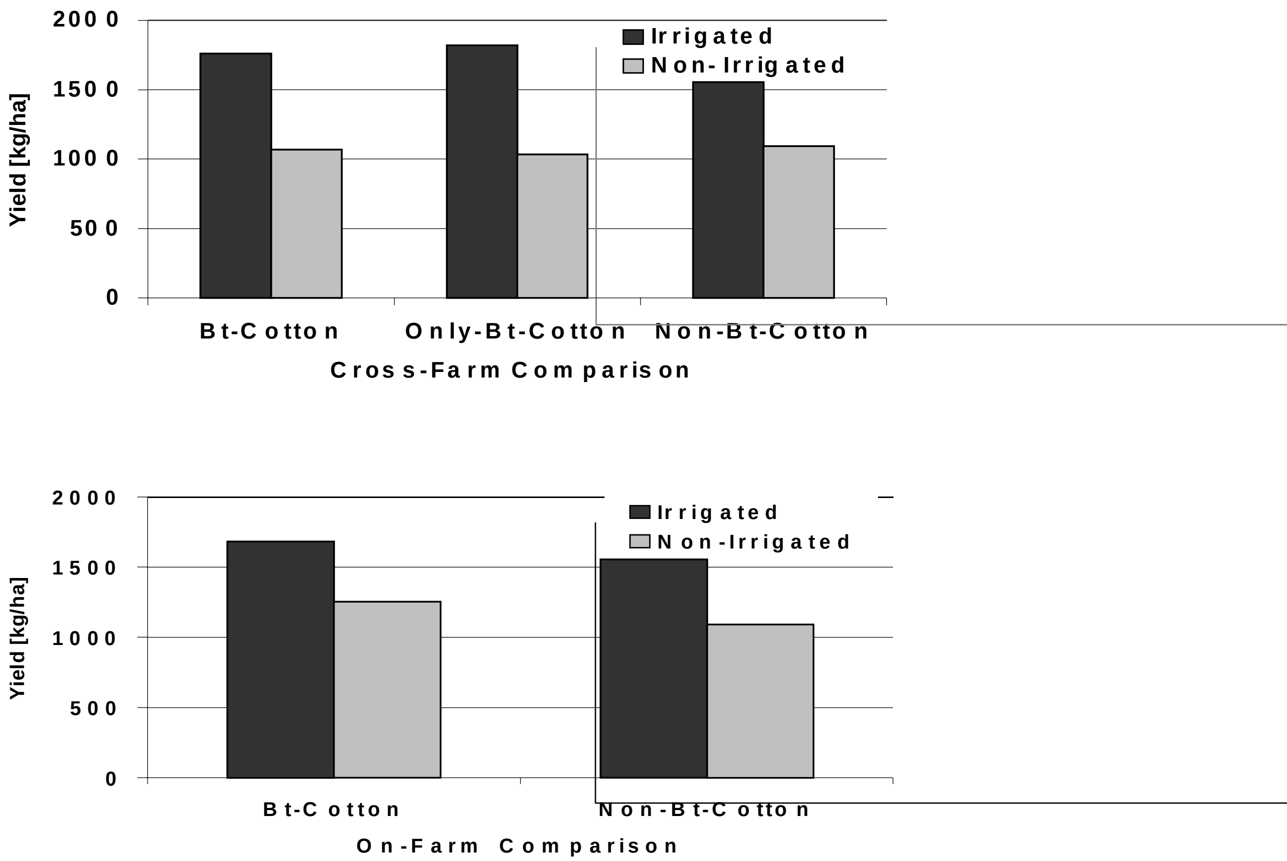
Source: Karnataka State Department, 2003

Water stress causes shortening of green shots and decreasing total plant heights. An even more serious consequence is the shedding of flower buds and young bolls (Monsanto, 2003). Many farmers reported this phenomenon during the survey. The dying of young bolls is also a secondary consequence of drought because nutrients cannot be sufficiently transported in the soil and inside the plant.

Since water is a major factor that determines productivity, the sample analysis was differentiated by irrigation.

Figure 4.6 shows yields for irrigated and non-irrigated cotton in across and in on-farm comparison.

Figure 4.6: Cotton yield for different conditions, across-farm and on-farm comparison, 2002



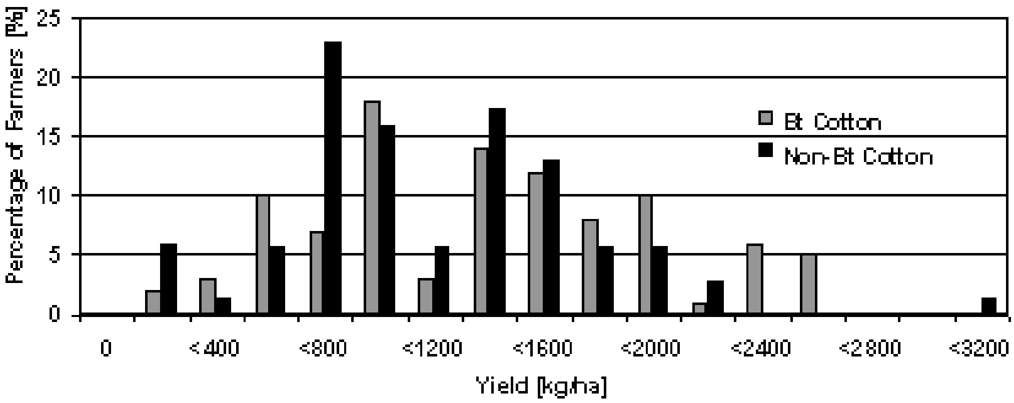
Source: Own Calculations, 2002

Under rain-fed conditions, there are no significant differences between Bt and non-Bt cotton yields for across-farm comparison (see Annex A-4 and A-5). The on-farm comparison shows a small yield increase for Bt cotton under rain-fed conditions. There are differences for cotton under irrigated conditions. The Bt cotton groups show significant higher yields as compared to non-Bt cotton.

The comparisons also show the influence of irrigation on both Bt- and non-Bt cotton yields. The yield of irrigated cotton was significantly higher than of non-irrigated cotton. Under irrigated conditions and for on-farm comparison Bt cotton was found to perform better than conventional cotton but the difference was lower than in the across-farm comparison. For Bt cotton the seed cotton yield increase due to irrigation was over 30 per cent while it was about 25 per cent for non-Bt cotton.

Figure 4.7 presents the distribution of Bt and non-Bt cotton farmers for different yield levels. About half the farmers produced less than 1400 kg seed cotton/ha. These figures are in line with regional and state averages for seed cotton production in the last four years (Karnataka State Department, 2002).

Figure 4.7: Distribution of farmers by seed cotton yield level, crop year 2002



Source: Field Survey, 2002

Based on these results, the Bt variety yielded better under farmer's conditions than the conventional non-Bt variety during the crop year 2002. However, the difference was much smaller than reported in previous studies, which are based on experimental data (e.g. Qaim and Zilberman, 2003; Khadi, 2002). As shown in this survey, access to irrigation is a major yield-influencing factor. Since the cotton bollworm populations were low in 2002, it is of course possible that yield differences will be more pronounced under high bollworm populations. However, it is not yields but profits that matter when assessing the relative advantage of a new technology. One factor that influenced profits were the prices received by farmers. Table 4.10 reports monthly averages, daily maximum and minimum retail prices for Bt and non-Bt varieties in Dharwad district during the 2002-harvesting season.

Table 4.10: Comparison of market prices non-Bt vs. Bt cotton [US$/qtl][9] in Dharwad, 2002

	Daily Minimum [US$]	Daily Maximum [US$]	Mean [US$]
Total Average Non-Bt	39.46	66.22	55.00
Total Average Bt	39.09	47.14	43.12

Source: Retailer, APMC Dharwad 2003

As shown in Table 4.10, on average, Bt cotton fetched lower prices. The starting price at the beginning of trading was about the same as the starting price for non-Bt cotton, however, over the harvesting period the difference became clear for the daily maximum price. On average, the retail market price for Bt cotton was 20 per cent lower than for non-Bt cotton. When asking farmers for the reasons of this difference they pointed out that Bt cotton is a medium staple variety. Staple length is a quality characteristic and therefore influences market prices.

Summarizing the findings presented in this section it becomes clear that during the 2002/2003 harvesting period farmers growing Bt cotton had overall higher yields (about 10 per cent) than those growing conventional cotton varieties. This was especially true when differentiating the sample by irrigation. The difference was bigger (compare Annex A-4 and A-5) for those farmers that grow Bt and non-Bt cotton side-by-side, indicating that more care was given to the new variety. Overall, it is not yet clear what the reason for this yield difference was because bollworm populations were low in 2002 and farmers sprayed only moderate amounts of pesticides. On the other hand, the relative yield advantage of Bt was offset by their lower prices in the Dharwad retail market as compared to conventional varieties. Therefore, as a final step, the economics of both types of cotton production was investigated.

[9] 1 US$ = 46.45 Indian Rupees

4.6 Economics of Cotton Production

In the economic analysis, input costs, output values and gross margins for non-Bt and Bt cotton production were compared. Comparisons were made across- farm for non-irrigated (Table 4.11) and irrigated (Table 4.12) conditions. Also a pair-wise on-farm comparison differentiating by irrigation was performed (Tables 4.13 and 4.14).

Hence, the first type of comparison shows farm and location-specific differences while the second one indicates farmer effects.

Table 4.11: Economics of cotton production, across farm comparison, non-irrigated [US$/ha]*

Type of Cost	Non-Bt Cotton	Bt Cotton	Only -Bt Cotton
	Mean	Mean	Mean
Pesticides	30.07	25.18	22.43
Fertiliser	45.64	49.99	58.43
Labour	113.48	117.01	134.24
Seed	18.57*	75.84*	79.43*
Total Variable Costs	176.16*	223.45	228.77*
Total Yield [kg/ha]	1092.90	1068.50	1033.20
Total Revenues	521.58	479.51	430.70
Gross Margin	338.86*	256.27	208.65*

* Means are statistically significant at 95% using t-test

Source: Own Calculation, 2003

Table 4.12: Economics of cotton production, across farm comparison, irrigated [US$/ha]

Type of Cost	Non-Bt Cotton	Bt Cotton	Only-Bt cotton
	Mean	Mean	Mean
Pesticides	54.43*	24.66	23.28*
Fertiliser	45.90	51.83	47.04
Labour	144.76	133.53	151.90
Seed	19.59*	79.24*	80.12*
Irrigation	34.50	52.27	91.90
Total Variable Costs	238.47	260.80	296.92
Total Yield [kg/ha]	1556.10	1759.30	1818.00
Total Revenues	515.87*	683.30	700.36
Gross Margin	359.07	443.90	431.43

*Means are statistically significant at 95%

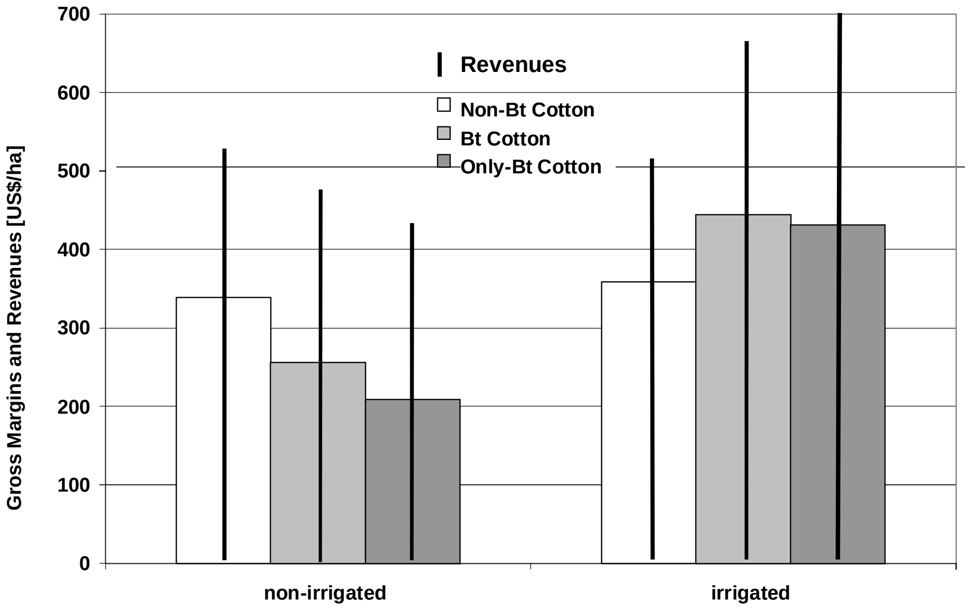
Source: Own Calculation, 2003

The costs for pesticides were only a small proportion of the total production costs. As mentioned before, according to Khadi et al. (2002), pesticides count for 80 per cent of total production costs. In this case study the pesticide costs were especially low due to climatic conditions. As expected, costs of pesticides in Bt cotton production were lower than for non-Bt cotton. For irrigated conditions, the pesticide costs were significantly higher for non-Bt cotton.

Seed costs for Bt cotton were about four times higher than for conventional varieties and outweighed the difference in pesticide costs. The irrigation cost for those farmers who grow only Bt cotton was higher than for those growing both. Possibly, farmers who switched to Bt cotton invested more in water given the prospects of higher yield from Bt cotton or they were farmers with better access to water in the first place. The fact that most of the irrigated cotton was Bt cotton (78 per cent) supports this assumption.

Besides irrigation costs, there was no other cost item which showed a significant difference. The gross margins for irrigated cotton were significantly higher than those for non-irrigated cotton (Figure 4.8). It is remarkable that the revenue of Bt cotton under non-irrigated conditions was lowest for farmers who switched to Bt varieties but highest when irrigation was available. After all, about two thirds of farmers who switched to Bt had irrigation.

Figure 4.8: Gross margins and revenues of across-farm comparison



Source: Field Survey, 2002

Tables 4.13 and 4.14 below give details of the on-farm comparison. In general, input and output results were similar to the across-farm comparison.

Table 4.13: Economics of cotton production, on-farm, pair wise comparison, non-irrigated, study area 2002

Variable	Non-Bt Cotton	Bt cotton
	Mean	Mean
Pesticides	30.07	26.11
Fertilizer	45.64	47.00
Labour	113.48	112.17
Seed	18.57*	74.59*
Total Variable Costs	176.16*	221.53*
Total Yield [kg/ha]	1092.90	1252.90
Total Revenues	521.58	493.80
Gross Margin	338.86	270.20

*Means are statistically significant at 95%

Source: Field Survey, 2002

Table 4.14: Economics of cotton production, on-farm comparison, irrigated, study area 2002

Variable	Non-Bt Cotton	Bt cotton
	Mean	Mean
Pesticides	54.43*	21.10*
Fertilizer	45.90	51.49
Labor	144.76	126.88
Seed	19.59*	78.96*
Irrigation	34.50	42.36
Total Variable Costs	238.47	258.60
Total Yield [kg/ha]	1556.10	1682.70
Total Revenues	515.87*	677.91*
Gross Margin	359.07	474.84

*Means are statistically significant at 95%

Source: Field Survey, 2002

Results of the pair wise on-farm comparison show a similar trend as the across-farm comparison. Under rain-fed conditions, there were only marginal differences between Bt and non-Bt cotton production. The gross margin for Bt cotton was slightly lower than for non-Bt cotton but the difference was not significant. For irrigated cotton, pesticide cost was significantly higher as was total variable costs.

The analysis shows that higher yields and revenues did not necessarily lead to higher gross margins.

Pesticide cost took about 10 to 20 percent of total production cost. Labour and seed costs (for Bt cotton) accounted for the major part of production cost.

A major conclusion from the comparison of gross margins is that irrigation seems to be a more important factor than cotton varieties. However, if irrigation is available (or rainfall is sufficient), Bt cotton performs better than conventional varieties but the biological and economic reason for this difference needs yet to be found out. On the other hand, under rain fed conditions the possible advantage of Bt cotton disappears. Nevertheless, even under irrigated conditions the differences were lower than expected based on results from experimental data. Hence it is not clear how strong incentive for larger scale adoption of Bt cotton is if based on its field performance. An important question is how Bt cotton would perform in a year with high bollworm populations, how often such a situation occurs and how likely other means of control might fail. Since the data collected were only from one growing season, these questions cannot be answered at this point in time.

5 Summary

The purpose of the study was to compare non-Bt cotton and Bt cotton production under farmer's conditions in Karnataka. The data presented in this report were compiled from farmer interviews using a standardised questionnaire. One hundred farmers in fifty villages were interviewed.

Results can be summarized as follows:

1. The distribution of the sample farm size was atypical as compared to the state average. The majority of respondents growing Bt cotton were medium and large farmers with more than 4 ha of farmland while the state average are small and marginal farmers with less than 4 ha of land.
2. Farmers' attitude towards Bt cotton was diverse; 35 per cent were convinced not to grow Bt cotton again in the next cotton season.
3. There seemed to have been a lack of knowledge regarding the true biological characteristics of Bt cotton among farmers and extension agents. Many farmers simply assumed that Bt cotton was a high yielding variety that would not need any pesticides.
4. The majority of farmers got their information about Bt cotton from seed dealers.
5. Seed company agents justified high Bt seed costs with high yield promises. Nevertheless, farmers complained about high costs of seeds.
6. In 2002, pest pressure (bollworm) was low and consequently pesticide was only three applications for conventional cotton and two applications for Bt cotton on average.
7. Pesticide cost was only a small part of total production cost. Results of this study do not confirm those presented by other authors (e.g. Khadi et al. 2002), who claimed pesticides account for 80 per cent of total production costs.
8. The average yield of all farmers was 1200 kg seed cotton/ha. Water shortage was identified as a major limiting factor in the study area during the season investigated. Hence yields under irrigation were higher by at least 20 per cent.

9. Bt cotton seems to be performing better under irrigated conditions; local varieties appear to be better adjusted to rain-fed conditions. This difference was even more pronounced for farmers who no longer grew conventional cotton in 2002.

10. Economic analysis of cotton production indicated that cost for labour and fertiliser were the major expense in non-Bt production while in Bt cotton, besides labour, seeds became a major cost factor.

11. The differences between seed, pesticide and input costs of Bt and non-Bt production were statistically significant. Pesticide costs were low for both Bt and non-Bt cotton.

12. Despite higher yields for Bt cotton under irrigated conditions, the differences in gross margins were non-significant. Gross margins for Bt cotton were higher on average under irrigation. The yield advantage of Bt that existed under irrigation was offset by higher production costs and especially by lower product prices.

6 Conclusions

This study shows that one must be extremely careful with conclusions like *"The Bt cotton crop has shown the bright side of a widespread genetically engineered crop"* (Millius, 2003). This study, which uses farm-level data from the first year of commercial Bt cotton use, cannot confirm such optimism. Also, conclusions drawn from agronomic analysis alone and ignoring economic factors as those by Qaim and Zilberman (2003) can be problematic. The authors referred to *"sizeable benefits"* of genetically modified crops due to yield advantages. As this study shows, yield differences do not necessarily translate into differences of profit. A major yield factor is irrigation; therefore the potential advantage of Bt cotton can only be realized if access to water is assured. Such favourable conditions apply to less than one third of India's cotton area. Based on the results of this study the productivity of Bt cotton under rain fed conditions in Karnataka was not better or was even below that of local varieties. This shows that the economic performance of a cotton crop is not only determined by its genetic make-up but also by the agro-ecological conditions under which it is grown.

An important factor that needs to be taken into account when assessing pest control technologies is the pest pressure. It must be noted that the results of this study were obtained under conditions of low bollworm infestation. Productivity, pesticide use and economics of cotton production may be significantly different when pest populations are high and if other control methods fail.

A large degree of misinformation among farmers with regards to the true biological traits of Bt cotton was found. This could lead to a negative image of this new technology. Hence, there is a need for more farmer education. Here, the Farmer Field Schools of the FAO-EU cotton IPM project could play an important role by generating a better understanding of the true properties of transgenic cotton varieties.

Overall, this study also underlines that one must be careful not to draw far reaching conclusions about the prospects of Bt cotton in India too quickly because 2002 was the first season of commercial use. Nevertheless, the results presented in this study can serve as a starting point for further evaluation. Due to the high diversity of cotton growing in

India more location-specific information is required. Thus, the benefits of conducting more economic studies in other areas would be significant.

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Annex

Annex A-1: Villages in study area

District	Taluka	Village
Belgaum	Bailhongal	Chikkabelligatti
Belgaum	Bailhongal	Govinkoppa
Belgaum	Bailhongal	Gudikatti
Belgaum	Bailhongal	Nayanagar
Belgaum	Bailhongal	Neginhal
Dharwad	Dharwad	Baad
Dharwad	Dharwad	Belligatti
Dharwad	Dharwad	Dasankoppa
Dharwad	Dharwad	Guladkoppa
Dharwad	Dharwad	Hangorki
Dharwad	Dharwad	Heballi
Dharwad	Dharwad	Jirewad
Dharwad	Dharwad	Kallapur
Dharwad	Dharwad	Kallur
Dharwad	Dharwad	Kavalgeri
Dharwad	Dharwad	Kotabagi
Dharwad	Dharwad	Kurabgatti
Dharwad	Dharwad	Kyrakoppa
Dharwad	Dharwad	Mandanbavi
Dharwad	Dharwad	Murkatti
Dharwad	Dharwad	Narendra
Dharwad	Dharwad	Singnalli
Dharwad	Dharwad	Tarakod
Dharwad	Dharwad	Timmapur
Dharwad	Dharwad	Yadwad
Dharwad	Hubi	Varur
Dharwad	Hubli	Agadi
Dharwad	Hubli	Aralikatti
Dharwad	Hubli	Bedanal
Dharwad	Hubli	Belagalli
Dharwad	Hubli	Byahatti
Dharwad	Hubli	Chabbi
Dharwad	Hubli	Gamangatti
Dharwad	Hubli	Karadikoppa
Dharwad	Hubli	Noolvi

Annex A-1 (continued): Villages in study area

Dharwad	Hubli	Pala
Dharwad	Hubli	Palikoppa
Dharwad	Hubli	Unkal
Dharwad	Kalghatagi	Devikoppa
Dharwad	Kalghatagi	Dumwad
Dharwad	Kalghatagi	Gambyapur
Dharwad	Kalghatagi	Jodalli
Dharwad	Kalghatagi	Kurvinkoppa
Dharwad	Kalghatagi	Masrikotti
Dharwad	Kalghatagi	Nagnur
Dharwad	Kalghatagi	Surshattikoppa
Dharwad	Kalghatagi	Tambur
Dharwad	Kalghatagi	Dyamapur
Dharwad	Kalghatagi	Jinnur

Annex A-2: Distribution of variable production cost according to farm size for non-Bt cotton [US$/ha]

Non - Bt	Small	Semi-Medium	Medium	Large
Pesticides	21.00	21.00	35.80	40.40
Fertilizer	39.70	39.70	47.30	50.40
Labour	87.00	87.00	109.30	133.60
Seed	19.70	19.70	17.15	19.50
Irrigation	0	0	27.90	39.80
Input	142.30	142.30	153.80	193.00

Annex A-3: Distribution of variable production cost according to farm size for Bt cotton [US$/ha]

Bt	Small	Semi Medium	Medium	Large
Pesticides	25.9	23.8	21.4	28.1
Fertilizer	53.2	45.4	50.5	55.7
Labour	122.7	85.7	110.9	129.3
Seed	67.5	75.9	72.6	78.2
Irrigation	0	12.6	41.2	47.4
Input	198.7	205.3	228.2	265.4

Annex A-4: Yield of Bt and non-Bt seed cotton, across-farm comparison, 2002

Yield [kg/ha]	Bt cotton	Non-Bt cotton	Only-Bt cotton
Total Yield Av.	1284.4	1160.9	1211.6
Yield (irrigated)	1759.3	1556.1	1818.0
Yield (non-irrigated)	1068.5	1092.9	1033.2

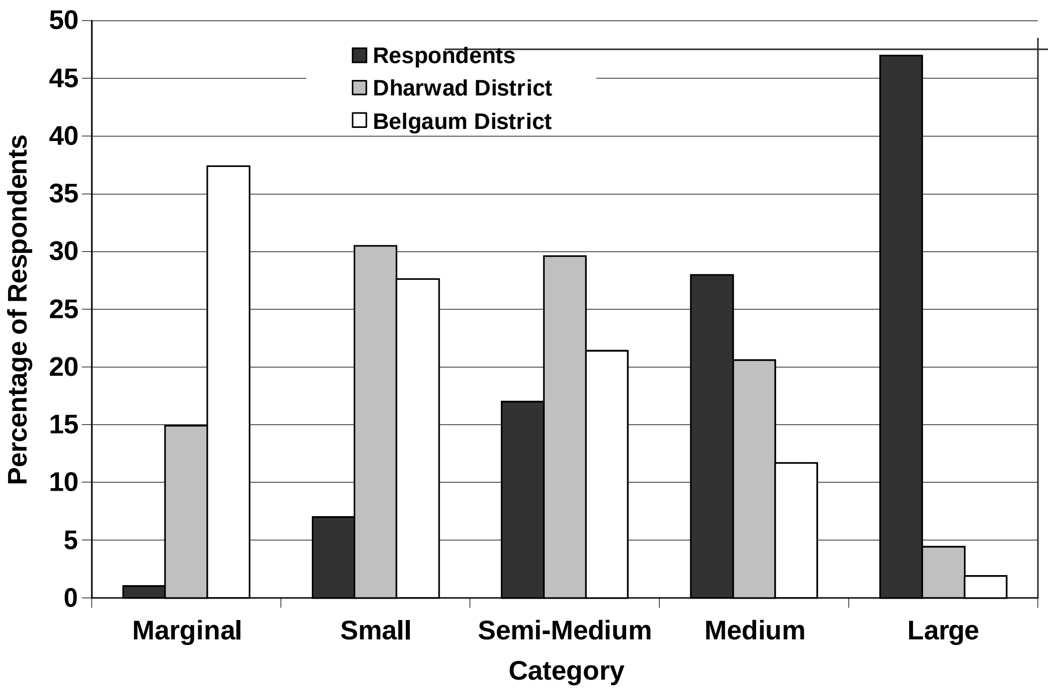
Source: Field Survey, 2002

Annex A-5: Yield of Bt and non-Bt seed cotton, on-farm comparison, 2002

Yield [kg/ha]	Bt cotton	Non-Bt cotton
Total Yield Av.	1390.0.	1160.9
Yield (irrigated)	1682.7	1556.1
Yield (non-irrigated)	1252.9	1092.9

Source: Field Survey, 2002

Figure A-6: Percentage of respondents according to their land holding [ha] in Karnataka districts



Source: Field Survey 2002, Karnataka State Department, 2000

Annex A-7: Sales rates for non-Bt and Bt cotton varieties in Dharwad district 2002 [Rs/qtl]

Date	Taluka	DCH 32		Others		Bt Cotton	
		Rate Start	Rate End	Rate Start	Rate End	Rate Start	Rate End
07-11-02	Kalghatagi	1800	2200	2400	2963		
08-11-02	Dharwad	1872	2749				
	Hubli	1509	2899				
11-11-02	Hubli	1409	3068			1750	1989
	Dharwad	1869	2939				
12-11-02	Kalghatagi	2601	3111	1800	2150		
	Hubli	1509	3079				
13-11-02	Hubli	1581	3092				
14-11-02	Hubli	1669	3070				
15-11-02	Dharwad	1669	2881				
	Hubli	1589	3159				
17-11-02	Dharwad					2291	2389
18-11-02	Hubli	1569	3109				
	Dharwad	1869	2801				
19-11-02	Kalghatagi	1781	2419				
	Hubli	2409	3170	1989	2489		
20-11-02	Hubli	1423	3109				
21-11-02	Hubli	2419	3089	1720	2469		
	Hubli	1600	3119				
22-11-02	Hubli	2400	3170	1900	2460		
23-11-02	Hubli	2069	2489				
	Dharwad	1969	3109			1800	2900
25-11-02	Kalghatagi	2650	3193	1800	2250		
	Hubli	1513	3189				
26-11-02	Hubli	1900	3079				
	Dharwad	1845	2897				
27-11-02	Hubli	1659	3173				
29-11-02	Hubli	1669	3193				
	Bailhongal	2550	3259	2050	2657		
30-11-02	Hubli	1269	2106				
02-12-02	Hubli	1600					
	Hubli	1950	3019				
03-12-11	Hubli	1510	1889				
05-12-11	Kalghatagi	1774	2929				
	Dharwad	1826	1886				

Annex A-7: (continued) Sales rates for non-Bt and Bt cotton varieties in Dharwad district 2002 [Rs/qtl]

07-12-02	Hubli	1969	2859
10-12-02	Hubli	1769	3269

Source: APMC, 2003

Annex A-8: Market prices [Rs/qtl] of cotton in the study area (Dharwad district)

Taluka	Month	Rate Start	Rate End	Mean Rate
Kalghatagi	November	2430	3190	2690
	December	2410	3049	2690
Hubli	November	1032	3189	2439
	December	1539	3309	2860
Dharwad	November	1739	2829	2284
	December	1849	2889	2369
Total Average		1833	3076	2555

Source: Dharwad Cotton Market (APMC), 2003

Annex A-9: Market prices [Rs/qtl] of Bt cotton in Dharwad, 2002

Month	Date	Rate Start	Rate End	Mean Rate
November	11-11-02	1750	1989	1870
	17-11-02	2291	2389	2340
	18-11-02	1660	1939	1800
	25-11-02	1800	2900	2350
December	20-12-02	1409	2189	1799
	31-12-02	1819	1969	1894
January	17-01-03	1889	2159	2024
February	21-02-03	1909	1989	1949
Total Average	-	1816	2190	2003

Source: Retailer, Dharwad, 2002

Annex A-10: Yield of different conventional cotton varieties, 2002

Variety*	Yield [Kg Seed Cotton/ha]
Bt	**1057**
Non-Bt	**943**
Bunny	1002
Brahma	906
DHH 11	1005
Kashinath	856
RCH 2	1335
Sanju	844
Others	758

* Bt Cotton: one variety: Mech-162, the varieties for non-Bt cotton are listed in the table.

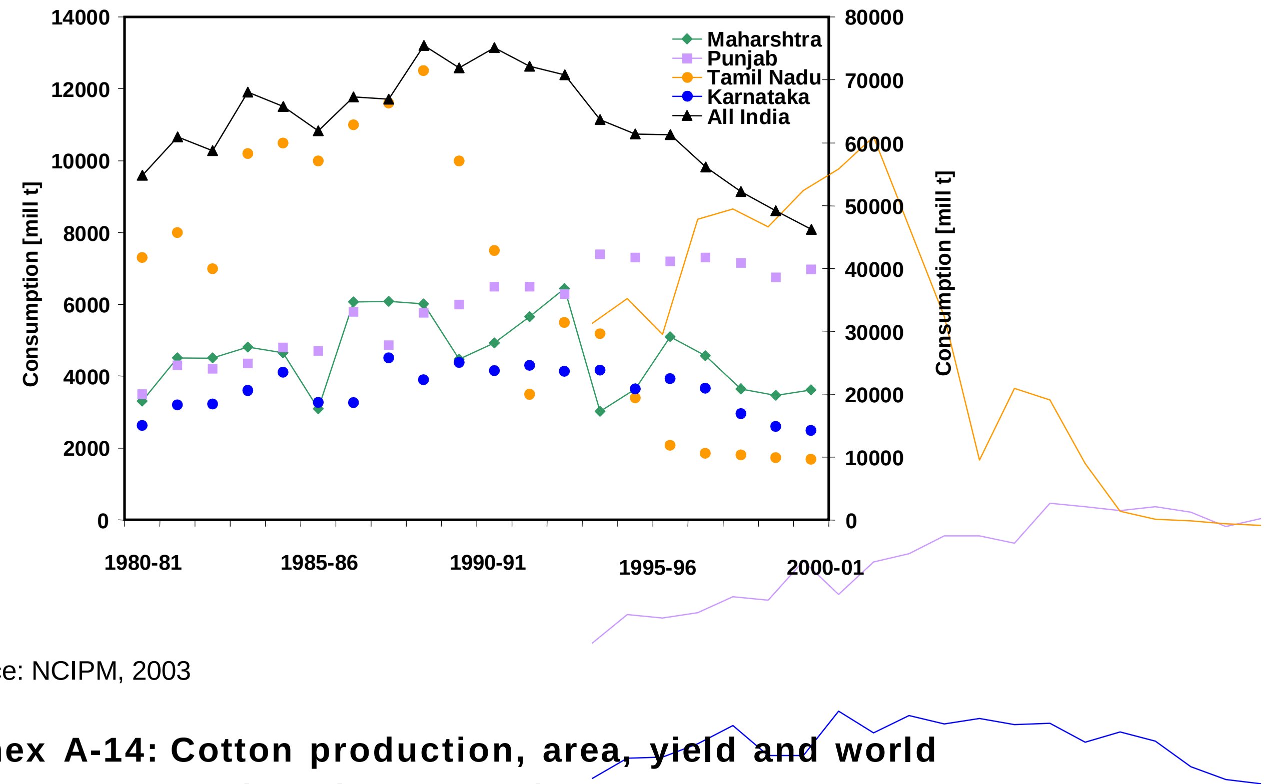
Source: Field Survey, 2002

Annex A-11: Area [mill. ha], production [bales] and yield [kg/ha] of important crops in India

Crops	Area	Production	Yield
Foodgrains	122.7	203.1	1656
Rice	44.8	86.9	1940
Wheat	26.7	72.1	2703
Millet	10.0	8.3	826
Maize	6.4	11.6	1810
Oilseeds	24.6	21.3	866
Sugarcane	4.2	295.8	70578
Cotton	8.9	11.2	214

Source: Statistics at a Glance, 2002

Annex A-13: Pesticide consumption in India and important states [mill. t]



Source: NCIPM, 2003

Annex A-14: Cotton production, area, yield and world market share, 1997/1998

Country	Market Share [%]	Area [mill ha]	Production [t]	Yield [kg/ha]
China	24.5	4.56	4.30	934
USA	16.5	5.37	4.13	769
India	15.2	8.90	2.86	321
Pakistan	7.5	2.89	1.59	552
Egypt	1.3	0.36	0.32	873
Turkey	4.6	0.71	0.75	1065
World	100.0	33.82	19.74	584

Source: Choudhary, 2001

Annex A-15: Productivity of cotton in India [kg/ha] by state

State	90-91	91-92	92-93	93-94	94-95	95-96	96-97	97-98	98-99	99-00
Punjab	424	597	539	339	407	325	367	182	171	340
Haryana	393	488	441	343	355	297	353	234	217	367
Rajasthan	263	393	393	415	366	386	364	337	320	458
Gujarat	275	224	304	365	340	377	382	490	451	392
Maharashtra	92	81	139	91	98	159	182	112	133	199
Madhya Pradesh	494	272	355	397	469	451	605	714	639	471
Andhra Pradesh	461	474	514	637	662	440	447	495	4242	430
Karnataka	248	260	322	240	265	240	229	213	237	257
Tamil Nadu	373	370	405	407	375	321	360	353	425	374
Mean	267	268	316	282	298	293	327	305	266	333

Source: Cotton Corporation of India, 2003

Annex A-16: Area [mill ha] under different species and hybrids in India

Total Area	G.hirsutum	G.barbadense	G.arboreum	G.herbaceum	Hybrids
Northern Z.	1.14	0	0.20	0	0
	(85)		(15)		
Central Z.	1.19	0	1.04	0.68	1.75
	(26)		(23)	(15)	(36)
Southern Z	0.35	0.01	0.05	0.20	0.95
	(22)	(1)	(3)	(13)	(65)
India	2.68	0.01	1.29	0.88	2.70
	(35.5)	(0.1)	(17)	(11.5)	(36)

Note: The values in brackets show the percentage of cotton area in the respective zone

Source: Basu, Paroda, 1995

Annex A-18: Estimates of area and production of cotton from 1997/1998 to 1999/2000 (by lint quality)

[area in 100,000 hectares, production in 100,000 bales of 170 kg each]

	Area			Production		
Staple Length	1997-98	1998-99	1999-00	1997-98	1998-99	1999-00
1. Long						
i. Superior Long (27 mm & above)	22.0	25.7	24.0	37.4	47.9	35.8
ii. Long (24.5 to 26 mm)	14.2	15.7	14.9	10.9	14.5	15.3
Sub-Total (long)	36.2	41.4	38.9	48.3	62.4	51.1
2. Medium						
i. Superior Medium (22 to 24 mm)	36.7	35.5	32.7	43.9	43.2	44.6
ii. Medium (20 to 21.5 mm)	2.6	2.0	2.0	3.2	2.8	2.5
Sub-Total (medium)	39.3	37.5	34.7	47.1	46.0	47.1
3. Short						
i. Short (19 mm & below)	13.2	14.5	13.5	13.1	14.5	17.1
Total	88.7	93.4	87.1	108.5	122.9	115.3

Source: Cotton Corporation of India, 2003

Annex A-19: Cotton area [1,000 ha] and yield [kg/ha] in Karnataka

Year	Area	Yield
1955-56	1152	47
1960-61	984	69
1965-66	1005	44
1970-71	1142	95
1975-76	1035	87
1980-81	1012	106
1985-86	674	135
1990-91	596	192
1995-96	678	254
1996-97	660	274
1997-98	499	259
1998-99	638	252

Source: Karnataka Statistics, 2000

Annex A-20: Area covered and consumption of pesticides in Karnataka

Year	Area covered under Plant Protection Measures [in 100,000 ha]	Consumption of Pesticides [tons]
1970-71	30.10	2107
1975-76	34.55	1546
1980-81	33.80	2631
1985-86	40.76	3277
1990-91	59.38	4170
1995-96	58.60	3924
2000-01	57.00	2600

Source: Karnataka Statistics, 2000

Annex A-21: Performance of different varieties / hybrids in Karnataka

Region	Seed Cotton Yield [qtl/ha]			
	DHH 11	NHH 44	DHB 105	DCH 32
Dharwad	17.68	8.50	15.05	5.00
Hagari	14.20	10.80	11.30	9.80
Belvatagi	6.10	3.80	7.40	5.20
Bheemarayanagudi	30.03	25.10	-	-
Hanumanamatti	15.70	10.50	21.80	15.80
Siruguppa	16.30	13.50	-	-
Raichur	18.90	18.10	-	-
Arabhavi	14.70	11.65	-	-
Mean	16.40	11.80	14.11	7.25

Source: CICR, 1998

Annex A-22: Bt cotton area in Karnataka, 2002/2003 season

District	Bt cotton-Area [ha] 2002/2003
Haveri	3372
Gadag	363
Bellary	395
Koppal	58
Gulbarga	1184
Raichur	790
Davangere	190
Bijepur	920
Dharwad	***1366***
Mysore	20
Total	**11732**

Source: ISAAA, 2002

Annex A-23: Qualities of some cotton varieties used by respondents

DHB 105

Release Year: 1994-95

Interspecific Hybrid

Yield Potential: 20-25 qtl/ha – irrigated or assured rainfed conditions

tolerant to bollworms

DCH 32

Yield Potential: 16-18 qtl/ha

DHH 11

Release 1996-97

Intra Hirsutum Hybrid

Yield Potential: 25-30 qtl/ha under irrigation, 20 qtl/ha rainfed

Tolerant to bollworms

Big boll size (5g)

RCH 2

Intra Hirsutum Cotton Hybrid

Medium duration (155-165 days)

Big boll size (5g)

Tolerant to bollworms

Yield Potential: 15-18 qtl/ha irrigated, 8-10 qtl/ha rainfed

Source: Dharwad University, 2003b, Venugopal, 2002

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