Final Report

BIOTECHNOLOGY IN AGRICULTURE:
POTENTIAL, PERFORMANCE AND CONCERNS

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Chapter 1: Introduction

Given the increasing demand, slowing production growth, and rising prices of agricultural commodities, breakthroughs are urgently required in Indian agriculture. In this context, biotechnology offers a huge new potential and promise for breakthroughs and perhaps even a new green revolution. There have been remarkable scientific advances in biotechnology in the recent years and these have made it possible to identify genes, know their functions, and also transfer them from one organism to another. These advances have spanned the entire biological sciences, and are offering numerous possibilities. Some of the major outcomes include the development of innovations such as *Bacillus thuringiensis* Cotton or Bt cotton.

Bt cotton was first developed by Monsanto and is currently one of the most widely grown transgenic crops, now cultivated in numerous countries including United States, China, India, Australia, Argentina, South Africa and Indonesia. The Table below gives a recent update of biotech crops world-wide. The history of commercialized of biotech crops started in 1996 and in a short span of time has reached 160 million hectares in 2011. They are now grown in 29 countries, 19 developing and 10 industrialized, which cover over 60 percent of the world's population.

Cotton is the most important cash crop in India and the country ranks first in cotton area and second in cotton production in the world. About 15 million farmers in the country spread across 10 states are engaged in cotton production and grow cotton on an area of over 10 million hectares. India also holds a prominent position in cotton textile industry in the world, manufacturing cotton textile products for a large number of end uses in India and abroad. Despite being one of the top most cotton countries, the cotton yields in India are one of the lowest in the world. A major reason for the low yields is the susceptibility to severe insect pest attacks which cause 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.

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 insect pests which cause severe damage to the crop. This became apparent as a huge problem, especially from 1993-94 onwards, leading to frequent crop failures and fluctuating and declining yields. Over 150 different insect pests species are reported to attack cotton at various stages of its growth causing sever reductions in yields. This leads to massive pesticide use by farmers, causing substantial environmental harm, and very high cost of cultivation, often with little result. It has been estimated that over 55 per cent of the pesticides sold in the country are used on cotton. As a result of this problem, the cotton farming was in serious trouble in the late 90's/ early 2000's and farmers were eagerly looking for a solution. It was at such a time that transgenic Bt cotton varieties became available on the world stage.

However, in India, it was after much hesitation and delay that the Government of India allowed the cultivation of three genetically modified Bt cotton hybrids in India in April 2002 for a period of three years. This was preceded by the controversial unauthorized introduction of Bt cotton hybrids in some areas of the country. Actually, the analysis from several years of Indian trial data had demonstrated the superiority of Bt technology in terms reduced pesticides application and increase in effective yields. 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 known to be satisfactory in government circles, there is discontent in other 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 fiber 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 very rapidly in India and elsewhere and farmers in developing countries have widely adopted the 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.

At the request of Ministry of Agriculture, Government of India, the Centre for Management in Agriculture (CMA), Indian Institute of Management, Ahmedabad (IIMA) had undertaken a coordinated study on the performance of Bt cotton during 2004-05 in four states namely Andhra Pradesh, Gujarat, Maharashtra and Tamil Nadu. CMA played a lead role and the study was conducted in cooperation the Agro-Economic Research Centres (AERC) in the above four states. The study dispelled a number of doubts and demonstrated the strong advantage of the technology. Besides, after its approval, Bt cotton has become extremely popular with the farmers, and helped substantially raise production and incomes, and even bring a second green revolution in some states.

However, biotechnology has continued to be controversial and is still seriously questioned. Other biotechnology innovations for agriculture have faced much resistance, and have yet to be officially approved for use. In light of these concerns, the Ministry of Agriculture, Government of India has requested CMA to re-visit the topic and conduct a fresh study on the performance of Bt cotton in India. The present study, conducted entirely by CMA-IIMA, examines this issue but also takes a broader look at the potential, performance and concerns of biotechnology for India's agriculture.

Questions and Objectives of the Research

In this context the following are some of the important questions:

- What is the promise and potential of biotechnology for agriculture and are these promises important for India?
- What is the performance of agri-biotechnology vs its promise. Does bio-technology make economic sense for India?
- What are the concerns and the nature of the risk-perception and resistance faced by biotechnology, and the reality regarding the possible harm/ risks?
- What are the challenges, and what should be the approach and policy of the country given the findings?

The broad objective of the research is to make an assessment of the benefits and concerns of agri-biotechnology in the context of India within the given constraints of time and resources. In this context, it examines the actual performance and record of biotechnology in India in physical and economic terms (which can only be examined for Bt cotton), and the record elsewhere. It also explores the reasons behind the resistance to agri-biotechnology in India, including the risk perception of the people. Based on this, it seeks to suggest policies and path action in the future for agri-biotechnology in India.

The research first surveys the available literature on the promise, performance and concerns of agri-biotechnology, also using secondary data for India. It the examines the issues of performance and concerns through primary data collected from four major cotton growing states of Andhra Pradesh, Gujarat, Maharashtra and Punjab. Where it is possible, statistical and econometric techniques are used for in-depth analysis. The study derives conclusions and possible implications for policies and path of action for biotechnology in India.

Chapter 2: Biotechnology, the Development of Bt Cotton, and Framework for Technology Adoption

There have been remarkable advances in biotechnology in the recent years and these have made it possible to identify genes, know their functions, and even transfer them from one organism to another. These advances have spanned the entire biological sciences, and are offering numerous possibilities. One of the major outcomes has been the development of innovations such as *Bacillus thuringiensis* Cotton or Bt cotton.

Bt cotton was first developed by Monsanto and it is currently one of the most widely grown transgenic crops, now grown in numerous countries including United States, China, India, Australia, Argentina, South Africa and Indonesia. The Table below gives a recent update of biotech crops world-wide. The history of commercialized of biotech crops started in 1996 and in a short span of time has reached160 million hectares in 2011. They are now grown in 29 countries, 19 developing and 10 industrialized, which covering over 60 percent of the world's population.

Table 2.1: Global Area of Biotech Crops in 2011: by Country (Million Hectares)

Rank	Country	Area	Biotech Crops
1	USA	69.0	Maize, Soyabean, Cotton, Canola, Sugarbeet, Alfalfa, Papaya, Squash
2	Brazil	30.3	Soyabean, Maize, Cotton
3	Argentina	23.7	Soyabean, Maize, Cotton
4	India	10.6	Cotton
5	Canada	10.4	Canola, Maize, Soyabean, Sugarbeet
6	China	3.9	Cotton, Papaya, Poplar, Tomato, Sweet pepper
7	Praguay	2.8	Soyabean
8	Pakistan	2.6	Cotton
9	South Africa	2.3	Maize, Soyabean, Cotton
10	Uruguay	1.3	Soyabean, Maize
11	Bolivia	0.9	Soyabean
12	Australia	0.7	Cotton, Canola
13	Philippines	0.6	Maize
14	Myanmar	0.3	Cotton
15	Burkina Faso	0.3	Cotton
16	Mexico	0.2	Cotton, Soyabean
17	Spain	0.1	Maize

18	Colombia	<0.1	Cotton
19	Chile	<0.1	Maize, Soyabean, Canola
20	Honduras	<0.1	Maize
21	Portugal	<0.1	Maize
22	Czech Republic	<0.1	Maize
23	Poland	<0.1	Maize
24	Egypt	<0.1	Maize
25	Slovakia	<0.1	Maize
26	Romania	<0.1	Maize
27	Sweden	<0.1	Potato
28	Costa Rica	<0.1	Cotton, Soyabean
29	Germany	<0.1	Potato
	Total	160.0	
Source: James, Clive (ISAAA) 2011.			

The Promises of Agri-Biotechnology: Are these important to India?

What are the major advantages and breakthroughs that biotechnology can offer to agriculture in India, and are these important for India? Some observations on this are given in Table 2 below. One of the most important benefits that biotechnology can bring to many crops in India is the resistance to pests and diseases. Many of these pests and diseases currently cause severe loss to crop production. Currently highly toxic pesticides are often used against these pests and diseases, and biotechnology offers a major advantage of reducing pesticide use and therefore the environmental harm that they are causing.

Table 2.2: The Potential of Agri-Biotechnology

- Resistance to pests and diseases
  - Reduce pesticide use
- Increase yields/ production/ incomes
  - Reduce production cost
  - Increase competitiveness
  - Reduce area required
- Improve output quality
  - Nutritionally-enrichment
  - Reduce fats/ harmful fats
  - Reduce allergens
- Herbicide tolerance
  - Weed control
- Drought tolerance
  - Reduce water use
- Salinity tolerance
- Soil fertility - nutrient availability/ efficiency
  - Reduce fertilizer use/ runoff
- Shelf-life enhancement
  - Food that last longer
- Renewable energy
- Biodegradable manufacturing materials

Source: The Biotechnology Promise, United Nations (2004)

Another major advantage that biotechnology can offer is increase in yields and through this increase in production, exports and incomes. Currently with growing demand for food and agriculture products, and rising prices of food, breakthroughs are urgently required and many biotechnology applications have the potential of providing these breakthroughs. This would also contribute to reducing production costs in India increase our competitiveness, and even reduce the area required for production, thereby reducing environmental harm.

Another major possibility that biotechnology offers is improvement in the output quality. This may include a nutritional enrichment (such as vitamin A and iron), reduction in fats or harmful fats in the food, and reducing allergens, which cause allergic reactions. Weeds are a serious problem in agriculture and often compete and substantially reduce the yields. Biotechnology can provide herbicide tolerance which can be used along with herbicides to effectively control weeds. This is becoming particularly important in view of rising labor costs.

Large areas in India and around the world face the threat of recurrent droughts leading to food scarcity and famine situations. Advances in biotechnology can provide drought tolerance to crops, which will reduce such consequences and would also help in reducing the use of water which is becoming an extremely scarce resource. Biotechnology can incorporate salt tolerance in plants which would be a boon for large areas affected by salinity. Biotechnology can also help to reduce fertilizer use and runoff by improving the nutrient availability and absorption efficiency of plants in the soil.

Biotechnology can also contribute to enhancement of the shelf-life of food, making food products last longer and, thereby reducing wastage. Biotechnology also offers the promise of creating new sources of renewable energy which are urgently required due to rising energy costs, and they can also help reduce biodegradable materials for manufacturing which could contribute significantly to reducing environmental harm.

Literature Survey on the Promise of Biotechnology

Beddington (2010), states that long range factors like population increase, urbanization, rising demand for energy, water and land, economic changes, climate change, and environmental concerns like maintaining soil and water quality and biodiversity conversation will add to the pressure on food production.

Tester and Langridge (2010) stressed that more food with improved nutrient content is required to feed the growing population. This has to be achieved with lesser use of nitrogenous fertilizers to address environmental concerns. They also highlighted that while breeding and agronomic improvements achieved an average growth rate of 32 million metric tons per year, to meet the increased demand and global food security an average growth rate of 44 million metric tons per year is required. Higher yields have to be stabilized and sustained, for the fertile as well as low yield or stressed environments.

Crop breeding for improved varieties and hybrids with higher yield potential and traits for biotic and abiotic stresses have been in vogue for the past several decades. However, conventional breeding requires many years and multiple sites for evaluating yield improvement and yield stability (Tester and Langridge, 2010).

Biotechnology holds promise in addressing most of the above issues. Some of the advantages of biotechnology that we would like to emphasise can be enumerated as below:

1. **Increase in crop production by increasing yields** – Edgerton (2009), demonstrates that maize yields in US can be increased by agronomic practices, marker-assisted breeding, and biotechnology traits. Yield increases due to agronomic practices are expected to continue at historical rates but enhanced yields are possible due to biotechnology traits, which can potentially double the productivity.

2. **Reduction in the use of chemical pesticides** – Gaur and Choudhary (2010) have shown that before the advent of Bt cotton in India in 1998, cotton accounted for 30% of the total pesticide market and 42% of insecticide market in India. In 2006, the share of cotton in the Indian pesticide and insecticide market fell to 18% and 28% respectively. The number of sprays reduced by 36 to 50% in case of Bt cotton compared to non Bt-cotton, with comparable reduction in the cost of pesticides. (Gandhi and Namboodiri, 2006).

3. **Resistance to pests and diseases** – In crops like rice, traits such as resistance to pests like yellow stem borer, brown plant hopper; resistance to diseases like blast, sheath blight, bacterial leaf blith, Tungro etc., can be transferred from wild species to cultivated species using biotechnology. (Khush and Brar, 2003).

4. **Improving crop tolerance to environmental problems like droughts, floods, salinity** – Gill and Tuteja (2010) suggested use of biotechnology to develop traits in rice, tobacco, tomato, apple, pears, for tolerance to salinity, temperature extremes, and drought. Genes which release chemicals called phytoamines are considered to enable plants to withstand abiotic stresses and these can be incorporated in crops to make them sturdier, especially in the wake of global climate change.

5. **Enhanced nutrient content** – Biofortification is considered to be the most effective and low cost method of tackling micronutrient malnutrition without necessitating any change in dietary habits. Biotechnology was used to increase the content of iron and β carotene in rice by incorporating genes from different sources like beans, daffodils and soybeans. (Khush, 2002).

6. **Enhancing shelf life of food and food products to reduce wastage** – One of the foremost applications of biotechnology in agriculture was to prolong the shelf life of tomato. India loses almost 35-40% of fruits and vegetable production due to excessive softening. Softening aggravates the condition of the produce during transportation, handling and eventually adversely impacts consumer preference and taste. Meli, Ghosh, Prabha, Chakraborty, Chakraborty & Datta (2010) demonstrated that transgenic tomato had firmer fruits and shelf-life was enhanced by around 30 days as compared to non-transgenic tomato.

Biotechnology thus not just holds promise of increasing yields or incorporating pest and disease resistance, but covers the gamut of food value chain aspects like post-harvest handling, extended preservation and nutrition enhancement. Crops having better nutrient absorption abilities and resistance to pests reduce the need for agricultural inputs like chemical fertilizers and pesticides, thereby addressing environmental concerns and in a way reducing the CO_2 emissions that result during the manufacture of these chemicals. These benefits of biotechnology are of high relevance to India.

Background of Bt Cotton

There is, however, much controversy surrounding biotechnology, and in India, the implementation of biotechnology except for Bt cotton has not been possible so far. Bt cotton is the only GM crop of which the field performance can be evaluated in India. Cotton is a major cash crop and is grown under rainfed as well as irrigated conditions in a number of states in India. Until recently, the pest problem was one of the worst in cotton among all crops in India, and the yields of cotton were very low and uncertain. The main pest is the boll worm, and the largest quantities of pesticides among all crops were being applied to control this pest – frequently with little success, and often leading to farmer suicides. Cotton cultivation had become uneconomic in many parts of the country, and it was under this background, after much hesitation, that Bt cotton was approved for cultivation in the country in 2002.

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, the bacterial gene was introduced genetically into the cotton genome, and it protects the plants from bollworms, 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 Table 2.3 and 2.4.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 2.3: Initial Progress of Field Trials and Commercial Releases of Bt Cotton Around the World

Argentina	Approved in 2001. By 2005–6 sown on around 13% of the total cotton area.
Australia	Introduced in 1996. By 2002–3 accounts for around 30% of total cotton crop. This increases to 80% in 2004–5 with the release of Monsanto's Bollgard II variety.
Brazil	Field trials approved in March 2005. Smuggling of Bt cotton seeds from Argentina and Paraguay is widespread. At least 5% of the 1.3 million tons produced in the 2005–6 season comes from "black market" Bt varieties.
China	Released in 1997. Now planted on well over half of the national cotton area.
Colombia	Imported by Monsanto in 2002, without environmental clearance. Legal action results in the suspension of the authorization.
Costa Rica	Monsanto began field trials without regulatory oversight in 1992. By 2004, 638 ha 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 in 2002. By 2004, Bt cotton accounts for 6% of total cotton area and is only permitted for cultivation in six states. In 2006–7, Monsanto begins sales of Bollgard II.
Indonesia	Introduced in South Sulawesi province in 2001. 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 subsidizes 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.
Pakistan	In May 2005 the Pakistan Atomic Energy Commission provides 40,000 kg of Bt cotton seed to farmers in the Punjab.

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.
Senegal	Irregular field trials later abandoned.
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
Thailand	Field tests in 1997. Abandoned after mass protests.
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 2.4 : Adoption of Bt Cotton in Major Cotton Growing Countries

Country	1996	1997	1998	1999	2000	2001	2002	2003	2006	2008
USA	√	√	√	√	√	√	√	√	√	√
Australia	√	√	√	√	√	√	√	√	√	√
China		√	√	√	√	√	√	√	√	√
India							√	√	√	√
Indonesia							√	√	√	√
Mexico	√	√	√	√	√	√	√	√	√	√
Argentina			√	√	√	√	√	√	√	√
Colombia							√	√	√	√
South Africa		√	√	√	√	√	√	√	√	√
Brazil									√	√
Burkina Faso										√

Source: James C (2003), Preview: Global Status of Commercial Transgenic Crops:2003, ISAAA Brief No. 30, Ithaca, NY
James C (2008) Global Status of Commercialized Biotech/GM Crops: 2008. ISAAA Brief No. 39. ISAAA: Ithaca, NY.

Early Literature on Bt Cotton

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 insecticide 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.

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 in China 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 nor 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.

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.

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.

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.

Biotechnology has been controversial and seriously questioned in India, and even though, after its approval in 2002, Bt cotton has become very popular with the farmers, helping to substantially raise production and incomes, and bring a second green revolution in some states, new biotechnology innovations for agriculture have faced much resistance, and have yet to be officially approved.

Some of the voices for and against Bt cotton are summarized below (see Table 4).

Reported advantages of Bt Cotton:

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

Reported criticisms or disadvantages of Bt Cotton:

- The gene may spread and its impact in the eco-system is not known.
- The Bt Cotton seed is expensive compared to Non-Bt seeds for the farmers and some companies may have a monopoly in seed multiplication and sales.
- Even on Bt cotton the farmers may require to use insecticides as in non-Bt cotton.
- The Bt cotton seed oil and cake will cause harm and Bt may enter in the human food chain.
- Farmers will have to purchase Bt cotton seeds every year.
- Transgenic crop varieties will lead to the destruction of the native crop of the country.
- Insects will soon develop resistance to Bt Cotton and the control of boll worms will become more difficulty in the near future.

Table 2.5: Voices for and against Bt Cotton	
Voices For	Voices Against
ɷ Resistant to Boll Worms – is a devastating pest ɷ Reduces the use of pesticides ɷ Better yields ɷ Cuts pesticide cost ɷ Increases profitability ɷ Reduces the harm to environment and people ɷ Lesser residue of pesticides ɷ Better fibre quality	ɷ The gene can spread, impact on the eco-system not known ɷ Benefits of pest resistance and yield doubtful, exaggerated, little profit ɷ Seed very expensive/ MNC ɷ Still requires the use of insecticides ɷ Seed cake and oil may cause harm ɷ Some think Bt Cotton has the terminator gene ɷ Will cause destruction of the native crop ɷ Insects will soon develop resistance

Literature Survey on the Performance of Bt Cotton & the Concerns

The performance of Bt cotton is an outcome of interplay of different factors involving the technology, variety, crop growing climate, pest incidence, and resources at the farmer's disposal. The most prominent advantages of Bt cotton include increase in productivity and reduction in use of insecticides. This has been demonstrated across geography and time both at macro and micro level. Several cross sectional and longitudinal studies have been studied here to establish that the direct benefits of Bt cotton are increased yields and profits, particularly in India which is dominated by resource-constrained farmers.

Direct Benefits of Bt Cotton

After the advent of Bt cotton in India in 2002 and its steady and steep adoption at the macro level, the average yield of cotton in India increased from 308 kg per hectare in 2001-02 to 526 kg per hectare in 2008-09. Consequently, cotton production in India rose from 15.8 million bales in 2001-02 to 31.5 million bales in 2007-08. The country turned from a small exporter of cotton (0.05 million bales) in 2001-02 to a prominently player exporting 8.8 million bales in 2007-08. (Chaudhary and Gaur, 2010).

A cross sectional survey by Gandhi and Namboodiri (2006) of 694 cotton farmers in the major cotton growing states of Gujarat, Maharashtra and Andhra Pradesh found higher yields (30.7%), lower pesticide consumption and higher profit (87.6%) associated with the cultivation of Bt cotton compared to non-Bt cotton.

A similar study across the states of Andhra Pradesh, Maharashtra, Karnataka and Tamil Nadu, covering 341 farmers showed insecticide use reduction by 50%, 34% higher yields, and higher profits despite higher seed cost. (Qaim et al, 2006).

It may be said that the advantages of Bt cotton have not been a one off incident but have been demonstrated almost every year since its first commercialization. Stone (2010), published a longitudinal study conducted between 2003 and 2007 in Warangal district of Andhra Pradesh, which is a major cotton growing region. The study indicates that cotton yields increased by 18% across the sample villages. The yield increases were high in villages where the non-Bt cotton yields were low before the use of Bt cotton and not as high in villages where farmers adopted better pest control practices before Bt cotton. Hence the aggregate yields appear at 18%, though the highest yield in one sample village was 60%.

When it comes to reduction in pesticide usage, the study conducted by Stone (2010) shows that the mean sprayings dropped by 54.7% in the sample villages. Since this was a longitudinal study, it holds greater relevance since it documents the benefits over a period of time.

A panel study by Krishna and Qaim (2012) conducted between 2002 and 2008 indicates that the decline in pesticide usage in Bt cotton has been sustainable. Despite an increase in sprayings for sucking pests, the total use of pesticide has significantly decreased over time.

Zilberman, Ameden and Qaim (2007) analysed several earlier studies and found that transgenic varieties resulted in higher yield increases in countries where pesticide usage was low and pest infestation was high, as in case of India. They further highlight that farmers in low-income countries are risk averse and are willing to pay a premium to reduce the risk they face. Since transgenic varieties of cotton lead to reduction in usage of pesticide and can counter the unknown probability of pest incidence, they not only find cultivating Bt cotton more profitable but also as an insurance against the risk of high pest attack. Since Bt as a technology is scale neutral, it is all the more useful for small farmers.

Rao (2013) examines the data and methodological issues related to the reported yield advantage of Bt cotton vs non-Bt cotton in various studies and indicates that often the other differences across the sample farmers are not accounted for, which can lead to over-estimation of the yield advantage. This would happen if more efficient farmers adopting the technology are compared with less efficient farmers not adopting the technology, as indicated by Stone (2011). However, Rao (2013) finds that several studies have specifically tried to overcome this problem, and the Bt effect on yield after isolating germplasm and farmer effects is still found to be positive.

Indirect Benefits of Bt Cotton

The advantages of cultivating Bt cotton are not just limited to the farmer, but extend to other actors and factors in the rural economy.

The first impact of any increase in income on a sustained basis is a change in consumption pattern, which is typically expected to increase. At an aggregate level, increase in expenditure of individual households is a key that drives the economy. Kathage and Qaim (2012) surveyed cotton farmers between 2002 and 2008 in four waves with a 2 year interval. These were panel surveys in the states of Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu, covering 63 villages in 10 different districts to assess the consumption expenditure as an outcome of using the Bt technology. In the initial phase, between 2002 and 2004, though the adoption rate of Bt and profit increased among farming households, there was no significant change in the consumption behaviour of the households adopting Bt cotton. However, in the period between 2006 and 2008, the annual consumption of Bt-adopting households increased by an average of Rs.15,841. This was 18% higher compared to non-adopters of Bt cotton. The authors deduce that farmers assessed the high yields and corresponding higher profits in the initial phase of Bt cotton adoption and only when they found the increase sustainable, did their consumption expenditure rise.

Subramanian and Qaim (2009) used Micro Social Accounting Matrix (SAM) model to evaluate the impact of Bt cotton on small farmers and others in the rural ecosystem. Usage of Bt cotton resulted in increased in aggregate labour returns by 42%, even as the same figure increases to 55% for hired female labourers. Their study found that poor and “vulnerable” farmers gained more from Bt cotton cultivation as their incomes were 134% higher compared to returns from non-Bt cotton. It can hence be inferred that Bt technology is equally, if not more, useful for betterment of poor farmers but also agricultural workers.

Concerns about Bt Technology

Some prominent concerns about Bt technology are its impact on non-target insects like honey bees, and effect on biodiversity.

Honey bees are extremely important pollinators for a large number of crops and their declining population is leading to anxiety. Duan et al (2008) did a meta-analysis of 25 labora42 studies covering Bt cotton and maize to assess the impact of Bt crops in general on honey bees. The studies did not report any significant effect of Bt toxin on the larval as well as adult stages of honey bees. Further, since the studies were in lab conditions and involved exposure of honey bees to much higher doses of the toxin than in field conditions, the absence of any adverse effect was found to be more reassuring about the safety of Bt technology. The studies were not restricted to survival of honey bees alone, but also assessed the impact on growth and development of the insect and the results did not suggest any adverse effect.

Another meta-analysis by Naranjo (2009) involved 135 laboratory-based and 63 field-based studies on non-target invertebrates. The lab findings indicated more hazards to non-target invertebrates than in the field. However, it is clearly mentioned that different taxa were studied in the two different situations, thus the comparison is not representative.

As regards to the biodiversity, the approval for commercial cultivation of more than 500 hybrids of Bt cotton in India by 2009 (Chaudhary & Gaur, 2010) sufficiently indicates that within the hybrid segment alone, there exists a broad range of cultivars.

Zilberman, Ameden and Qaim (2007) argue that the replacement of traditional varieties with a single generic transgenic variety will lead to a tremendous loss of biodiversity. However, if local transgenic varieties are abundantly grown along with generic transgenic varieties, the biodiversity would be maintained. By local transgenic varieties, the scientists imply the transgenic version of a local variety that farmers have been cultivating in a particular geography. They also cite various other factors include price of the seed of local transgenic versus generic transgenic, the strength of plant breeding sector in a country, regulatory practices, and marketing and distribution facilities for different transgenic varieties that could have an impact on biodiversity. When this model is evaluated against the number of commercially available Bt variants of cotton in India, it may be safely inferred that the biodiversity of cotton still remains vibrant.

Another major concern that is usually associated with Bt cotton is the resistance developed by the target insects, specifically the bollworms. Surprisingly, one of the earliest reports of the pink bollworm developing resistance to Bt cotton in India was reported by the pioneer of the technology, Monsanto. Monsanto, on their part, advised adoption of recommended cultural practices by farmers like planting refugia (non-Bt variants of the Bt variety) and need-based use of insecticide. The company also claimed that this problem could be overcome by use of an advanced Bt technology branded as Bollgard II, which contained Cry1Ac and Cry2Ab genes. Activist groups however trashed this as a ploy by Monsanto to sell its new technology.

Li, G.P. et al (2007) conducted bioassays of two generations of *Helicoverpa armigera* and observed that the tolerance to the Cry1Ac toxin was increasing in the field populations. The scientists indicated the resistance could increase over a period of 11-15 years unless effective resistance management steps were not taken.Lin et al (2013) conducted another set of studies involving *Helicoverpa armigera* from two difference provinces in China and found that the pest had developed resistance to Cry1Ac and Cry2Ab.

Ranjith M.T., Prabhuraj A., and Srinivasa Y.B. (2010) reported survival of *Helicoverpa armigera* on commercial Bt cotton hybrids containing Cry1Ac as well as the combination of Cry1Ac and Cry2Ab in experimental plots. It was observed that the species were also able to complete their life cycle and reproduce on non-Bt as well as Bt hyrbids. Although the survival of larvae and pupa weight were highest on non-Bt hybrids, the same parameters were not significantly low on Bollgard I (Cry1Ac) and Bollgard II (Cry1Ac and Cry2Ab) either.

A report in the Times of India quoting the work done by Tabashnik, Carriere and Brevault (2013), which was spread across eight countries and 13 pest species, analysing data from 77 studies, stated that the efficacy of Bt crops was based on “evolutionary theory”. The scientists reported that planting of refuges abundantly was necessary to “delay resistance substantially”. Does this mean that Bt technology has failed to live up to its promise and may as well be banned? The fact the farmers have made substantial profits cultivating Bt cotton across the world is too relevant and important to be overlooked while taking a decision against Bt cotton (Kathage, 2013). Scientists have instead suggested methods involving advanced genetic research and cultural practices to sustain the efficacy of Bt cotton against the bollworms.

Tabashnik (2008) explained that growing refuge crop alongside the transgenic is important to delay build-up of resistance in pests against Bt toxin. Soberon et at (2007) suggested that modified Bt toxin of Cry1Ac using “cadherin” gene promoted resistance to Bt cotton as compared to native Cry1Ac.

Risk Perceptions of Biotechnology

Although agriculture is a source of food, feed, fibre and also fuel to an extent, food takes the centre stage as a bulk of agricultural production goes towards satisfying human hunger and nutritional requirements. An increasing global population with higher disposable incomes will be the major demand driver for food in the coming decades. Increased urbanization, sedentary lifestyle, accessibility to imported and exotic foods, better affordability, and proliferation of transnational food companies like McDonald’s, KFC, etc., might result in higher incidence of nutrition-related non-communicable diseases (NR NCDs) like diabetes, obesity. On the other hand, increased life expectancy, health consciousness and environmental concern among consumers might lead to demand for functional foods (fortified, enriched etc.) and organically grown foods. Despite a growing clamour for organic foods, it may not be possible to meet such demand as the yields of organic agriculture are lower than conventional methods. Biotechnology in the form of GM crops holds the promise of improved quality and quantity of agricultural production, but with questions on human and environmental safety (Kearney, 2014).

Besides a change in consumer lifestyles and preferences, agriculture faces a tough challenge from climate change and land-related abiotic stresses. While biotechnology has been used to address biotic stresses like insect-tolerance and herbicide-resistance, molecular genetic modification can be coupled with conventional breeding to develop cultivars to tolerate temperature extremes, floods and salinity (Fedoroff et al., 2010).

There seems to be an undercurrent that supports the necessity of biotechnology in agriculture, standalone or coupled with conventional farming. However, the popular perception about biotechnology is that it is risky and there is a strong element of mistrust.

Savadori et al., (2004) compared risk perceptions of samples public (non-expert) and experts to the applications of biotechnology. While the public perceived all biotechnology applications as more risky compared to the experts, both groups perceived food-related applications (as in genetically modified seeds for pest resistance) of biotechnology riskier than medical applications (as in genetically modified organisms to produce insulin).

Among the developed economies, the adoption of biotech or transgenic crops has been very high in US while the EU has adopted a highly cautious approach. The health and environmental policies of EU have revolved around “to err on the side of caution” approach. In other words, the EU has followed the precautionary principle, in which case, if there is no scientific certainty, the adoption of technology will be restrictive. When compared with other technologies like telecom, solar energy, computers, new materials and space exploration, respondents in a survey were most apprehensive of biotechnology and felt that it would contribute the least in improving the quality of life (Costa-Font, Mossialos and Costa-Font, 2006).

The 2010 Euro barometer survey on life sciences and biotechnology revealed that nearly 61% of the respondents opposed GM food, and about 23% supported it. Interestingly, with increasing awareness about GM foods, the acceptance was low. This trend was observed in EU and Japan. China, with very low awareness about GM food, showed higher acceptability of GM foods. (Evans & Ballen, 2013).

A 2003 survey in US on consumer attitude towards GM food brought to light the fact that the awareness was low with 45% respondents knowing something and 43% respondents knowing nothing about food biotechnology. Contrasting this was a 2006 survey where 45% Americans were more comfortable about safety of GM foods. The reason for this increase in support for GM food was supposedly due to additional information being provided to consumers. (Evans & Ballen, 2013). However, this premise turns the earlier argument, that higher awareness resulted in lower acceptance of biotech foods, on its head.

In the Indian case, almost 68% of the respondents of a survey supported the introduction of GM vegetables. However, the acceptance of GM vegetables was found to be low with better education and higher exposure to mass media. At the same time, the willingness to pay for residue-free food did not translate into willingness to pay for GM vegetables. (Krishna, & Qaim, 2014).

It may be inferred that safety of food is paramount for the consumer. Wherever the consumer is unable to get scientific backing about the safety for a particular technology, she is sceptical. Increased awareness about biotech products needs greater efforts to clear the apprehensions the consumer may have in her mind about the safety of the technology.

On the other hand, the precautionary principle has its own valid logic, but a policy of zero-risk is inherently flawed as no technology is totally safe. This approach tends to overlook the fact that the consumption of GM crops has been on for more than a decade till now without any adverse incident. (Federoff et al., 2010). The casualty in this process is the growth and development of biotechnology, which is being largely driven by private rather than public investment and the restrictive regulatory regime could hamper further research that might result in answers to the present questions.

Government Policy, Research and Influence

The Green Revolution was driven to a large extent by the public sector with a public research system at the core. The next wave of revolution in agriculture is expected to be driven by biotechnology, which for various reasons has attracted larger investments by the private sector. Fiscal pressures, insufficient human and capital resources are likely to constrain very high public investment in agri-biotech research, particularly in developing countries. Biotech in agricultural research, backed by IPR enforcement, has transformed knowledge from a public good to an excludable good. This has attracted huge private investment in biotech agricultural research and firms were able to develop requisite human, financial and technical capabilities. (Spielman, 2006). Conversely, countries like China, Brazil, India and South Korea have higher public investment in biotech research as they have the scientific wherewithal, an economy where agriculture plays a dominant role and the recognition of biotechnology as a driver of growth. (Pray & Naseem, 2007). However, it is argued that the government remain in the driver's seat as far as agricultural research is concerned but with a framework that regulates and facilitates active participation of the private sector. The international agricultural research system should be restructured such that technology can be developed to benefit the developing countries and the poor. (Spielman, 2006).

The basic framework of governmental policy should aim to minimize risks arising out of biotech research, particularly those to human health and the environment. The Cartagena Protocol on Biosafety can be the best starting point to evolve a sound biotech research structure. Once the government is firmly in saddle, it also has to take up the onus of educating the public about the safety of biotech crops and foods.

Studies have shown that the public perception of risk due to applications of biotechnology can be reduced by providing information on the benefits arising due to the technology. The source of information also plays an important role – information provided by industries was least trusted while that provided by research institutes and environmental groups was most trusted by public. (Savadori et al., 2004). A survey conducted in India, where a majority of the respondents did not know much about GM foods, showed that when benefits like reduced pesticide use or enhanced nutritional levels were cited as benefits of GM foods, an overwhelming proportion (77-85%) of the respondents were willing to consume such foods. (Deodhar, Ganesh & Chern, 2008).

Access to data and information is essential to build trust among various stakeholders. As most of the agri-biotech research is in the private domain, ensuring transparency and making data and information accessible will go a long way in analysis, policy development and eventually building confidence in the technology. Currently, data unavailability of research is constrained due to material-transfer agreements. (Adenle, 2011)

Europe has adopted a bottom-up governance for regulating GM crops, with the presumption that the process would result in democratic decision making. Public engagement in the form of surveys, focus groups and citizen juries was adopted to build a consensual decision-making approach. Despite these initiatives, it was found difficult to build trust. Nevertheless, public engagement is considered to be the only and best way to move ahead with regulating GM crops. (Tait & Barker, 2011).

In the Indian context, the major source of information on GM crops has been media reports, which have largely spread fear and mistrust, even as the debate about GM crops has not gained much prominence in the country. “Gatekeepers” were of the view that consumer awareness in India was low but not negative as in Europe. They also opined that consumers were likely to adopt GM foods if the benefits were conveyed or if such foods were available at a lower price. Even the government has adopted a supportive stance and looks at biotechnology as the source of another green revolution. (Knight & Paradkar, 2008). Thus, the government has to be an enabler of research and analysis, promote transparency and educate the public through reliable information sources that are not seen to be political or industry-influenced.

Reality and the Nature of the Risk Perception

Despite substantial potential and possibilities, biotechnology has faced resistance substantially because of the risk perception that people have about agri-biotechnology. In this context it may be note the experience of the United States, see Table. that in the US, it is estimated that between 70 percent and 75 percent of all processed foods available in the grocery stores may contain ingredients from genetically engineered plants. Breads, cereal, frozen pizzas, hot dogs and soda are just a few of them. Soybeans, cotton and corn dominate the 100 million acres of genetically engineered crops in the US. Soybean oil, cottonseed oil and corn syrup are used extensively in processed foods. Others such as squash, potatoes, and papaya, have been engineered to resist plant diseases. More than 50 biotech food products have been evaluated by the FDA and found to be as safe as conventional foods, including canola oil, corn, potatoes, soybeans, squash, sugar beets and tomatoes.

Table 2.6: Is biotechnology risky? Some facts from the US
ω In the US soybeans, cotton and corn dominate the 100 million acres of genetically engineered crops grown since 1995
ω Soybean oil, cottonseed oil and corn syrup is used extensively in processed foods. Others such as squash, potatoes, and papaya, have been engineered to resist plant diseases. No ill effects or cases have been reported
ω In the US it is estimated that 70 to 75 percent of all processed foods available in the grocery stores may contain ingredients from genetically engineered plants. Breads, cereal, frozen pizzas, hot dogs and soda
ω More than 50 GM food products have been evaluated by the FDA and found to be as safe as conventional foods, including canola oil, corn, potatoes, soybeans, squash, sugar beets and tomatoes.
Source: Knight and Paradkar (2008)

What kind of a role do news-media, NGO's and the government play in the creation of fear perceptions on issues such as biotechnology? (see Table below). Observing the process, Knight and Paradkar (2008) indicate that when there are food health fears that people have and if there is lack of proper information, the media fills the void of information and uncertainty. Alarmist predictions are made, and bad news sells more than good news. There is social amplifications and the over-estimation of the risks of rare events. The view of experts generally differs substantially from the view of the public and the latter seem to carry more weight. Whereas the experts who have substantial scientific knowledge consider many agri-biotechnologies as safe, the public may still believe them to be risky. People are often willing to take substantial lifestyle risks, such as fast driving, but are usually against even the slightest technological risk.

Table 2.7: What is the Role of News-media /NGOs /Govt ?
ω People have food health fears – do not know/ are not sure ω Media fills void of uncertainty ω Alarmist predictions ω Bad news sells more than good news ω Social amplification ω Over-estimate risk of rare events ω Experts vs the Public ω Technological risks vs Lifestyle risks
Source: Knight and Paradkar (2008)

Studies have shown that the risk perception depends on the personality of the hazard and the qualities of the danger, Knight and Paradkar (2008). Familiarity and control can go a long way in reducing the perception of risk. The catastrophic potential of many technologies is almost insignificant and equal to most day-to-day activities – but this needs to be communicated effectively to people. The level of knowledge plays a major role in risk perception, and perceived risks need to be balanced with perceived benefits in effective communications. This can go a long way in the willingness to accept the risks. Developing an understanding of this process of fear and risk perception creation can help substantially in developing an effective approach and strategy for addressing the situation.

Table 2.8: Risk Perception

ω Personality of the hazard/ qualities of the danger
    ω Familiarity
    ω Control
    ω Catastrophic potential
    ω Level of knowledge
ω Perceived risk vs Perceived benefits
ω Willingness to accept the risk

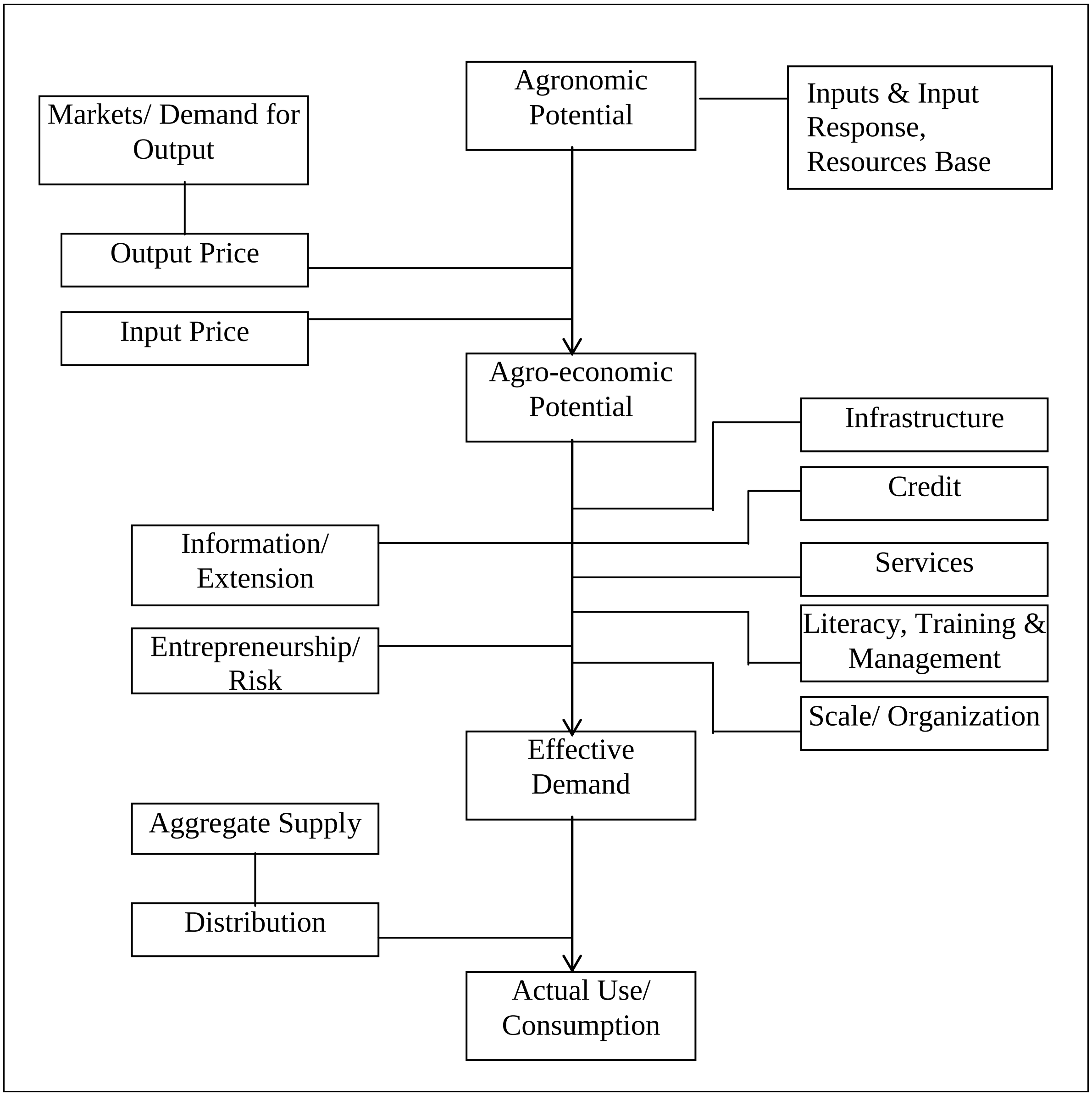
Source: Knight and Paradkar (2008)

Framework to Understand Technology Adoption

Bt cotton has been adopted over time quite readily and there is a vast literature on studying process of adoption of technologies in agriculture. The experience across developing countries on the adoption and growth of new inputs in agriculture indicates that this growth is affected by a large number of factors including price as well as non-price factors (Desai and Stone 1987). The framework of neo-classical economics is frequently unsuitable for explaining this growth in developing countries because these markets are in almost perpetually dis-equilibrium due to numerous shifts. Single factors such as price are found insufficient in explaining this phenomenon. For understanding this growth a more comprehensive analytical framework is required.

Studies to understand the growth and fluctuations of fertilizer consumption in India, China and Sub-Saharan Africa (such as Desai and Stone 1987, Gandhi and Desai 1992, Gandhi and Patel 2001) suggest a more comprehensive framework which can be used for explaining the growth of input use and markets in developing countries. The framework is depicted in Figure 2.1 and described below and can be used for understanding the adoption and growth of technologies such as Bt cotton.

Figure 2.1: A Framework for the Process of Adoption of Technology in Agriculture



Source: Based on Gandhi and Patel (2001), Desai and Stone (1987)

The different elements of the framework are explained below:

Agronomic Potential of an input is its fundamental physical potential. This comes from an input's capacity to produce a physical benefit such as an increase (or saving) in the quantity (or quality) of the output - the input response. The maximum extent to which an input can be used to give a positive physical benefit can be considered it agronomic potential. The available land, and the area planted to different crops is an important basic determinant. Research and development enhances the agronomic potential through development of new varieties, technologies, or agro-chemicals. The approval of the technologies for use by the government may be an important step in creating their potential. The use of complimentary inputs such as water/ irrigation or application of deficient nutrients may help to expand the agronomic potential. The agronomic potential can also increase or decrease over time due to factors such occurrence/ susceptibility/ resistance to pests, variation in rainfall, and other changes in the environment.

Agro-economic Potential: The existence of an agronomic potential is not enough. Farmers use the inputs for earning profits and incomes, and therefore, unless a good economic return is generated, the input would not be used. Thus, the agronomic potential must be transformed to an agro-economic potential. For this the output demand and the output price must be significantly high, and the input price reasonably low, so that a good profit can be made. This may also depend on government price supports and input subsidies, as well as output quality aspects and consumer perception. Due to the economics, more inputs may be used on high value crops, and the input demand will vary with the output demand and prices. The agro-economic potential of some inputs such as farm machinery and herbicides may depend on the cost of labour or animal power which they substitute.

Effective Demand: Existence of an agro-economic potential is necessary but not sufficient for creating an effective demand for the input from the farmers. For this firstly, it is important that the farmers know about this input and its potential, and this may require effective communication through extension, company promotion or other means. Besides, the farmers need to show entrepreneurship and be willing to take the risk of adopting the new technology. Development of infrastructure such as roads, transport and communication is also critical for facilitating information-flow, sourcing and marketing especially for far flung small farmers. Often, credit may also be required due to lack of enough cash at the beginning of the season or when the input is to be purchased. Creation of effective demand may also depend on proper management by farmers, which may call for training on what and how to use, and the package of practices. In this, literacy may also play an important role. Use of some inputs may depend on the necessary scale, land rights or the organization of the farmers.

Aggregate Supply: For businesses and markets to work/ transact, demand must be matched by supply. The creation of an adequate and reliable supply is required, and this needs production and/or imports. Production may require finance, investment and an attractive rate of return. It may also require access to the technology, such as for seeds and agro-chemicals, which may depend on intellectual property rights and royalties. The availability of supply also depends on the nature of the production process and this may be seasonal and farmer dependent such as for seeds. Investment, production and imports may be influenced in a big way by government policies such as for fertilizers.

Distribution: With small farmers and the huge geographic spread of farms, an effective distribution system for inputs is usually a must. This is critical to develop and often goes through stages of government, cooperative and private modes and depends on channel profitability and farmer demand. Factors such as timely availability, quality, credit/ incentives, guidance/ information, and other terms/

services offered by the distribution system also play an important in the growth of the input.

Developments on all these fronts together effectively determine and explain the growth of any agricultural input. Efforts to grow the input use must look at the key determinants and constraints in all the different elements of this framework. It must identify and address particularly the critical constraints to growth. Such a framework can be used to explain and understand the adoption process of Bt cotton in India.

Chapter 3: Cotton Production and Bt Cotton in India

With cultivation of about 12 million hectares, India's cotton acreage is the largest in the world and India is the second largest cotton producer after China. This chapter briefly describes the position of India in world cotton economy, India’s recent performance in cotton production and the performance of cotton production in the four selected states. It also describes the record of Bt cotton adoption in India and the world.

World Cotton Scenario

The world annual production of cotton is estimated be about 100 million bales (one bale equals 480 lbs) (Table 3.1). China occupies the top position with a share of 29 percent of the global production, followed by India with a share of 21.7 percent, and USA has a share of 12.8 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, it ranks lower in 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 3.2). The yield in India is less than one-fourth of some of the high yield smaller producing countries such as Australia, Syria and Greece.

Table 3.1: World Cotton Production: Average for 2008-09 to 2011-12

Sl. No.	Countries	Million Bales of 480 lbs.	Percentage to World Total
1	China	33.175	28.96
2	**India**	**24.825**	**21.67**
3	United States	14.675	12.81
4	Pakistan	9.225	8.05
5	Brazil	7.175	6.26
6	Uzbekistan	4.2	3.67
7	Australia	3.1	2.71
8	African Franc Zone	2.3	2.01
9	Turkey	2.275	1.99

10	Turkmenistan	1.575	1.37
11	EU-27	1.275	1.11
12	Greece	1.075	0.94
13	Mexico	0.75	0.65
14	Burkina	0.75	0.65
15	Mali	0.55	0.48
16	Others	7.625	6.66
	World Total	114.55	100

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

Table 3.2: Area, Production & Yield of Cotton in Major Cotton Producing Countries: 2005

Sl. No.	Countries	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/

Cotton Production in India

This section examines 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 2010-11 has been scrutinized in two periods viz., 1990-91 to 2001-02 and 1990-91 to 2011-12. This is to examine the impact of adoption of Bt cotton in the country initiated in 2002-03 (Table 3.3 and figures 3.1 and 3.2).

Cotton production doubled from 57 lakh bales in 1960/61 to 117 million bales in 1990/91 (bale=170kg), see Table 3.3. However, in the decade 1991/92 to 2001/02, the production growth rate decelerated to -0.422 percent, much of this due to yields, which show a growth rate of -2.442 percent in this period, indicating a problem with the technology. However, the area growth rate was 2.01 percent, indicating that the crop still found favor with the farmers.

Since the introduction of Bt cotton in 2002, the performance shows a substantial turn around, see Table 3.3 and Figure 3.1. The production growth rate shot up to 13.14 percent and yield growth rate to 9.57 percent. Even the area has grown at 3.17 since the introduction of Bt cotton and 5.13 percent in the last 6 years, with some deceleration in the yield growth rate.

Table 3.3: 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	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	258.8	94.1	467
2008-09	228.8	94.1	413

2009-10	240.2	101.3	403
2010-11	330	112.4	499
2011-12**	361	119.9	512
Annual Growth Rates			
1981/82-2001/02	2.657	1.090	1.566
1991/92-2001/02	-0.422	2.015	-2.442
2001/02-2011/12	13.148	3.577	9.578
2005/06-2011/12	9.683	5.138	4.558
**First Advance Estimates released on 14.09.2011 Source: Directorate of Economics and Statistics, Department of Agriculture and Cooperation.			

Figure 3.1: Production and Area of Cotton in India

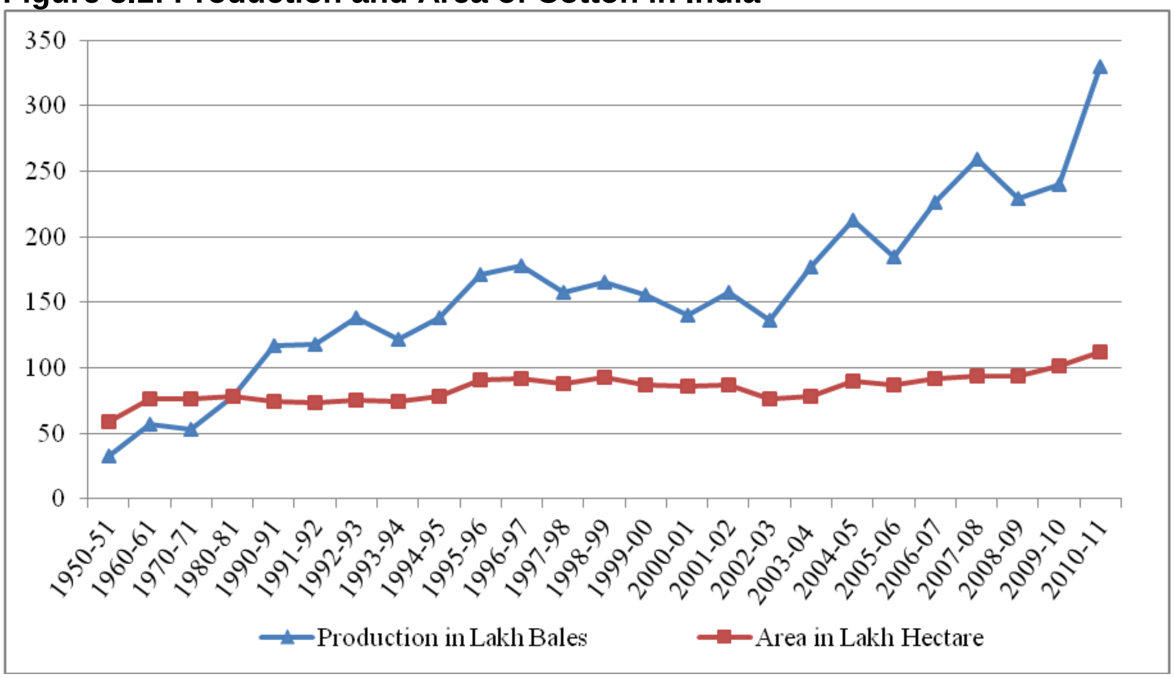


Figure 3.2: Yield of Cotton in India (Kg / Ha)

Cotton Area, Production and Yield of Cotton Across States

Based on cotton production during the 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 (Table 3.4). 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.

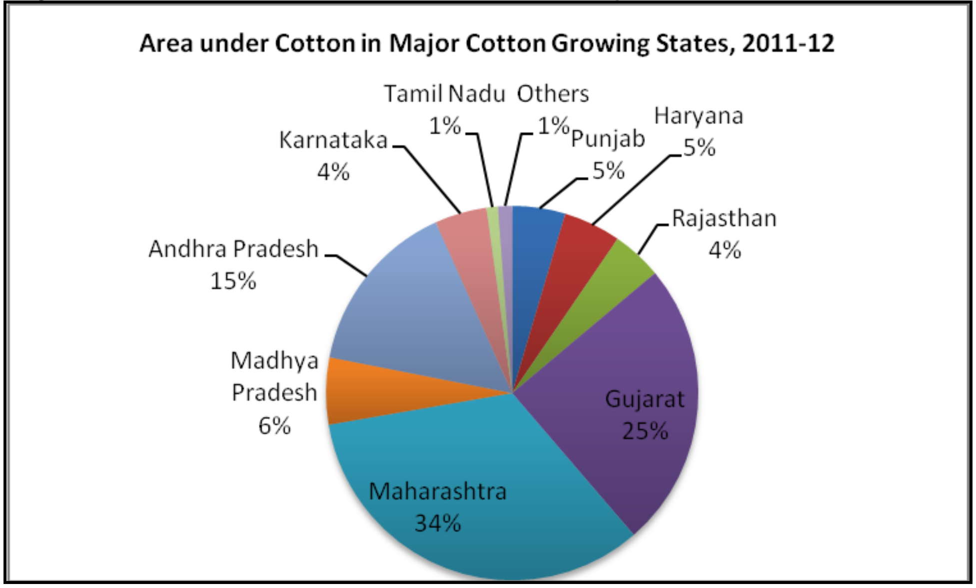
Table 3.4: Area, Production and Yield of Cotton in Major States of India: Triennium ending 2007-08*

Sl. No.	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)
10	Others	1.00	0.64	273.15
		(0.48)	(0.76)	(8)
	Total	298.37	91.80	514.01
		(100)	(100)	

*Figures in brackets under production and area are percentage to total. Figures in brackets under yields are the rank in yield. States have been arranged in descending order of area.

The distribution of cotton area by state in 2011-12 is given in the Figure below. The distribution indicates that Maharashtra has the largest area followed by Gujarat and Andhra Pradesh, and together they account for about 75 percent of the cotton area.

Figure 3.3: Distribution of Cotton Area by State 2011-12



Source: AICCIP annual report 2011-12

Performance of Cotton in the Selected States

Andhra Pradesh

Andhra Pradesh shows a huge acceleration in production rate of growth from 3.76 percent in 1990-91 to 2001-02 to 13.66 percent in 2002-03 to 2010-11. This shows a huge impact of Bt cotton technology introduction. The growth rate during 2002-03 to 2010-11 on account of area and yield were at 8.83 percent and 4.81 percent respectively to achieve the overall production growth rate of over 13.66 percent (Table 3.5 and Figures 3.4 to 3.6).

Table 3.5: Growth in Production, Area and Yield of Cotton in Andhra Pradesh

Year	Area (Lakh hectares)	Production (Lakh bales)	Yield (Kg. per hectare)
1990-91	6.55	11.1	288
1991-92	7.06	12.99	313
1992-93	8.05	11.47	242
1993-94	7.28	13.49	315
1994-95	8.45	14.26	287

1995-96	10.59	16.1	258
1995-97	10.15	18.78	315
1997-98	9.06	13.2	248
1998-99	12.81	15.22	202
1999-00	10.46	15.79	257
2000-01	10.22	16.63	277
2001-02	11.08	18.77	288
2002-03	8.03	10.86	230
2003-04	8.37	18.9	384
2004-05	11.78	21.9	316
2005-06	10.33	21.08	347
2006-07	9.72	21.82	382
2007-08	11.34	34.91	523
2008-09	13.99	35.69	434
2009-10	14.68	32.32	374
2010-11	17.76	38.9	372
Annual Compound Growth Rate (%)			
1990-91 to 2001-02	4.87	3.76	-1.10
2002-03 to 2010-11	8.83	13.66	4.81

Gujarat

Gujarat has experienced high variability in cotton production during the 90s largely due to yield fluctuation (Table 3.6 and Figures 3.4 to 3.6). The state experienced a decline in the growth rate (-3.62) in yield during 1990-91 to 2001-02. Since 2002-03, the growth in cotton production in the state was been phenomenal, and the state's annual rate of growth of production shot up from 1.54 percent to 17.14 percent comparing 1990-91 to 2001-02 and 2002-03 to 2010-11. This shows a huge impact of Bt cotton technology introduction.

Table 3.6: Growth in Production, Area and Yield of Cotton in Gujarat

Year	Area (Lakh hectares)	Production (Lakh bales)	Yield (Kg. per hectare)
1990-91	9.2	14.9	275
1991-92	11.4	14.9	222
1992-93	11.5	22.3	330
1993-94	11.3	19.8	298
1994-95	12.1	26.6	374
1995-96	14.1	32.2	388
1995-97	14.9	34.3	391
1997-98	15.2	42	470
1998-99	16.1	47	496
1999-00	15.4	20.8	230
2000-01	16.2	11.6	122
2001-02	17.5	16.9	164
2002-03	16.4	16.9	175
2003-04	16.5	40.4	416
2004-05	19.1	47.72	425
2005-06	19.1	67.72	603
2006-07	23.9	87.87	625
2007-08	24.22	82.76	581
2008-09	23.53	70.13	507
2009-10	26.25	79.86	517
2010-11	26.33	104	671
Annual Compound Growth Rate (%)			
1990-91 to 2001-02	5.17	1.54	-3.62
2002-03 to 2010-11	6.57	17.14	10.57

Maharashtra

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 the largest over the years. The state achieved 3.6 percent growth rate in cotton production during 1990-91 to 2002-03 But during the period 2002-03 to 2010-11 the state achieved an annual growth in cotton production of 14.04 percent largely due to growth in yield (Table 3.7 and figures 3.4 to 3.6). This shows a huge impact of Bt cotton technology introduction.

Table 3.7: Growth in Production, Area and Yield of Cotton in Maharashtra

Year	Area (Lakh hectares)	Production (Lakh bales)	Yield (Kg.per hectare)
1990-91	27.21	18.75	117
1991-92	27.59	11.56	71
1992-93	25.74	18.9	125
1993-94	24.81	26.26	180
1994-95	27.6	26.25	162
1995-96	30.64	27.99	155
1996-97	30.85	31.43	173
1997-98	31.39	17.53	95
1998-99	31.99	26.19	139
1999-00	32.54	30.99	162
2000-01	30.8	18	99
2001-02	31	26.9	148
2002-03	28	26	158
2003-04	27.6	30.8	190
2004-05	28.4	29.4	176
2005-06	28.8	31.6	187
2006-07	31.1	46.2	253
2007-08	32	70.2	373
2008-09	31.5	47.5	256
2009-10	35	58.6	285
2010-11	39.3	85	368
Annual compound growth rate (%)			
1990-91 to 2001-2002	2.00	3.60	1.61
2002-03 to 2010-11	3.97	14.04	10.06

Punjab

The area and production of cotton in Punjab is lower than in other sample states but the yields are generally the highest. Punjab showed a negative growth rate in area, production and yield during 1990-91 to 2001-02 but showed a positive growth rate of 7.05 percent during 2002-03 to 2010-11, showing an impact of Bt technology. This growth rate is, however, much lower than that of the other study states – the reasons for this include the late release of Bt technology for Punjab after 2004-05, and poor performance in 2008-09 and 2009-10, but a turnaround in 2010-11. (Table 3.8 and Figures 3.4 to 3.6).

Table 3.8: Production, Area and Yield of Cotton in Punjab

Year	**Area (Lakh hectares)**	**Production (Lakh bales)**	**Yield (Kg. per hectare)**
1990-91	7.01	19.09	463
1991-92	6.6	23.57	607
1992-93	7.01	21.85	530
1993-94	5.79	15.15	445
1994-95	6.06	17.79	449
1995-96	7.5	19.5	442
1996-97	7.42	19.25	441
1997-98	6.19	7.51	206
1998-99	6.17	7	201
1999-00	4.75	9.6	345
2000-01	6	15	425
2001-02	6.07	13.07	366
2002-03	4.49	10.73	406
2003-04	4.52	14.78	556
2004-05	5.09	20.87	697
2005-06	5.57	23.94	731
2006-07	6.07	26.78	750
2007-08	6.04	23.56	613
2008-09	5.27	17.5	565
2009-10	5.11	13	432
2010-11	5.3	18.5	593
Annual Compound Growth Rate (%)			
1990-91 to 2001-02	-1.30	-3.39	-2.11
2002-03 to 2010-11	2.09	7.05	4.85

Figure 3.4: Cotton production in selected states (lakh bales)

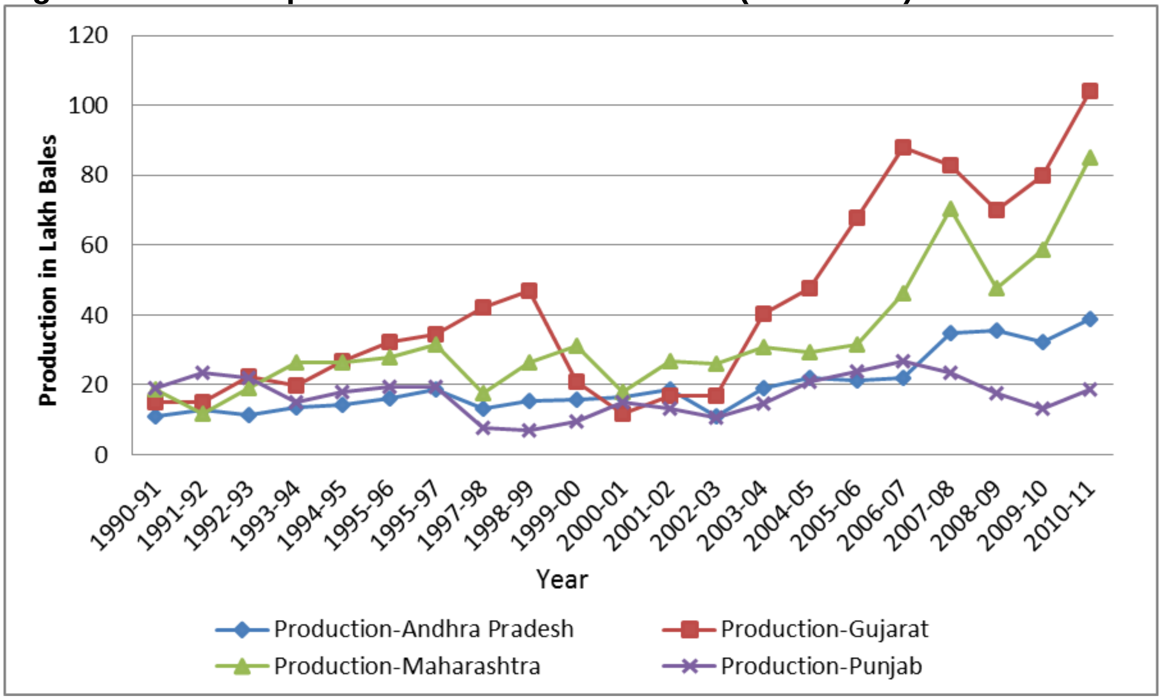


Figure 3.5: Area under cotton in selected states (lakh hectares)

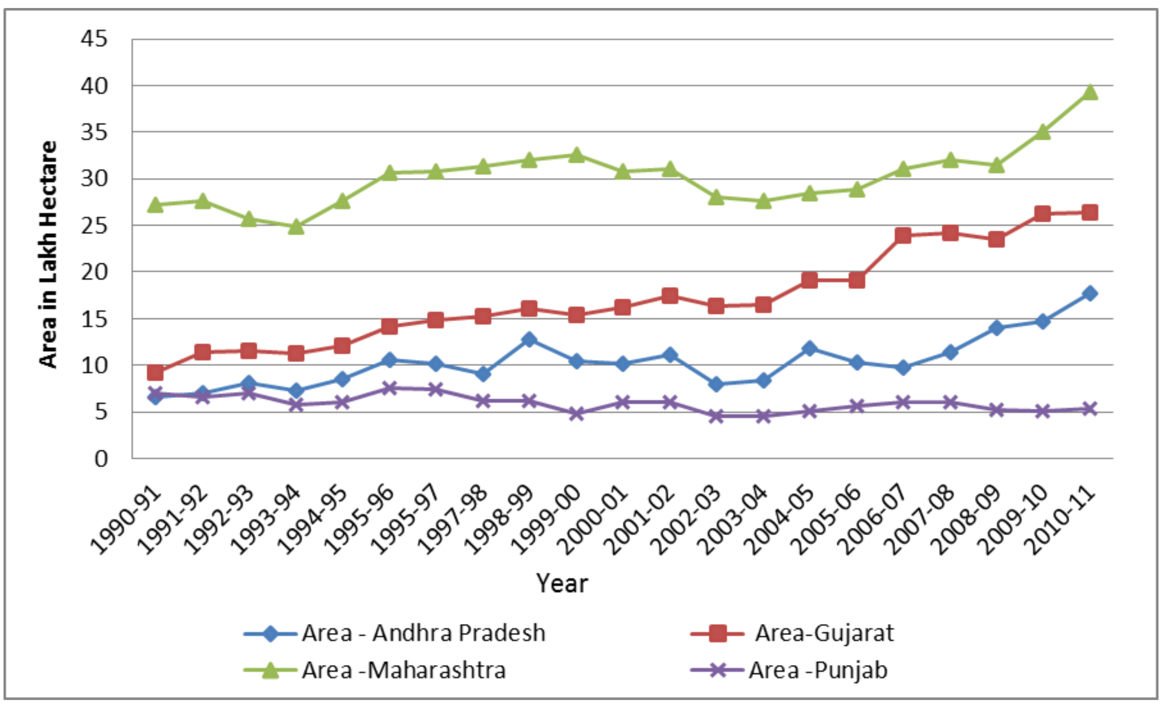
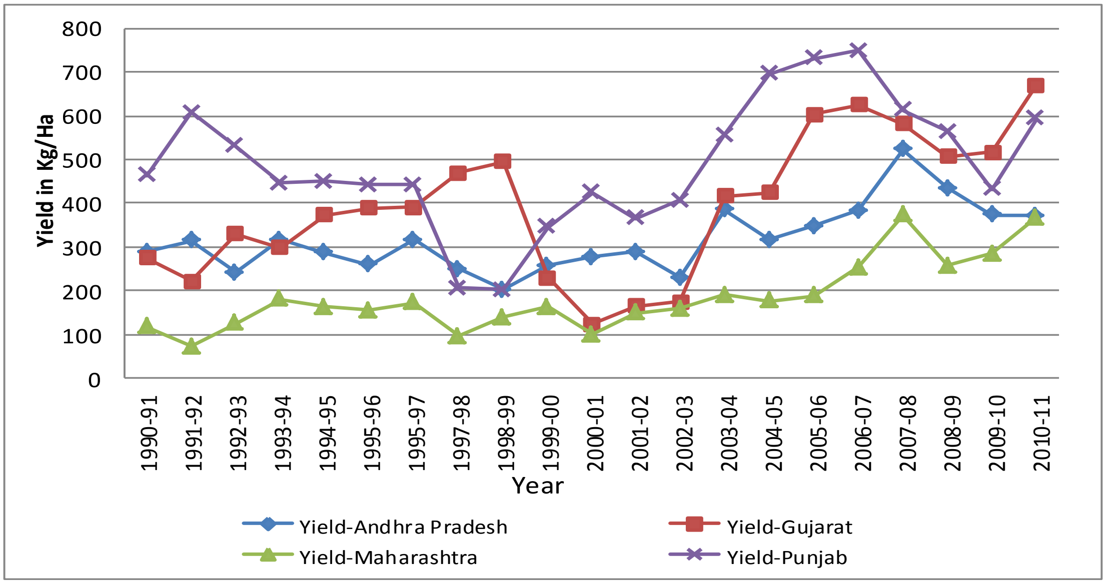


Figure 3.6: Cotton yield in selected states (Kg/Ha)



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.

Table 3.9: 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: Barwale et. al. (2004)				

It was realized soon that 3 hybrids were too less and was a major limiting factor for a country of the size of 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. From 2005, more hybrids and seed companies were granted approval, and by 2009, 522 Bt hybrids and 35 companies had been approved, see Table 6. This included Bollguard I and Bollguard II technologies.

Table 3.10: Deployment of Bt cotton by no. of hybrids and companies in India

Region		**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
North Zone	Hybrids				6	14	32	62	164
	Companies				3	6	14	15	26
Central Zone	Hybrids	3	3	4	12	36	84	148	296
	Companies				4	15	23	27	35
South Zone	Hybrids	3	3	4	9	31	70	149	294
	Companies				3	13	22	27	35
Total	Hybrids	3	3	4	20	62	131	274	522*
	Companies	1	1	1	3	15	24	30	35

Note: North Zone (Haryana, Punjab, Rajasthan), Central Zone (Gujarat, Madhya Pradesh, Maharashtra), South Zone (Andhra Pradesh, Karnataka, Tamil Nadu)
Source: Compiled by ISAAA, 2009

Table 3.11: Deployment of Bt cotton by State

Deployment of approved Bt cotton events/hybrids/variety by companies/institutions in India								
Region	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
NORTH ZONE				6 Hybrids	14 Hybrids	32 Hybrids	62 Hybrids	164 Hybrids
Haryana				1 Event	3 Events	4 Events	4 Events	5 Events
Punjab				3 Companies	6 Companies	14 Companies	15 Companies	26 Companies
Rajasthan								
CENTRAL ZONE	3 Hybrids	3 Hybrids	4 Hybrids	12 Hybrids	36 Hybrids	84 Hybrids	148 Hybrids	296 Hybrids
Gujarat				1 Event	4 Event	4 Event	4 Event	6 Event
Madhya Pradesh				4 Companies	15 Companies	23 Companies	27 Companies	35 Companies
Maharashtra								
SOUTH ZONE	3 Hybrids	3 Hybrids	4 Hybrids	9 Hybrids	31 Hybrids	70 Hybrids	149 Hybrids	294 Hybrids
Andhra Pradesh				1 Event	4 Event	4 Event	4 Event	6 Event
Karnataka				3 Companies	13 Companies	22 Companies	27 Companies	35 Companies
Tamil Nadu								
SUMMARY								
Total hybrids	3	3	4	20	62	131	274	522*
Total events	1	1	1	1	4	4	4	6
Total companies	1	1	1	3	15	24	30	35
Source: Compiled by ISAAA, 2009								

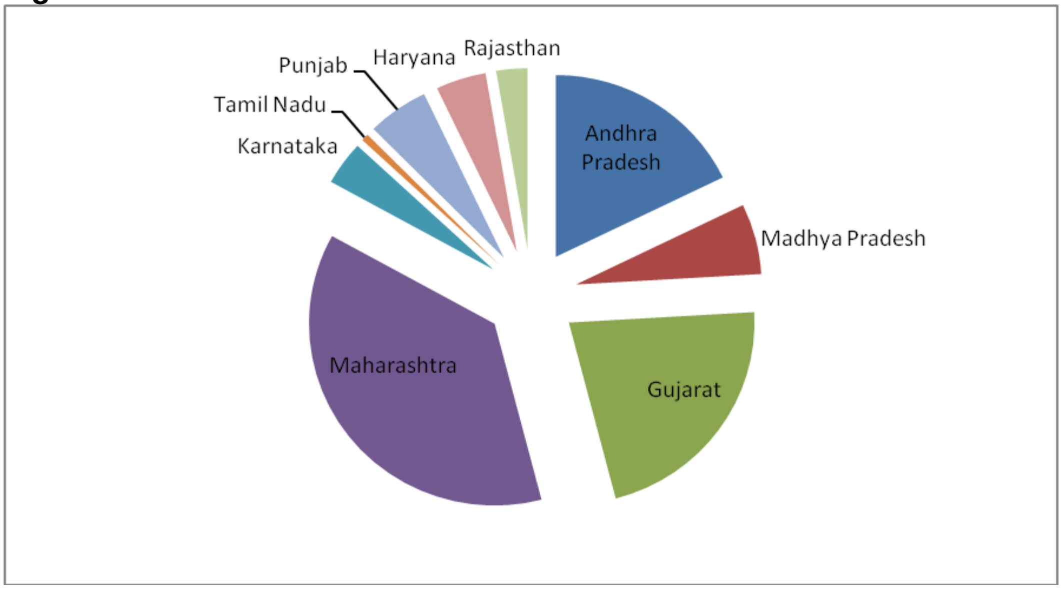
Gujarat and Maharashtra were the early adopters of Bt cotton in the country that commenced in 2002 followed by Andhra Pradesh and Karnataka (Table 3.12 and Figure 3.7). By official estimates, the area under Bt cotton in India was about 1 million hectare, or about 11 percent of the total area under cotton 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, about 18 percent in Maharashtra. These statistics do not include the substantial un-reported area in the state of Gujarat.

By 2010-11, the area under Bt cotton in India was about 9.4 million hectare, or about 85 percent of the cotton area, see Table 7 below. The data shows that despite the concerns voiced, the adoption by the farmers has been extremely rapid, which indicates that farmers must be experiencing substantial benefits from Bt hybrids as compared to earlier/ alternative technologies. This is further examined through primary sample survey data below.

Table 3.12: Area under Bt Cotton by State in India (area in '000 hectare)

State		**2003-04**	**2004-05**	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**
Andhra Pradesh		5.5	71.2	90.4	657.4	1001.0	1143.0	1430.0	1706.0
Madhya Pradesh		13.4	86.1	136.2	310.0	480.0	480.0	592.7	545.2
Gujarat		41.7	125.9	149.3	403.0	429.0	890.0	1825.0	1894.0
Maharashtra		21.9	161.5	508.7	1655.0	2562.0	2880.0	3150.0	3576.0
Karnataka		3.0	34.3	29.3	74.0	146.7	225.0	262.0	370.0
Tamil Nadu		7.7	12.0	17.0	40.0	46.1	75.2	78.1	50.2
Punjab				70.4	160.0	490.0	477.0	474.0	460.0
Haryana				10.8	50.0	278.7	378.0	475.0	470.0
Rajasthan				2.3	3.8	38.7	121.0	265.0	265.0
Total	Area	93.1	491.0	1014.4	3353.2	5472.1	6669.2	8551.8	9336.4
	Percent	1.2	5.5	11.5	36.7	58.1	70.9	84.4	84.4

Figure 3.7: Distribution of area under Bt cotton in various states – 2010



Chapter 4: Profile of the Sample Data and Cotton Varieties Grown

In order to address the topic and objectives of the research, a primary sample survey of cotton farmers (as well as consumers/ urban people - discussed later) was planned within the constraints of time and resources. Multi-stage stratified and random sampling was done. The first stage of sampling was the selection of sample states, the second stage was the selection of sample districts in each sample state, the third stage was the selection of villages in each sample district, and the fourth stage was the selection of sample farmer households in the selected villages. Effort was made to cover both Bt and Non-Bt farmers in the sample, but if non-Bt growers were not available (as was commonly experienced with the high adoption rate of Bt cotton), to ask farmers about the non-Bt experience and cover it through recall. This was not easy and had its limitations. Effort was also made through stratification to cover both irrigated and unirrigated farms, as well as small, medium and large farmers. The sampling method and the sample profile are discussed below. The primary data collected pertains to the agricultural year July 2012 to June 2013.

Selection of States

The comparative picture of different states in cotton production has been discussed in Chapter 3. The area, production and yields of cotton in different states are given Table 3.3. Based on this, it can be seen that the highest four cotton producing states are Gujarat, Maharashtra, Andhra Pradesh and Punjab, and these were selected in the study sample.

The comparative picture of these 4 states is shown in the Table below. It shows that Maharashtra has the largest area under cotton followed by Gujarat, and Gujarat has the highest production followed by Maharashtra. Gujarat has the highest cotton yields in the country, followed by Punjab at third national rank. Together these four sample states account for 75 percent of the cotton area and

76 percent of the cotton production in the country, and seem to constitute a good sample.

Table 4.1: Area, Production and Yield of Cotton Sample States of India (Triennium ending 2007-08)

Sl. No.	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	Punjab	23.33	6.04	666.31
		(8.39)	(6.58)	(3)

Figures in brackets under production and area are percentage to total. Figures in brackets under yields are the rank in yield. States have been arranged in descending order of area.

Selection of Districts

The next stage in the sampling was the selection of districts. Given the limitations of time and resources, it was decided to limit to one sample district in each state. The selection of districts was made on the basis of the area, production and yield data of the cotton growing districts in each state. This selection is described below.

Andhra Pradesh

The available district wise data for cotton in Andhra Pradesh is given in the Table below and indicates that cotton is cultivated widely in the state. However, the area, production and yield vary widely. Among the highest cotton producing districts are Guntur, Adilabad and Warangal and of these, on an average the highest production is seen in Guntur. Hence, Guntur district has been selected for study in the sample. Much of the cotton area in Guntur is rainfed.

Table 4.2: Andhra Pradesh: District-wise area, production and yield of cotton (Area: '000 ha'; Production: '000' bales ; Yield: Kg Lint/ha.)

Sl. No.	District	2005-06			2006-07			2007-08		
		A	P	Y	A	P	Y	A	P	Y
1	Srikakulam	3	5	250	2	5	523	2	8	685
2	Vizianagaram	16	22	245	11	12	176	7	7	166
3	Visakhapatnam	1	4	480	1	3	523	0	0	685
4	E. Godavari	7	22	500	9	19	365	8	19	398
5	W.Godavari	7	17	435	4	13	523	5	20	685
6	Krishna	35	88	422	32	85	459	35	116	562
7	Guntur	139	351	428	132	469	601	150	691	783
8	Prakasam	19	56	510	20	41	344	24	70	496
9	Nellore	4	10	482	4	12	523	5	20	685
10	Kurnool	33	49	250	17	23	226	29	48	283
11	Anantapur	4	7	280	2	2	219	3	1	77
12	Kadapa	16	34	350	8	6	121	9	14	265
13	Chittoor	0	0	0	0	0	0	0	0	0
14	Rangareddy	15	37	419	16	22	230	17	40	395
15	Nizamabad	9	18	350	8	6	130	9	16	299
16	Medak	11	20	317	19	51	454	29	101	594
17	M'boobnagar	37	90	417	47	58	212	69	148	364
18	Nalgonda	83	200	410	80	163	346	106	228	365
19	Warangal	148	395	455	154	359	397	160	474	504
20	Khammam	95	257	460	110	249	385	119	381	544
21	Karimnagar	134	352	445	117	23	324	137	450	559
22	Aadilabad	156	381	416	179	361	343	221	642	517
	Total	972	2415	422	972	2182	381	1134	3494	525

Source: Cotton Statistics at a glance, Directorate of Cotton Development, Ministry of Agriculture, Government of India, 2010.

Gujarat

The district wise data available for cotton in Gujarat is given in the Table below and indicates that cotton is cultivated in a large number of districts of the state. However, the area, production and yield vary widely. Among the highest cotton producing districts are Rajkot, Bhavnagar and Surendranagar and of these, on an average the highest production is seen in Rajkot district. Hence, Rajkot district has been selected for study in the sample.

Table 4.3: Gujarat: District-wise Area, Production and Yield of Total Cotton in Gujarat (Area ('00 ha), Production ('00 bales) & Yield (kg lint per ha))

Sl. No.	Name Of The District	2004-05			2005-06			2006-07		
		Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
1	Ahmedabad	1895	3327	298	1703	2661	266	1530	3892	432
2	Anand	38	154	689	146	584	680	36	103	486
3	Banaskantha	61	259	722	1781	4639	443	211	569	458
4	Bharuch	1297	3350	439	1480	3093	355	1464	4979	578
5	Dahod	18	73	689	410	1191	494	13	31	405
6	Dang	0	0	0	0	0	0	0	0	0
7	Gandhinagar	327	1171	609	159	607	649	272	1344	840
8	Kheda	206	653	539	232	710	520	170	534	534
9	Mehsana	467	1122	408	34	128	640	471	1198	432
10	Narmada	435	1510	590	463	1271	467	435	1263	494
11	Navsari	0	0	0	0	0	0	0	0	0
12	Panchmahal	104	337	551	833	1338	273	69	165	407
13	Ratan	1011	1101	185	104	255	417	779	1399	305
14	Sabarkantha	861	2932	579	9	27	510	946	3822	687
15	Surat	70	180	437	713	3213	766	78	304	663
16	Vadodara	1728	4499	541	55	181	559	1797	5916	560
17	Valsad	0	0	0	0	0	0	0	0	0
18	Amreli	1164	2908	425	1481	5671	651	1920	7011	621
19	Bhavnagar	1987	5159	441	2246	10627	804	2766	11299	694
20	Jamnagar	467	2567	934	921	4945	913	2152	9949	786
21	Junagadh	249	1401	957	381	2624	1171	503	2485	840
22	Kutch	547	1217	378	117	377	548	634	1663	446
23	Porbandar	32	72	383	404	1393	586	144	302	357
24	Rajkot	2028	10683	896	2210	13348	1027	3389	17700	888
25	Surendrangar	4071	9760	408	4226	9833	396	4121	11950	493
	Gujarat State	19063	54435	494	20108	68716	581	23900	87878	625

Source: Cotton Statistics at a glance, Directorate of Cotton Development, Ministry of Agriculture, Government of India, 2010.

Maharashtra

The district wise data available for cotton in Maharashtra is given in the Table below and indicates that cotton is cultivated in a large number of districts of the state. However, the area, production and yield vary widely. Among the highest cotton producing districts are Jalgaon, Aurangabad, Jalna, Yavatmal and

Amravati, and of these, on an average the highest production is seen in the Jalgaon district. Hence, Jalgaon district has been selected for the study in the sample.

Table 4.4: Maharashtra: District wise area, production and yield of cotton (Area in "00" ha, Production in "00" bales of 170 kg each, Yield in kg/ha)

Sl. No.	District	2004-05			2005-06			2006-07		
		Area	Prodn.	Yield	Area	Prodn.	Yield	Area	Prodn.	Yield
1	Nasik	141	200	241	174	346	338	526	975	315
2	Dhule	718	883	209	733	749	174	970	1546	271
3	Nandurbar	381	344	153	349	504	245	365	187	87
4	Jalgaon	3961	6166	265	3934	6042	261	4283	10481	416
5	Ahmednagar	159	267	285	166	228	233	384	599	265
6	Pune	1	2	337	1	3	456	0	0	0
7	Solapur	10	19	328	8	13	277	22	27	209
8	Satara	6	6	164	47	43	156	36	40	190
9	Sangli	13	2	26	27	24	151	18	11	105
10	Kolhapur	1	1	170	1	1	170	1		
11	Aurangabad	2095	2632	214	2501	3227	219	2810	5802	351
12	Jalna	1740	2065	202	2161	2704	213	2535	5950	399
13	Beed	1015	1166	195	1386	1614	198	1608	2289	242
14	Latur	70	67	163	34	34	168	56	63	192
15	Osmanabad	57	53	159	45	56	210	27	23	147
16	Nanded	2332	1949	142	2278	1292	96	1865	1086	99
17	Parbhani	1980	1727	148	1850	2216	204	1513	2305	259
18	Hingoli	713	657	157	543	722	226	619	1274	350
19	Buldhana	1987	1493	128	1975	2274	196	2420	3089	217
20	Akola	2076	1378	113	2044	1414	118	2057	4453	368
21	Washim	678	486	122	668	697	177	606	677	190
22	Amravati	2682	2143	136	2564	2229	148	2255	2069	156
23	Yavatmal	3328	2863	146	3240	2815	148	4135	4889	201
24	Wardha	998	1288	219	801	877	186	931	1177	215
25	Nagpur	753	1043	235	733	988	229	658	832	215
26	Bhandara									
27	Gondia									
28	Chandrapur	499	484	165	486	488	171	537	802	254
29	Gadchiroli	1	1	170	1	1	170	5	3	105
	State Total	28395	29385	176	28750	31601	187	31242	50651	276

Source: Cotton Statistics at a Glance, Directorate of Cotton Development, Ministry of Agriculture, Government of India, 2010.

Punjab

Cotton is grown only in some districts of Punjab. It is grown in 10 of the 22 districts. The district wise data available for cotton in Punjab given in the Table below indicates that cotton is cultivated in the given 10 districts of the state, and the area, production and yield vary widely. Among the highest cotton producing districts are Bhatinda, Ferozpur, Kukatsar and Mansa, and of these, on an average the highest production is seen in Bhatinda district. Hence, Bhatinda district has been selected for study in the sample.

Table 4.5: Punjab: District wise area, production and yield of cotton
(Area in '000' Hect Yield Kg/Hect, Production in '000' Tonnes)

District		2004-05	2005-06	2006-07
Bathinda	A	141	151	161
	Y	714	741	780
	P	593	659	739
Faridkot	A	21	25	29
	Y	554	736	802
	P	68	108	137
Ferozepur	A	133	140	151
	Y	701	745	729
	P	548	614	648
Ludhiana	A	-	1	2
	Y	-	748	763
	P	-	5	9
Mansa	A	82	91	96
	Y	726	682	717
	P	350	365	405
Moga	A	6	7	7
	Y	565	685	712
	P	20	28	29
Kukatsar	A	105	117	131
	Y	707	788	777
	P	437	542	599
Sangrur	A	19	23	27
	Y	580	502	626
	P	65	68	100
Tarn Taran	A	-	-	2
	Y	-	-	763
	P	-	-	9
Patiala	A	1	1	1
	Y	540	529	531
	P	3	3	3
Source: Cotton Statistics at a Glance, Directorate of Cotton Development, Ministry of Agriculture, Government of India, 2010.				

Village and Farmer Sample

The villages within each district were selected to cover cotton growing including Bt cotton cultivation and provide a diversity of agro-ecological settings, locations and village sizes through a random process. This was done in discussion with district officials and/or seed dealers at the district headquarters who were knowledgeable about the district. The farmers were selected in each village through a random process and effort was made as far as possible to have both Bt and Non-Bt farmers in the sample, and if not, to have Bt farmers who could reflect on their non-Bt growing experience. This was not always easy and had its limitations. Effort was also made to cover both irrigated and unirrigated farms, as well as small, medium and large farms. The ability to do this depended on the presence, size and access to each of these strata in the survey locations.

Questionnaire

A highly detailed questionnaire was developed for the study based on the objectives, research questions and the behavioural framework presented above. The farmer questionnaire covered a large number of aspects including: Name/ Identification of Survey Location, Experience of cotton/Bt cotton, Profile of Farmer Respondent, Major crops grown, Comparison of Cotton varieties grown in last few years, Comparative Cost of Cultivation of Cotton, Insect/ Pest Attack / Incidence observed on the cotton crops, Details of Spraying of Pesticides/Insecticides on Cotton, Perception of farmers on various aspects of Bt cotton and its cultivation: agronomic potential, agro-economic potential, effective demand, aggregate supply, distribution; In what aspects does Bt cotton have advantages vis-à-vis non-Bt Cotton, Information sources on Bt cotton, Has the Bt Cotton technology had a direct or indirect impact on the following, Response on Current Issues & Problems with Bt cotton, Response on Pest resistance & related issues in cotton and Bt cotton, Trends in cotton cultivation-Change over the years, Overall judgment, What would you suggest for improving Bt cotton and its profitability, Are there any specific advantages and disadvantages of Bt cotton cultivation, Is there any particular pest/insect against which Bt cotton is relatively less effective, Are there some pests that are problematic after introduction of Bt-cotton, What according to you needs to be done to improve Bt cotton and its adoption by farmers, Any other comments / suggestions. The questionnaires helped to obtain detailed responses from the respondents on the research objectives and questions.

Sample Profile

As discussed above, the study has covered farmers and consumers from four different states in the country: Andhra Pradesh, Gujarat, Maharashtra, and Punjab, with one sample district from each state. In each state, a sample of 100 was planned consisting of 80 farmers and 20 consumers. The distribution of the actual farmer sample is given in the Table below. A total of 326 farmers were covered, with roughly about 25 percent from each state.

Table 4.6: Farmer Sample Distribution

State	District	Sample Size	Total (%)
Andhra Pradesh	Guntur	82	25.2
Gujarat	Rajkot	81	24.8
Maharashtra	Jalgaon	82	25.2
Punjab	Bhatinda	81	24.8
Overall		326	100.0

The table below gives the distribution of the farmer sample by farm size and presence of irrigation. Overall 98 farmers were small, 185 were medium, and 43 were large. 207 farmers had irrigation whereas 119 did not have irrigation. The states had varying sample patterns, whereas in Punjab and Gujarat either all or most of the farmers had irrigation, whereas in Andhra Pradesh, almost all the farmers did not have irrigation. In the case of Maharashtra, about 60 per cent of the farmers had irrigation and 40 per cent did not. Andhra Pradesh, Maharashtra, and Punjab showed a large number of small farmers whereas Gujarat showed a large number of medium and large farmers.

Table 4.7: Sample profile on irrigation and farm size			
State/Farm Size	Irrigated	Un-Irrigated	Total
Andhra Pradesh			
Small (Below 2 Ha)	2	18	20
Medium (2 to 10 Ha)	3	52	55
Large (Above 10 Ha)	0	7	7
Total	5	77	82
Gujarat			
Small (Below 2 Ha)	3	6	9
Medium (2 to 10 Ha)	47	2	49
Large (Above 10 Ha)	22	1	23
Total	72	9	81
Maharashtra			
Small (Below 2 Ha)	19	18	37
Medium (2 to 10 Ha)	19	15	34
Large (Above 10 Ha)	10	0	10
Total	48	33	81
Punjab			
Small (Below 2 Ha)	32	0	32
Medium (2 to 10 Ha)	47	0	47
Large (Above 10 Ha)	3	0	3
Total	82	0	82
Overall			
Small (Below 2 Ha)	56	42	98
Medium (2 to 10 Ha)	116	69	185
Large (Above 10 Ha)	35	8	43
Total	**207**	**119**	**326**

The table below gives a profile of the consumer sample covered. Against a target of 20 per state, the number of consumers covered in the states varied from 22 to 33. The age profile of the consumer sample indicates that the largest number were from the middle age group of 31 to 50 years, constituting about 47 per cent of the sample. But a large number were also from the younger age group of 19 to 30 years constituting about 36 per cent of the sample.

Table 4.8: Consumer Survey- Sample profile		
State	Respondents	Respondents (%)
Andhra Pradesh	33	28.70
Gujarat	22	19.13
Maharashtra	32	27.83
Punjab	28	24.35
Total	115	100.00
Age	Respondents (%)	
18	0.9	
19-30	35.6	
31-50	47.0	
> 50	16.5	
Average Age	37.5	

Cotton Varieties Grown by Sample Farmers

An important aspect of the study was to observe and report on the cotton varieties (including hybrids), both Bt and non-Bt, grown by the farmers. The Table below gives the names of the most common varieties reported grown by the sample farmers in each state. The profile indicates that there is a huge diversity in the reported varieties. Only a few varieties were found common across the states. Mallika is reported in the states of Andhra Pradesh, Gujarat, and Maharashtra, The variety Jadoo is reported in Andhra Pradesh and Maharashtra. In Gujarat, a few non-BT varieties are also reported. Thus, there is a huge difference in the variety preference of the farmers across states. Very few varieties are suitable across all the states and very few varieties seem to perform well across the states. This is indicative of the need for a large selection of available varieties.

Table 4.9: Most Reported Cotton Varieties in each state		
State	**Cotton type**	**Most reported varieties**
Andhra Pradesh	BT	Mallika, Jadoo, Bhaskar, Jackpot, ATM
Gujarat	BT	Vikram, Mallika, Badshah, Ajit 155, Jay, Rashi-2
	Non BT	Prabhav, Jambo, Hariyali

Maharashtra	BT	Mallika, Rashi-2, Brahma, Ajit-155, Ankur-2, Jadoo, Jai, Pratik, 9
Punjab	BT	6588, 6488, Nikki, Raghav, 3028, Pancham, 7007, Mak Plus, 7010

The Table below gives a profile of the varieties and company names for Andhra Pradesh. The BT variety Mallika of Nuziveedu Seeds is reported by as many as 41 per cent of the farmers. The BT variety Jadoo of Kaveri Seeds is reported by 24 per cent of the farmers, the BT variety Bhaskar of Tulasi Seeds by 12 per cent of the farmers, and the Bt variety Jackpot of Kaveri Seeds by 10 per cent of the farmers. All the other varieties are reported by less than 5 per cent of the farmers. Thus the Bt varieties of Mallika, Jadoo, Bhaskar and Jackpot dominate in the sample covered in Andhra Pradesh, adding to 87.5 percent of the responses.

Table 4.10: Varieties Reported by Sample Farmers in Andhra Pradesh (N=81)

Variety	BT/Non BT	Company	Percent reporting
Mallika	BT	Nuziveedu Seeds	41.4
Jadoo	BT	Kaveri Seeds	24.3
Bhaskar	BT	Tulasi Seeds	12.1
Jackpot	BT	Kaveri Seeds	9.7
ATM	BT	Kaveri Seeds	2.4
Bunny	BT	Nuziveedu Seeds	1.2
Brahma	BT	Monsanto Seeds	1.2
Others	BT/Non BT	-	2.4
Total			100

The varieties reported in Gujarat are given in the table below. The most common variety is the Bt variety Vikram of Vikram Seeds reported by 25 per cent of the farmers. This is followed by the non-confirms/non-Bt variety Prabhav of unknown origin grown by 10 per cent of the farmers, and the Bt Mallika variety of Nuziveedu Seeds grown by about nine per cent of the farmers. The rest of the varieties are reported by less than five per cent of the farmers. Thus, Vikram, Prabhav, and Mallika varieties dominate in Gujarat, but together constitute only

43.5 percent of the response. Thus there is a much greater diversity of varieties reported in Gujarat – the state seems to show a huge diversity of Bt and non-confirmed Bt varieties grown by the farmers.

Table 4.11: Varieties Reported by Sample Farmers in Gujarat (N=82)			
Variety	BT/Non BT	Company	Percent reporting
Vikram	BT	Vikram Seeds	24.7
Prabhav	NON BT/NC	-	9.9
Mallika	BT	Nuziveedu seeds	8.6
Badshah	BT	Mahyco	4.9
Ajit 155	BT	Ajit Seeds	4.9
Jay	BT	Ankur Seeds	3.7
Rashi-2	BT	Rashi Seeds	2.5
Arya 177	BT	Arya Seeds	1.2
Bullet	BT	Nuziveedu Seeds	1.2
Tulsi	BT	Tulasi Seeds	1.2
Rashi-1	BT	Rashi Seeds	1.2
Flox	BT	Prabhat Seeds	1.2
Other Varieties	BT/NC	Jambo, Hariyali, Varsha, Vidhata, Uttam, Shri Hari, Samay, RC2, PCH-2, Omupaj, Mwakin, Medlika, Manglam, Mahavir, Mahasang, Jadibuti, Gangakav Doctor D, Denim, Chaitanaya, Balram, Arshi, Aneri	30.2
Total			100

The table below the profile of the cotton varieties reported in Maharashtra. The Bt variety Mallika of Nuziveedu Seeds is reported by 28 per cent of the farmers. This is followed by the Rashi-2 Bt variety of Rashi Seeds grown by 19 per cent of the farmers. The Bt varieties Brahma of Monsanto, Ajit-155 of Ajit Seeds and Ankur-2 of Ankur Seeds are grown by about nine per cent of the farmers each. The rest of the varieties are grown by less than five per cent of the farmers. Thus the varieties Mallika, Rashi-2, Brahma, Ajit-155, and Ankur-2 dominate in

Mahrashtra constituting 72.8 percent of the responses. However, a number of other varieties are also reported.

Table 4.12: Varieties Reported by Sample Farmers in Maharashtra (N=82)			
Variety	BT/Non BT	Company	Percent reporting
Mallika	BT	Nuziveedu	28.4
Rashi-2	BT	Rashi Seeds	18.7
Brahma	BT	Monsanto	8.6
Ajit-155	BT	Ajit Seeds	8.6
Ankur-2	BT	Ankur Seeds	8.5
Jadoo	BT	Kaveri Seeds	4.9
Jai	BT	Ankur Seeds	3.7
pratik	BT	Krishidhan Seeds	3.7
9	BT	Ankur Seeds	2.5
ATM	BT	Kaveri Seeds	1.2
Maruti	BT	Krishidhan Seeds	1.2
Goni	BT	Paras Seeds	1.2
Tulshi	BT	Tulasi Seeds	1.2
651	BT	Ankur Seeds	1.2
Others (Kak, Swadesi, Vraj, Hanuman)	BT/NC	-	6.4
Total			100

The Table below gives the varieties that are reported in Punjab. The Bt variety 6588 of Mahyco is reported by 17 per cent of farmers. This is followed by the Bt varieties 6488 of Ankur Seeds, Nikki of Mahyco, Raghav of Nuziveedu, and 3028 of Ankur Seeds, reported by about eight per cent of the farmers each. Further to this, the Bt varieties Pancham of Mahyco and 7007 of Bayer are reported by about seven per cent of the farmers each. The rest of the varieties are reported by less than five per cent of farmers. Thus, in Punjab the varieties 6588, 6488, Nikki, Raghav, 3028, Pancham, and 7007 dominate, constituting 64.3 percent of the reponses. However, as in case of Gujarat, a huge number of different varieties of Bt cotton are grown.

Table 4.13: Varieties Reported by Sample Farmers in Punjab (N=82)			
Variety	BT/Non BT	Company	Percentage
6588	BT	Mahyco	16.9
6488	BT	Ankur Seeds	8.4
Nikki	BT	Mahyco	8.4
Raghav	BT	Nuziveedu	8.1
3028	BT	Ankur Seeds	8.1
Pancham	BT	Mahyco	7.2
7007	BT	Bayer	7.2
Mak Plus	BT	Muktand	2.4
7010	BT	Mahyco	2.4
Vikram	BT	Vikram Seeds	1.2
6588	BT	Sriram Bioseed	1.2
RCH 650	BT	Rashi Seeds	1.2
Rav - 11	BT	Rashi Seeds	1.2
Rashi	BT	Rashi Seeds	1.2
Mist	BT	Monsanto	1.2
Baj - II	BT	Lakshmi Seeds	1.2
Chun - 1	BT	Mahyco	1.2
Ankur 28	BT	Ankur	1.2
9082	BT	Mahyco	1.2
8028	BT	Mahyco	1.2
SP	BT	Bayer	1.2
Sarjan	BT	Mahyco	1.2
6488	BT	Bayer	1.2
6480	BT	Mahyco	1.2
605	BT	Rashi Seeds	1.2
518	BT	Mahyco	1.2
3083	BT	Mahyco	1.2
9	BT	Ankur Seeds	1.2
Others (Vishwas, Tomko, OM 39, Mahi)	BT/Non BT	-	8.1
Total			100

The Table below provides an analysis of the major physical/ agronomic features of varieties most grown by the farmers. The findings indicate that Bollworm resistance is a very important feature and the most grown varieties are generally strong on bollworm resistance. On the other hand, most of them show lesser resistance to other pests but those that are reasonably good are preferred. The yields under irrigated condition is another very important characteristic in the preference of farmers, and the most grown varieties all show excellent performance on this feature. The quality of the fibre and market acceptance are two other prominent characteristics of the preferred varieties.

Table 4.14: Response on Physical/ Agronomic Characteristics of the Most Grown Varieties

Characteristics	Most Grown Variety	Excellent	Good	Satisfactory	Somewhat poor	Very poor	N
Bollworm resistance	1	33.9	37.9	16.1	8.4	3.7	322
	2	21.6	35.9	27	11.7	3.8	315
	3	9.9	22.7	19.8	30	17.6	273
Resistance to other pests	1	12.5	37.4	30.2	14.6	5.3	321
	2	5.7	31	37.3	20.3	5.7	316
	3	4.4	21.7	26.1	32	15.8	272
Yield in irrigated conditions	1	51.5	28.7	10.1	8.2	1.5	268
	2	44.1	31.6	12.9	9.9	1.5	263
	3	32.3	23.6	27.1	12.2	4.8	229
Yield in irrigated conditions	1	11.3	27.2	30.5	28.5	2.6	302
	2	11.7	29.4	27.1	27.4	4.3	299
	3	7.1	18.3	31.7	36.5	6	252
Quality of fibre	1	50	38.5	10.2	1	0.3	314
	2	35.6	48.9	14.6	1	0	309
	3	25.2	37.6	32.3	4.1	0.8	266

The Table below provides an analysis of the major economic features of varieties most grown by the farmers. The market acceptance is a prominent characteristics of the preferred varieties. The responses indicate that availability of seed also plays an important role in farmer preference, indicating the major role of seed marketing by companies. The Table shows that the seed costs of varieties most grown is high to very high. This indicates that farmers are willing to pay a high price for their preferred varieties. The findings indicate that low pesticide cost and overall cost of cultivation are major features of the preferred varieties. High profitability appears to be the strongest feature of the most preferred varieties, indicating the great importance of economics in the decision making. In general, the satisfaction level is high to very high for the most preferred varieties.

Table 4.15: Response on Economic Characteristics of the Most Grown Varieties

Characteristics	Most Grown Variety	Excellent	Good	Satisfactory	Somewhat poor	Very poor	N
Availability of the seed	1	54.1	34.6	7.5	3.5	0.3	318
	2	50.2	33.7	11.4	4.4	0.3	315
	3	56.6	25.4	12.9	3.3	1.8	272
Market Acceptance	1	65.4	22.9	6.7	3.8	1.3	315
	2	63.2	22.3	9.7	3.5	1.3	310
	3	65	17.5	10.1	4.9	2.6	268
Seed cost	1	28	47.8	20.2	3.4	0.6	322
	2	20.9	47.5	22.5	8.9	0.3	316
	3	12.4	22.3	26.3	27.7	11.3	274
Pesticide cost/usage	1	9.3	23.7	31.8	32.7	2.2	321
	2	10.7	29	32.2	27.1	0.6	317
	3	28.8	28.1	26.3	13.1	3.3	274
Cost of cultivation	1	21.1	30.8	33.1	14.4	0.3	299
	2	15.5	32.6	36.8	14.1	1	291
	3	11.2	28.3	44.6	13.9	2	251
Profitability	1	48	29.7	9.3	9.6	3.4	323
	2	29.7	41.3	15.8	10.1	2.8	317
	3	16.4	33.9	32.5	12.4	4.7	274
Satisfaction	1	52.7	27.1	6.3	9.1	4.7	317
	2	28.8	44.6	13.1	9.3	4.2	312
	3	16	31.1	30.4	17.4	5.2	274

Chapter 5: Pest Resistance and Factors Affecting Bt Cotton Technology Adoption

Pest Resistance

The most important targeted advantage offered by Bt cotton technology is pest resistance particularly against boll worms. The study sought to examine the actual experience on advantage in pest resistance indicated by the farmers.

All States - India

The results on the pest incidence in Bt cotton compared to non-Bt cotton as indicated by the farmers are given in the Table below. The results indicate that Bt cotton appears to show substantial resistance/ substantially lower incidence in the case of boll worms including American, Pink and Spotted bollworms, particularly Pink bollworm. Bt cotton also shows resistance towards foliage feeding pests such as leaf rollers and caterpillars. However, Bt cotton shows a greater incidence of sucking pests particularly mealy bugs, aphids & jassids, and white fly. Bt cotton also shows a higher incidence of the disease of alternaria leaf spot. Thus, Bt cotton appears to tackle the problems of boll worms and leaf feeding insects which are major pests, but it shows a higher incidence for sucking pests and alternaria leaf spot.

Table 5.1: Comparison of Bt Cotton and No-Bt Cotton on Pest Incidence - India

Name of pest	Bt cotton						Non Bt cotton					
	Very Heavy	Heavy	Moderate	Light	None	N	Very Heavy	Heavy	Moderate	Light	None	N
A. Boll Worm												
1. American Boll Worm	17	20.8	11	29.9	21.4	318	37.3	37.6	4.6	9.9	10.6	263
2. Pink Boll Worm	6.3	13.8	8.2	38.4	33.3	318	22.9	37.6	12.8	11.2	15.5	258
3. Spotted Boll Worm	10.8	17.1	8.9	34.5	28.8	316	36.8	24.1	11.5	10.7	16.9	261
B. Sucking Pests												
1. Thrips	19	28.9	12.2	27.7	12.2	311	17.2	31.4	14.9	16.9	19.5	261
2. Leafhopper	15.9	28.2	17.2	28.2	10.4	308	18	30.9	12.5	19.5	19.1	256
3. Whitefly	35.8	29.4	22.4	9.3	3.2	313	27.4	26.2	10.7	21	14.7	252
4. Mealy Bug	39.5	24.7	13.8	15.5	6.6	304	8.9	8.9	5.8	12.5	63.8	257

5. Jassids and Aphids	19.8	53.1	10.4	12.5	4.2	96	6.7	5.6	19.1	29.2	39.3	89
C. Foliage Feeding Pests												
1. Leaf Roller	11.4	24.4	10.2	30.2	23.8	315	10	36.1	11.2	18.6	24.2	269
2.Caterpillar	12.5	18.3	6.4	27	35.7	311	21.3	21.7	11	14.6	31.5	254
D. Soil Pests												
1. Termite	5.8	23.5	10.3	12.3	48.1	243	6.2	21.2	10.1	12.5	50	208
E. Diseases												
1. Bacterial blight	16.7	35.3	15.4	21.9	10.8	306	18.4	35.2	10.9	19.5	16	256
2. Alternaria leaf spot	23.4	35.9	15.8	17.4	7.6	304	28.7	26.8	7.5	21.3	15.7	254
3. Grey mildew	15	23.6	21.3	24.5	15.6	314	18.1	22.7	15	17.3	26.9	260
4.Leaf Curl	21.4	28.1	13.7	24	12.8	313	19	23.6	14.1	19	24.3	263
5. Tobacco Streak Virus	9.3	25.6	13.1	30.1	21.8	289	9.9	24.9	12.3	26.9	26.1	253

Has there been a change in the pests incidence in Bt cotton over the years? The responses of the farmers on this are summarized in the Table below. The results indicate that many farmers do not see any change. However, in the case of bollworms, 20-30 percent of farmers have experienced an increase but almost an equally large percentage of farmers have experienced a decrease. This may be probably due to differing experiences across the states. However, increases in incidence are seen in the case of sucking insects of aphids and jassids, and mealy bugs, and also in the diseases of alternaria leaf spot, and grey mildew.

Table 5.2: Change in Pest Incidence Seen in Bt Cotton in Recent Years - India

Name of pest	Change in pest incidence with time in Bt cotton?					N
	Large Increase	Increase	No change	Decrease	Large Decrease	
A. Boll Worm						
1. American Boll Worm	30.8	11.8	15.6	15.6	26.3	289
2. Pink Boll Worm	26	14.7	22.5	9.8	27	285
3. Spotted Boll Worm	27.8	12.1	20.1	13.2	26.7	273
B. Sucking Pests						
1. Thrips	9.3	34.7	30.2	21	4.8	291
2. Leafhopper	11	29.1	30.1	27.4	2.3	299
3. Whitefly	21.6	28.8	21.2	11.6	16.8	292
4. Mealy Bug	23.5	28	17.4	19.3	11.7	264
5. Jassids and	33.7	25.3	12.6	21.1	7.4	95

Aphids						
C. Foliage Feeding Pests						
1. Leaf Roller	7.4	20.3	38.4	21	12.9	271
2.Caterpillar	8	20.6	32.4	23.7	15.3	262
D. Soil Pests						
1. Termite	5.3	10	55.3	8.9	20.5	190
E. Diseases						
1. Bacterial blight	15.7	28.7	29.7	18.8	7.2	293
2. Alternaria leaf spot	20.7	31.9	23.2	14.4	9.8	285
3. Grey mildew	21.1	23.5	36.1	12.3	7.1	269
4.Leaf Curl	15	28.8	27	17.5	11.7	274
5. Tobacco Streak Virus	9.9	26.9	31.8	25.6	5.8	242

Andhra Pradesh

The findings on the pest incidence in Andhra Pradesh are given in the table below. The findings indicate substantial resistance shown by BT cotton in the state towards almost all the pests including bollworms, sucking pests, foliage feeding pests and diseases. On the other hand non-BT cotton shows susceptibility to almost all the pests and diseases. Thus BT cotton appears to have substantial advantage in pest resistance in Andhra Pradesh.

Table 5.3: Comparison of Bt Cotton and No-Bt Cotton on Pest Incidence – Andhra Pradesh

Name of pest	Bt cotton						Non Bt cotton					
	Very Heavy	Heavy	Moderate	Light	None	N	Very Heavy	Heavy	Moderate	Light	None	N
A. Boll Worm												
1. American Boll Worm	1.30	22.08	18.18	18.18	40.26	77	30.91	23.64	12.73	9.09	23.64	55
2. Pink Boll Worm	7.59	21.52	11.39	35.44	24.05	79	41.51	15.09	13.21	20.75	9.43	53
3. Spotted Boll Worm	10.26	21.79	7.69	38.46	21.79	78	44.64	19.64	14.29	14.29	7.14	56
B. Sucking Pests												
1. Thrips	4.17	18.06	8.33	27.78	41.67	72	38.60	15.79	17.54	8.77	19.30	57
2. Leafhopper	1.43	22.86	15.71	18.57	41.43	70	42.86	16.07	7.14	16.07	17.86	56
3. Whitefly	5.48	10.96	49.32	13.70	20.55	73	23.40	21.28	19.15	17.02	19.15	47
4. Mealy Bug	7.14	17.14	18.57	22.86	34.29	70	48.44	17.19	9.38	12.50	12.50	64
5. Jassids and Aphids	2.08	18.75	8.33	39.58	31.25	48	48.57	5.71	22.86	8.57	14.29	35
C. Foliage Feeding Pests												
1. Leaf Roller	3.80	16.46	5.06	35.44	39.24	79	38.46	16.92	7.69	16.92	20.00	65

2.Caterpillar	5.13	16.67	7.69	33.33	37.18	78	36.67	20.00	8.33	16.67	18.33	60
D. Soil Pests												
1. Termite	10.67	5.33	5.33	61.33	17.33	75	30.00	8.57	4.29	44.29	12.86	70
E. Diseases												
1. Bacterial blight	8.82	25.00	17.65	25.00	23.53	68	28.30	18.87	11.32	11.32	30.19	53
2. Alternaria leaf spot	8.96	23.88	22.39	13.43	31.34	67	21.82	27.27	9.09	10.91	30.91	55
3. Grey mildew	8.86	15.19	10.13	27.85	37.97	79	46.88	17.19	6.25	15.63	14.06	64
4.Leaf Curl	6.58	23.68	3.95	31.58	34.21	76	38.71	20.97	9.68	16.13	14.52	62
5. Tobacco Streak Virus	15.71	10.00	4.29	42.86	27.14	70	34.33	22.39	7.46	25.37	10.45	67

Gujarat

The results on pest incidence in Gujarat are shown in the table below. BT cotton shows substantial resistance to bollworms as well as foliage eating pests in Gujarat whereas non-BT cotton shows susceptibility. However, BT cotton shows a considerable incidence of Whitefly and Mealy bug, and the diseases of bacterial blight and Alternaria blight. Thus in Gujarat, bollworms are not much of a problem for BT cotton, but some other pests and diseases are.

Table 5.4: Comparison of Bt Cotton and No-Bt Cotton on Pest Incidence - Gujarat

Name of pest	Bt cotton						Non Bt cotton					
	Very Heavy	Heavy	Moderate	Light	None	N	Very Heavy	Heavy	Moderate	Light	None	N
A. Boll Worm												
1. American Boll Worm	2.5	7.5	10.0	32.5	47.5	80	69.4	29.2	0.0	0.0	1.4	72
2. Pink Boll Worm	0.0	5.0	5.0	30.0	60.0	80	48.6	40.3	5.6	2.8	2.8	72
3. Spotted Boll Worm	2.5	17.5	16.3	23.8	40.0	80	67.1	15.1	11.0	5.5	1.4	73
B. Sucking Pests												
1. Thrips	18.8	43.8	21.3	13.8	2.5	80	35.2	39.4	5.6	12.7	7.0	71
2. Leafhopper	15.0	43.8	20.0	15.0	6.3	80	35.7	40.0	7.1	10.0	7.1	70
3. Whitefly	23.8	42.5	18.8	12.5	2.5	80	30.6	38.9	15.3	8.3	6.9	72
4. Mealy Bug	35.1	16.9	16.9	24.7	6.5	77	19.4	12.9	4.8	11.3	51.6	62
5. Jassids and Aphids	0.0	33.3	0.0	33.3	33.3	3	0.0	0.0	33.3	33.3	33.3	3
C. Foliage Feeding Pests												
1. Leaf Roller	2.6	16.7	6.4	28.2	46.2	78	15.5	32.4	14.1	14.1	23.9	71
2.Caterpillar	3.8	1.3	1.3	17.9	75.6	78	18.2	21.2	16.7	9.1	34.8	66
D. Soil Pests												
1. Termite	0.0	6.8	5.1	6.8	81.4	59	4.0	12.0	4.0	4.0	76.0	50

E. Diseases												
1. Bacterial blight	20.3	39.2	15.2	15.2	10.1	79	28.4	34.3	9.0	13.4	14.9	67
2. Alternaria leaf spot	15.2	46.8	17.7	11.4	8.9	79	29.9	31.3	6.0	14.9	17.9	67
3. Grey mildew	10.3	20.5	28.2	21.8	19.2	78	26.2	27.7	9.2	13.8	23.1	65
4.Leaf Curl	16.5	15.2	21.5	21.5	25.3	79	20.9	23.9	14.9	14.9	25.4	67
5. Tobacco Streak Virus	5.5	21.9	26.0	21.9	24.7	73	12.5	28.1	10.9	18.8	29.7	64

Maharashtra

The results for Maharashtra are shown in the table below. They indicated that BT cotton does have some bollworm problem there, though non-Bt cotton has more. Whitefly, Mealy bug, and aphids-jassids appear to be significant problems in BT cotton in Maharashtra. Besides this, the diseases of bacterial blight, Alternaria blight and Leaf curl are also significant problems. Thus, BT cotton appears to have significant problems of pests and diseases in Maharashtra.

Table 5.5: Comparison of Bt Cotton and No-Bt Cotton on Pest Incidence - Maharashtra

Name of pest	Bt cotton						Non Bt cotton					
	Very Heavy	Heavy	Moderate	Light	None	N	Very Heavy	Heavy	Moderate	Light	None	N
A. Boll Worm												
1. American Boll Worm	18.5	37.0	6.2	25.9	12.3	81	26.6	35.9	3.1	18.8	15.6	64
2. Pink Boll Worm	0.0	9.9	9.9	50.6	29.6	81	6.3	34.9	11.1	25.4	22.2	63
3. Spotted Boll Worm	15.0	10.0	3.8	33.8	37.5	80	25.8	19.4	12.9	14.5	27.4	62
B. Sucking Pests												
1. Thrips	3.8	20.0	6.3	41.3	28.8	80	6.3	22.2	14.3	25.4	31.7	63
2. Leafhopper	6.2	19.8	9.9	38.3	25.9	81	1.6	23.8	11.1	36.5	27.0	63
3. Whitefly	39.5	38.3	8.6	9.9	3.7	81	21.3	27.9	4.9	21.3	24.6	61
4. Mealy Bug	36.4	29.9	14.3	11.7	7.8	77	3.3	6.7	6.7	15.0	68.3	60
5. Jassids and Aphids	25.0	12.5	25.0	12.5	25.0	8	0.0	0.0	0.0	25.0	75.0	4
C. Foliage Feeding Pests												
1. Leaf Roller	2.5	11.3	7.5	45.0	33.8	80	1.6	33.3	9.5	27.0	28.6	63
2.Caterpillar	6.3	19.0	10.1	29.1	35.4	79	11.3	16.1	11.3	17.7	43.5	62
D. Soil Pests												
1. Termite	0.0	3.8	7.5	17.0	71.7	53	0.0	5.3	7.9	18.4	68.4	38
E. Diseases												

1. Bacterial blight	19.8	30.9	8.6	27.2	13.6	81	11.3	24.2	11.3	35.5	17.7	62
2. Alternaria leaf spot	31.6	38.0	6.3	19.0	5.1	79	26.2	24.6	6.6	24.6	18.0	61
3. Grey mildew	4.9	22.2	22.2	30.9	19.8	81	6.6	21.3	21.3	21.3	29.5	61
4.Leaf Curl	18.8	32.5	15.0	23.8	10.0	80	11.5	19.7	9.8	27.9	31.1	61
5. Tobacco Streak Virus	1.4	12.2	5.4	47.3	33.8	74	7.3	7.3	10.9	36.4	38.2	55

Punjab

The results for Punjab on pest incidence are given the table below. They indicate that BT cotton has substantial resistance to bollworm in Punjab as compared to non-BT cotton. However, BT cotton in Punjab shows substantial susceptibility to sucking pests such as Whitefly and Mealy bug. It also shows incidence of Alternaria blight to a significant extent. Thus BT cotton in Punjab has good resistance to bollworm is but substantial incidence of other pests.

Table 5.6: Comparison of Bt Cotton and No-Bt Cotton on Pest Incidence - Punjab

Name of pest	Bt cotton						Non Bt cotton					
	Very Heavy	Heavy	Moderate	Light	None	N	Very Heavy	Heavy	Moderate	Light	None	N
A. Boll Worm												
1. American Boll Worm	7.5	20.0	10.0	38.8	23.8	80	25.0	69.4	4.2	1.4	0.0	72
2. Pink Boll Worm	1.3	5.1	6.4	51.3	35.9	78	21.4	50.0	21.4	4.3	2.9	70
3. Spotted Boll Worm	3.8	2.6	7.7	59.0	26.9	78	38.6	45.7	8.6	5.7	1.4	70
B. Sucking Pests												
1. Thrips	13.9	24.1	12.7	36.7	12.7	79	7.1	50.0	22.9	14.3	5.7	70
2. Leafhopper	3.9	29.9	23.4	36.4	6.5	77	14.9	40.3	23.9	16.4	4.5	67
3. Whitefly	58.2	21.5	15.2	3.8	1.3	79	34.7	18.1	5.6	33.3	8.3	72
4. Mealy Bug	51.3	28.8	6.3	8.8	5.0	80	1.4	4.2	2.8	7.0	84.5	71
5. Jassids and Aphids	5.4	81.1	10.8	2.7	0.0	37	2.1	4.3	17.0	46.8	29.8	47
C. Foliage Feeding Pests												
1. Leaf Roller	1.3	34.6	21.8	30.8	11.5	78	2.9	60.0	12.9	17.1	7.1	70
2.Caterpillar	2.6	19.7	6.6	44.7	26.3	76	36.4	31.8	7.6	12.1	12.1	66
D. Soil Pests												
1. Termite	1.8	8.9	25.0	23.2	41.1	56	4.0	10.0	26.0	22.0	38.0	50
E. Diseases												
1. Bacterial blight	3.8	44.9	20.5	20.5	10.3	78	6.8	62.2	12.2	12.2	6.8	74
2. Alternaria	16.5	41.8	17.7	16.5	7.6	79	28.2	36.6	8.5	19.7	7.0	71

leaf spot												
3. Grey mildew	6.6	23.7	25.0	30.3	14.5	76	24.3	25.7	22.9	17.1	10.0	70
4.Leaf Curl	16.7	33.3	14.1	26.9	9.0	78	27.4	32.9	20.5	13.7	5.5	73
5. Tobacco Streak Virus	4.2	26.4	16.7	40.3	12.5	72	9.0	35.8	19.4	31.3	4.5	67

Factors Influencing the Adoption of Bt Technology

Resistance to pests is only one of the factors influencing the adoption of Bt technology by farmers. As discussed above, the process of technology adoption is much more complex. Where does the crop and technology stand on other important factors influencing technology adoption? This is examined using the framework described earlier.

Agronomic Potential

Results on the factors of agronomic potential are given below. The results indicate that cotton is a very important crop for most sample farmers and they have lands which are suitable for cotton cultivation. However some farmers may not have sufficient water for cotton cultivation. Most farmers indicate that BT cotton has shown good pest resistance and is responsive to fertilisers and irrigation. Almost all farmers indicate that BT cotton yields more than non-BT cotton. However, there is little difference in the by-product yield and BT cotton is not as drought and salinity tolerant as non-BT cotton. On the whole the agronomic potential of Bt cotton appears to be strong except for the issues of drought and salinity toleration.

Table 5.7: Results on Agronomic Potential

Statement	Strongly Agree	Agree	Partially Agree	Disagree	Strongly disagree	**Mean**	N
Resources & Importance							
1. Cotton is major crop on your farm	50.2	38.1	6.8	3.4	1.5	4.3	323
2. Your land is highly suitable for cotton cultivation	50.2	38.1	6.8	3.4	1.5	4.3	323
3. There is enough water available for cotton cultivation	28.1	33.2	17.9	16.6	4.2	3.6	313

Technology							
4. BT cotton has less insects/pest problem than non-BT cotton	27.0	56.9	6.0	8.5	1.6	4.0	318
5. BT cotton is more responsive to fertilizer than non-BT cotton	37.3	38.2	16.1	6.2	2.2	4.0	322
6. BT cotton is more responsive to irrigation than non-BT cotton	34.2	37.1	18.1	8.4	2.3	3.9	310
7. BT cotton yields is more as compared to non-BT cotton	54.1	38.4	5.6	1.2	0.6	4.4	320
8. BT cotton yields more by-products as compared to non-BT cotton	15.9	26.2	46.2	7.6	4.1	3.4	315
9. BT cotton is more tolerant to drought/salinity	7.8	32.1	17.8	37.7	4.7	3.0	321

The table below gives results on the agro economic potential of BT cotton. The results indicate that there is good demand for BT cotton even though the price may not be very different compared to non-Bt. Government procurement and price support does not exist for most farmers and neither does contract farming. A huge majority of farmers find BT cotton quality to be better than non-BT cotton. Most farmers indicate that the seed cost of BT cotton is relatively high and the fertiliser water and labour costs are also high. Thus overall BT cotton costs more to produce per hectare but almost all farmers indicate that BT cotton is substantially more profitable than non-BT cotton, indicating a strong agro-economic potential, and this is based on the private market and not government support.

Table 5.8: Results on Agro-economic Potential

Statement	Strongly Agree	Agree	Partially Agree	Disagree	Strongly disagree	**Mean**	N
1. BT cotton fetches higher price than that of non-BT cotton	14	36.3	37	9	3.7	3.5	322
2. There is good demand for BT cotton	30.7	46.9	17.4	3.4	1.6	4.0	322
3. Government procurement & price support for BT cotton exists	7.1	22.6	10.8	23.8	35.6	2.4	323

4. There is contract farming / factory procurement of BT cotton	8.4	6.5	2.2	28.3	54.5	1.9	321
5. The quality of BT cotton fibre is better than non-BT cotton	43.3	41.7	6.9	5.3	2.8	4.2	319
6. Seed cost is relatively low for BT cotton	3.8	11.9	13.1	51.6	19.7	2.3	320
7. Pesticides/ insecticides cost is relatively low for BT cotton	11.8	25.5	14.3	41.6	6.8	2.9	322
8. Fertilizer/water/labour costs are relatively low for BT cotton	2.8	13.9	27.2	42.4	13.6	2.5	316
9. BT cotton production costs lesser per acre than non-BT cotton	5.6	28.1	15	38.1	13.1	2.8	320
10. By-products of BT cotton fetch more price than that of non-BT cotton	6.2	12.4	42.5	20.4	18.6	2.7	313
11. BT cotton is more profitable than non-BT cotton	48.9	37.5	2.5	7.9	3.2	4.2	315

Given that the agronomic and agro economic potential of BT cotton are good, it would be interesting to examine whether any problems exist in converting this potential to effective demand and use. The results in the table below give findings on factors affecting creation of effective demand. The findings indicate that the cotton farmers are willing to take risks and be opinion leaders for other farmers, showing that they are enterprising. Almost all of them are aware of the benefits of BT cotton and the package of practices to follow. However, many farmers are not aware about the right varieties and brands to use. Some farmers do not have sufficient access to credit. However, the villages of most farmers are well-connected with markets. Cotton is extremely important for family income and livelihoods of the farmers who grow it, and this would strongly drive demand for good technology.

Table 5.9: Creation of Effective Demand							
Statement	Strongly Agree	Agree	Partially Agree	Disagree	Strongly disagree	**Mean**	N
1. You are generally willing to take the risk of trying new technologies	34.2	43.2	8.1	10.2	4.3	3.9	322
2. You are opinion leader and guide other farmers for cotton cultivation	37.7	38.3	7.5	9.7	6.9	3.9	321
3. You are well aware of the benefits of BT cotton	40.9	48.9	8.4	1.5	0.3	4.5	323
4. You are well aware of the correct package of practice for BT cotton	41.5	42.4	11.5	2.8	1.9	4.2	323
5. You are well aware of varieties/brands and their benefits/problems	19.2	49.2	20.1	10.8	0.6	3.8	323
6. You have sufficient money/access to credit to buy BT cotton seeds & other inputs	32.9	27.6	6.2	20.2	13	3.5	322
7. Cotton is a very important crop for your family income	53.6	35	4.6	4.6	2.2	4.3	323
8. Your village is well connected with towns and markets	49.5	47.7	1.2	1.2	0.3	4.4	321

Assuming that effective demand exists based on the above findings, it is important to examine whether demand is met well by supply resulting in actual use, or that gaps exist here. The table below gives the results on aggregate supply and distribution situation for BT cotton seeds. Farmers indicate that a large number of companies supply BT cotton seeds and numerous varieties are available in sufficient quantity when needed. Nobody prevents the access to BT cotton technology for the farmers. On the distribution front, farmers indicate that large numbers of dealers nearby are ready to sell BT cotton seeds. However many feel that the dealers charge a high price for BT cotton seeds and often do not provide credit. The dealers provide guidance on the kind of seeds to use and most farmers are satisfied with the quality of the seeds. However the dealers do not take back unused seeds and do not compensate farmers in the case of crop failure, thus the risk is on the farmer.

Table 5.10: Results on Aggregate Supply and Distribution							
Statement	Strongly Agree	Agree	Partially Agree	Disagree	Strongly disagree	**Mean**	N
Aggregate Supply							
1. A large number of companies are supplying BT cotton seeds in this region	34.5	46	7	10.5	1.9	4.0	313
2. BT cotton seeds of different varieties are available in sufficient quantity in your region	39.5	43.9	9.6	6.4	0.6	4.2	314
3. You are not prevented from access to BT cotton technology	48.7	25.2	6.5	11.6	8.1	3.9	310
Distribution							
1. A number of dealers generally have the stock of BT cotton seeds when required	38.1	41.8	11.1	6.2	2.8	4.1	323
2. Dealers are located nearby/ at a convenient distance	32.8	61	4.6	1.2	0.3	4.2	323
3. The dealers charge a reasonable price for the BT cotton seed	26.6	26.9	12.1	28.8	5.6	3.4	323
4. The dealers provide credit to buy BT cotton seed	22	22.6	6.8	19.5	29.1	2.9	323
5. The dealers provide guidance for the right kind of seed and practices	28.8	39.6	7.1	14.9	9.6	3.6	323
6. BT cotton seeds available to you are always of good quality	38.8	47.8	8.1	3.7	1.6	4.2	322
7. The packaging size of BT cotton seed is appropriate	18.7	37.4	29	11.5	3.4	3.6	321
8. The dealer/company takes the unsold/unused seeds back	4	6.9	2.8	26.5	59.8	1.7	321
9. In case of failure, the dealer/company often compensates	2.5	2.2	1.2	15.3	78.8	1.3	321

The above analysis indicates that the adoption process for BT cotton appears to be strong and working well. The technology appears to have excellent agronomic and agro-economic potential and there is little problem in the conversion of this potential to strong demand by the farmers. One concern is the limited knowledge that farmers have about the varieties and brands suitable for their areas and farms. The aggregate supply and distribution also appear to be quite strong and working well. These findings are validated by the rapid adoption and continuing cultivation of BT cotton experienced in India.

Sources of Information and Advice

What sources of information are used by the farmers with respect to Bt cotton? This is important to understand because it indicates what and who influences the decision-making of the farmers. The findings on positive information are given in the table below. The findings indicate that seed dealers are the most common source of information, and also the most important. The next most common/ important source is fellow farmers. This seed company and other input dealers also play a small role. However, the government sources such as extension workers and call centres do not play much of a role as far as information on BT cotton is concerned. Mass media such as newspapers and television also play only a limited role. The main advantages conveyed by the information sources include yield advantage, pest resistance and profitability.

Table 5.11: Sources of positive information about Bt cotton

Kind of Information	Sources of Information	Source/ aspect considered most important
Information about Bt cotton and its advantages?	1. Seed dealer (59.9 %) 2. Fertilizer dealer (13.1 %) 3. Seed Company (7.2 %) 4. Pesticide dealer (3.6 %), 5. Extension Worker (0.6 %) 6. Fellow Farmer (40.1 %) 7. Village Leader (1.8 %), 8. Cooperative (2.4 %) 9. NGOs (0.3 %) 10. Newspaper (3.9 %) 11. T.V (2.7 %) 12. Mobile (0.6 %) 13. Radio (0.3 %) 14. Others (0.9 %) (Kisan Call Centre, Krishi Rath)	1. Seed Dealers (55.5 %) 2. Fellow Farmers (39.6 %) 3. Seed Company (4.9%), 4. Fertilizer Dealers (4.3 %), 5. Pesticide Dealers (2.1 %) 6. TV and Radio (2.7 %), 7. Cooperatives (0.3 %) 8. Krishi Rath (0.3 %) 9. Kishan Call Center (0.3 %)

Advantage conveyed	1. Yield (59.8 %) 2. Insect/Pest resistance (34.4 %), 3. Profitability (16.70 %) 4. Less cost of cultivation (2.4 %)	1. Yield (66.54 %) 2. Insect/Pest resistance (23.79 %) 3. Profitability (5.20 %) 4. Less cost of cultivation (4.46 %)

Findings on the information on the disadvantages and negative aspects are given below. They indicate that by and large nobody conveys such information, and of this the most important source is fellow farmers, and not newspapers, mass media or NGOs. Very little negative information is conveyed, and this mainly relates to the risk and the highest seed cost, rather than harm to human beings and the environment.

Table 5.12: Sources of negative information about Bt cotton

Kind of Information	**Sources of Information**	**Source/ aspect considered most important**
Information about the negative aspects of Bt cotton?	1. Fellow Farmers (13.8 %) 2. Village Leaders (0.9 %) 3. Gram Sevak (0.3 %) 4. Seed Dealers (1.2 %) 5. Pesticide Dealers (0.6 %) 6. Newspaper & TV (1.2 %) 7. NGO & Cooperatives (0.6 %) 8. Nobody (80.7 %)	1. Fellow Farmers (75.55 %) 2. Village Leaders (2.23 %) 3. Newspaper & TV (5.45 %) 4. NGO & Cooperatives (5.45 %),
Problems conveyed	1. High risk (8.8 %) 2. High seed cost (10.9 %), 3. Harmful to human (7.2 %) 4. Harmful to environment (1.2 %) 5. False claims (1.5 %) 6. None (71.8 %)	1. High risk (7.79 %) 2. High seed cost (55.84 %) 3. Harmful to human (7.79 %) 4. Harmful to environment (3.90 %) 5. False claims (7.79 %)

Chapter 6: Costs, Yields and Profitability of Bt Cotton

Insights into the economics of Bt cotton and its comparison to non-Bt cotton are very important to understand the nature of the cost-benefits of the technology. This also helps explain the behavior of the farmers and the economic benefits of the technology, as well as the problems and concerns. The data on this obtained in the survey are examined below. Kindly note that the sample numbers and accordingly the results may vary based on the available responses and data.

There have been some concerns expressed in the literature about the number of non-adopters included in such studies. In a criticism of the Bt cotton studies, Glenn Stone (2012) mentioned how lack of counterfactuals may make claims of yield or profit advantage of Bt cotton doubtful. In this context it is indicated that some years ago, such as in 2004-05 when the previous IIM study data was collected, it was possible and easy to find non-adopters. When the data collection for the current study was done, 2012-13, the Bt adoption had reached nearly 90 percent in India and almost 100 percent in the study districts. Finding non-adopters was almost impossible. Thus, having non-adopters in the sample was very difficult. The non-Bt data collect for this study is based largely on the recall of the farmers surveyed from their experience of growing non-Bt cotton some years ago. The data is subject to recall inaccuracy and errors expected in such data and is also from an earlier time period. The comparative results are therefore subject to this stated nature of the data. However, the fact remains that over 90 percent of the farmers have adopted Bt cotton and this cannot happen without Bt offering a substantial advantage. The farmer perception results of Chapter 8 can also be seen. Besides the earlier study, in which a sizable non-adopter sample was there, had shown the statistically significant advantage of Bt cotton in yields as well as profits, through a sound regression framework which took into account the factors such as the differences and contribution of other inputs. Glenn Stone (2012) mentions two biases 1. Selection bias and 2. Cultivation bias. The Selection bias is addressed in this study through a wide stratified random sample comprising of 98 small farmers, 185 medium farmers and 43 large farmers. The cultivation bias is addressed through econometric analysis by including various other inputs as independent variables. Besides farmer perception data is also collected on various independent aspects including yield, profit and insect resistance.

All States - India

The table below shows the analysis of the findings from the survey. It must be noted that the non-BT Cotton findings are based on a limited set of responses and usually based on recall by farmers since hardly any currently grow non-BT Cotton. The findings indicate that there is a substantial difference in the seed, fertiliser, harvesting, and marketing costs. As a result the total cost increases by 72%. However, the yield increases by 33% and the revenue by 79% with the adoption of Bt cotton. As a result there is a substantial increase of 83% in the profits. The findings on perception also indicate that farmers perceive a substantial increase in the yields and particularly in profits with the adoption of BT Cotton. This economic advantage explains the rapid adoption of BT Cotton and its huge popularity with the farmers.

Table 6.1: India – Costs, Yields and Profits of Bt Cotton Compared to Non-Bt Cotton Varieties

Sl. No	Input/ Operation	BT Average Cost/ Value (Rs/ha)	N	Non BT Average Cost (Rs/ha) (when last grown)	N	Percent Increase	Perception about Difference of BT over Non BT Cotton					N
							Substantially positive	Positive	No Impact	Negative	Substantially Negative	
1	Seed	3695	215	1301	44	184.0	3.4	39.3	25.7	25.2	6.3	215
2	Fertilizers	6446	326	777	105	729.6	3.4	37.2	45.5	12.9	1	261
3	Farm Yard Manure	9629	158	5924	28	62.5	5.9	23.1	57.5	12.4	1.1	158
4	Pesticide	6522	156	4601	26	41.8	9.5	22.2	23.4	43	1.9	156
5	Irrigation	3977	185	5125	19	-22.4	2	28.1	56.2	12.8	0.5	186
6	Farm Power	6978	224	5129	45	36.0	2.3	13.7	28.8	61.9	1.3	214

7	Land prep & sowing	2003	245	1287	41	55.6	6.1	23.8	63.2	6.5	0.4	245
8	Weeding & others	4300	260	2317	52	85.6	8.3	32.7	34.2	21.4	3.4	260
9	Harvesting	7826	257	3641	47	114.9	10.8	39	29.1	18.3	2.8	252
10	Marketing	1581	148	652	31	142.5	7.9	26	60.6	5.5	0	148
11	**Total Cost**	43967	293	25607	105	71.7	8.3	26.2	20.2	8.3	36.9	293
12	**Yield (Kg/ha)**	3003	321	2265	105	32.6	54.1	38.4	5.6	1.2	0.6	320
13	**Revenue**	125922	325	70377	105	78.9	27	56.9	6	8.5	1.6	322
14	**Profit**	81954	325	44769	105	83.1	48.9	37.5	2.5	7.9	3.2	315
Note: All values are not reported by all farmers. Since they are derived from varying samples, the totals may not match.												

Andhra Pradesh

The results for Andhra Pradesh are given in the table below. The results indicate that there is a substantial increase in the seed, fertiliser, farm yard manure, and harvesting costs leading to an increase in the total cost of 205%. However the yield increases by 52% and the total revenue by 99%. Thus, profits increases by 70% with the adoption of BT Cotton. The farmer perception substantiates the great advantage that BT Cotton has in yields and profits, leading to the widespread adoption of BT Cotton in Andhra Pradesh.

Table 6.2: Andhra Pradesh – Costs, Yields and Profits of Bt Cotton Compared to Non-Bt Cotton Varieties

Sl. No.	Input/ Operation	BT Average Cost (Rs/ha)	N	Non BT Average Cost (Rs/ha) (when last grown)	N	Percent Change	Perception about Cost Difference of BT over Non BT Cotton					N
							Substantially positive	Positive	No Impact	Negative	Substantially Negative	
1	Seed	5026	81	1133	32	343.6	2.4	30.5	9.8	14.6	42.7	82
2	Fertilizers	12375	82	1917	20	545.5	4.9	35.4	45.1	13.4	1.2	82
3	Farm Yard Manure	7375	1	687	2	973.5	4.5	22.4	55.2	14.9	3.0	67
4	Pesticide	13839	14	10916	3	26.8	1.9	13.0	22.2	57.4	5.6	54
5	Irrigation	11208	6	5000	1	124.2	1.6	21.9	59.4	17.2	0.0	64
6	Farm Power	10963	38	5736	24	91.1	0.0	9.5	82.5	7.9	0.0	63
7	Land prep & sowing	3379	28	828	8	308.1	4.2	16.7	70.8	6.9	1.4	72

8	Weeding & others	3396	47	865	20	292.6	8.3	31.9	33.3	22.2	4.2	72
9	Harvesting	9965	38	2246	16	343.7	10.4	47.8	29.9	9.0	3.0	67
10	Marketing	3125	8	892	7	250.3	0.0	25.8	67.7	6.5	0.0	31
11	**Total Cost**	37544	82	12282	24	205.7						
12	Yield (Kg/ha)	2826	82	1863	67	51.7	52.6	41.0	6.4	0.0	0.0	78
13	Revenue	111880	82	56109	59	99.4	51.3	33.3	11.5	0.0	3.8	78
14	Profit	74336	82	43826	59	69.6	76.3	19.7	0.0	0.0	3.9	76
Note: All values are not reported by all farmers. Since they are derived from varying samples, the totals may not match.												

Gujarat

The findings for Gujarat are given in the table below. The findings indicate that there is a substantial increase in the seed, fertiliser, farmyard manure, and marketing costs with the adoption of BT Cotton. However, other costs increases are limited and the overall costs increases by 50%, which is less compared to other states. The yields increase by 30% and the revenue by 326% leading to a substantial increase in profits of 139%. The impact of BT Cotton on profits in Gujarat appears to be among the highest in the States, explaining the widespread adoption of BT Cotton in Gujarat.

Table 6.3: Gujarat – Costs, Yields and Profits of Bt Cotton Compared to Non-Bt Cotton Varieties

Sl. No.	Input/ Operation	BT Average Cost (Rs/ha)	N	Non BT Average Cost (Rs/ha) (when last grown)	N	Percent Increase	Perception about Cost Difference of BT over Non BT Cotton					
							Substantially positive	Positive	No Impact	Negative	Substantially Negative	N
1	Seed	2437	40	1000	1	143.7	0.0	29.3	23.2	9.8	37.8	82
2	Fertilizers	3354	81	44	5	7522.7	0.0	26.8	62.2	11.0	0.0	82
3	Farm Yard Manure	7953	51	1062	2	648.9	0.0	100.0	0.0	0.0	0.0	2
4	Pesticide	4977	40	2906	4	71.3	0.0	50.0	41.7	8.3	0.0	12
5	Irrigation	3463	68	3000	3	15.4	0.0	47.7	36.4	13.6	2.3	44
6	Farm Power	5387	51	3937	5	36.8	0.0	0.0	30.4	62.5	7.1	56
7	Land prep & sowing	1739	70	1333	3	30.5	0.0	38.1	47.6	9.5	4.8	21
8	Weeding & others	3565	69	1116	3	219.4	0.0	9.4	37.7	47.2	5.7	53

9	Harvesting	7570	70	2458	3	208.0	0.0	22.0	34.0	38.0	6.0	50
10	Marketing	1437	36	175	1	721.1	0.0	40.0	40.0	20.0	0.0	15
11	**Total Cost**	33466	78	22366	5	49.6	11.1	17.8	6.7	48.9	15.6	45
12	**Yield (Kg/ha)**	2988	77	2292	40	30.4	54.3	30.9	9.9	0.0	4.9	81
13	**Revenue**	108933	81	25521	38	326.8	15.9	46.3	26.8	0.0	11.0	82
14	**Profit**	75466	81	31527	38	139.4	24.7	39.5	4.9	0.0	30.9	81
Note: All values are not reported by all farmers. Since they are derived from varying samples, the totals may not match.												

Maharashtra

The results for Maharashtra are given in the table below. The results indicate that there is a substantial increase in the fertiliser, pesticide, harvesting and marketing costs in the shift from non-BT to BT Cotton. As a result the total cost increases by 94%. The increase in the yield is 46% and the revenue by only 20%. As a result the profits in Maharashtra increased by 44%. This is among the lowest in the sample states, though the perceived increase in yield, revenue and profits is highly positive. This appears to show a gap between perception and reality in BT Cotton in the state of Maharashtra.

Table 6.4: Maharashtra – Costs, Yields and Profits of Bt Cotton Compared to Non-Bt Cotton Varieties

Sl. No.	Input/ Operation	BT Average Cost (Rs/ha)	N	Non BT Average Cost (Rs/ha) (when last grown)	N	Percent Increase	Perception about Cost Difference of BT over Non BT Cotton					
							Substantially positive	Positive	No Impact	Negative	Substantially Negative	N
1	Seed	3440	59	2181	11	57.7	3.7	12.3	22.2	19.8	42.0	81
2	Fertilizers	6937	59	1157	22	499.6	4.9	33.3	58.0	3.7	0.0	81
3	Farm Yard Manure	12336	59	7284	22	69.4	10.0	22.0	60.0	8.0	0.0	50
4	Pesticide	6507	65	2479	17	162.5	22.5	37.5	22.5	17.5	0.0	40
5	Irrigation	4441	47	6197	12	-28.3	6.7	23.3	66.7	3.3	0.0	30
6	Farm Power	8337	59	5294	48	57.5	12.7	27.3	60.0	0.0	0.0	55
7	Land prep & sowing	1960	82	1412	27	38.8	12.1	31.8	51.5	4.5	0.0	66
8	Weeding & others	5934	80	3711	26	59.9	14.9	55.2	26.9	3.0	0.0	67

9	Harvesting	6636	79	3018	25	119.9	19.7	39.4	24.2	16.7	0.0	66
10	Marketing	1453	70	619	22	134.7	18.5	25.9	55.6	0.0	0.0	54
11	**Total Cost**	51133	70	26292	39	94.5	0.0	0.0	0.0	11.8	88.2	17
12	**Yield (Kg/ha)**	3408	82	2327	30	46.5	67.9	29.6	1.2	0.0	1.2	81
13	**Revenue**	120210	82	100034	29	20.2	33.3	43.2	18.5	0.0	4.9	81
14	**Profit**	69077	70	48026	39	43.8	51.9	40.3	2.6	0.0	5.2	77
Note: All values are not reported by all farmers. Since they are derived from varying samples, the totals may not match.												

Punjab

The findings of Punjab are given in the table below. The findings indicate that there is a substantial difference/ increase in the fertiliser, farmyard manure, weeding, and marketing costs, but a reduction in the pesticide and harvesting costs. Overall, this leads to a 66% increase in the total cost. The yield increases by 32% and the revenue by 44%. The overall increase in profits is by 34% which appears to be the lowest among the sample states. However, the perceptions about the yield and property increases are very high, indicating a gap between perception and reality. Thus in terms of profitability, BT Cotton does not seem to offer a very high advantage in Punjab compared to non-Bt cotton.

Table 6.5: Punjab – Costs, Yields and Profits of Bt Cotton Compared to Non-Bt Cotton Varieties

Sl. No.	Input/ Operation	BT Average Cost (Rs/ha)	N	Non BT Average Cost (Rs/ha) (when last grown)	N	Percent Increase	Perception about Cost Difference of BT over Non BT Cotton					
							Substantially positive	Positive	No Impact	Negative	Substantially Negative	N
1	Seed Cost	2550	36	1000	1	155.0	1.2	2.4	0.0	29.3	67.1	82
2	Fertilizers	3152	82	43	3	7230.2	0.0	39.0	56.1	3.7	1.2	82
3	Farm Yard Manure	8098	47	1062	2	662.5	1.6	21.9	65.6	10.9	0.0	64
4	Pesticide	5634	38	11875	3	-52.6	0.0	44.7	10.6	44.7	0.0	47
5	Irrigation	3504	64	3000	3	16.8	4.1	32.7	59.2	4.1	0.0	49
6	Farm Power	5403	47	3937	5	37.2	9.1	28.8	57.6	4.5	0.0	66
7	Land prep & sowing	1799	66	1333	3	35.0	0.0	39.4	57.6	3.0	0.0	66

8	Weeding & others	3696	65	1116	3	231.2	10.4	28.4	58.2	1.5	1.5	67
9	Harvesting	8255	71	17458	3	-52.7	16.7	25.8	50.0	6.1	1.5	66
10	Marketing	1636	34	175	1	834.9	7.4	31.5	57.4	3.7	0.0	54
11	**Total Cost**	57373	64	34586	38	65.9	3.2	16.1	11.3	30.6	38.7	62
12	**Yield (Kg/ha)**	3782	81	2871	42	31.7	41.3	52.5	5.0	0.0	1.3	80
13	**Revenue**	162132	81	112991	41	43.5	23.5	64.2	12.3	0.0	0.0	81
14	**Profit**	104759	81	78404	41	33.6	44.4	49.4	2.5	0.0	3.7	81
Note: All values are not reported by all farmers. Since they are derived from varying samples, the totals may not match.												

Comparison across the States

The table below provides a comparison across the States of the percentage increase in costs, yields, revenues and profits in BT Cotton over non-BT Cotton. The table indicates that there is a considerable increase in the seed cost but this varies from over 300% in Andhra Pradesh to just 57% in Maharashtra. Fertiliser costs showing a huge increase in all states and even farmyard manure shows a large increase in most states. Pesticide costs do not show much change, except in Punjab where they show a decrease. Two other costs which show change are harvesting costs and marketing costs. On an all India average, total cost shows a 71% increase, but this ranges from as high as 205% in Andhra Pradesh to just 50% in Gujarat. The highest yield increase is seen in Andhra Pradesh followed by Maharashtra. Revenue increased is most substantial in Gujarat at over 300% in the least in Maharashtra at just 20%. The profit increase is the greatest in Gujarat at 140% followed by Andhra Pradesh at 70%. The lowest increase is shown by Punjab at 34%.

Table 6.6: Comparison across States – Percent Increase in Costs, Yields and Profits: Bt Cotton vs Non-Bt Cotton						
Sl. No.	**Input/ Operation**	**Andhra Pradesh**	**Gujarat**	**Maharashtra**	**Punjab**	**All States India**
1	Seed Cost	343.6	143.7	57.7	155.0	184.0
2	Fertilizers	545.5	7522.7	499.6	7230.2	729.6
3	Farm Yard Manure	973.5	648.9	69.4	662.5	62.5
4	Pesticide	26.8	71.3	162.5	-52.6	41.8
5	Irrigation	124.2	15.4	-28.3	16.8	-22.4
6	Farm Power	91.1	36.8	57.5	37.2	36.0
7	Land prep & sowing	308.1	30.5	38.8	35.0	55.6
8	Weeding & others	292.6	219.4	59.9	231.2	85.6
9	Harvesting	343.7	208.0	119.9	-52.7	114.9
10	Marketing	250.3	721.1	134.7	834.9	142.5
11	**Total Cost**	205.7	49.6	94.5	65.9	71.7
12	**Yield (Kg/ha)**	51.7	30.4	46.5	31.7	32.6
13	**Revenue**	99.4	326.8	20.2	43.5	78.9
14	**Profit**	69.6	139.4	43.8	33.6	83.1
Note: The values/ percentages are derived from varying samples and may not be aggregative.						

The table below shows a comparison of the levels of costs, yields, revenues and profits in BT Cotton per hectare cross the States. Andhra Pradesh shows among the highest costs in seeds, fertilisers, pesticides, irrigation and farm power. On the other hand Gujarat shows some of the lowest costs such as in seeds, pesticides, irrigation and farm power. The total cost is also the lowest in Gujarat at Rs. 33466 per hectare and the highest cost is shown by Punjab at Rs. 57373 per hectare. However, the yield and revenue are also the highest in Punjab leading to the highest per hectare profit in Punjab of Rs. 104759. This is followed by Gujarat at Rs. 75466 per hectare, and the lowest being in Maharashtra at Rs. 69077 per hectare.

Table 6.7: Comparison across States – Costs, Yield, Revenue and Profit in Bt Cotton Rs. per hectare

Sl. No.	Input/ Operation	Andhra Pradesh	Gujarat	Maharashtra	Punjab	All States India
1	Seed Cost	5026	2437	3440	2550	3695
2	Fertilizers	12375	3354	6937	3152	6446
3	Farm Yard Manure	7375	7953	12336	8098	9629
4	Pesticide	13839	4977	6507	5634	6522
5	Irrigation	11208	3463	4441	3504	3977
6	Farm Power	10963	5387	8337	5403	6978
7	Land prep & sowing	3379	1739	1960	1799	2003
8	Weeding & others	3396	3565	5934	3696	4300
9	Harvesting	9965	7570	6636	8255	7826
10	Marketing	3125	1437	1453	1636	1581
11	**Total Cost**	37544	33466	51133	57373	43967
12	**Yield (Kg/ha)**	2826	2988	3408	3782	3003
13	**Revenue**	111880	108933	120210	162132	125922
14	**Profit**	74336	75466	69077	104759	81954

Note: The values/ percentages are derived from varying samples and may not be aggregative

Chapter 7: Econometric Analysis of Bt Cotton Performance

Even though the different features of BT Cotton have been examined through data, percentages and averages, it is important to establish the statistical significance of the major findings in order to confirm them and establish their statistical strength. For this econometric analysis is important and is carried out here. Regression analysis is used here with the yield and other relevant variables examined as the dependent variables, and a Bt Cotton dummy variable as the independent variable to compare the impact of Bt varieties as against other varieties. The results would be identical to that of obtained through analysis of variance (Green and Carroll 1978). Note that these results may not match fully match since the sample numbers and responses vary.

Findings for the full sample of states are given in the table below. The findings indicate that BT Cotton is statistically significant in increasing the yields, and on an average gives an impact of 35% increase in the yields. The impact on the value of output is also statistically significant and is found to be 93%. However, the total cost increase is also large and significant and is of 111%. This derives from increases in pesticide cost and seed cost of 42 percent and 184 percent respectively and are statistically significant. The findings indicate that there is also a 54 percent increase in price (but this may be partly related to historical cotton prices). Despite the cost increases, the yield, value of output, and price advantages of Bt cotton lead to a statistically significant 75% increase in the profits, which is very substantial.

Table 7.1: Regression Results on the Impact of Bt Cotton on various cost and performance variables: All Sample States - India

		Variables		N=652
Dependent Variable		Constant	Bt	Percent Impact of Bt
Yield	Coefficient	1977.48	691.48	34.97
	t-stat	20.97	5.84	
	Signifi.	***	***	
Value of Output	Coefficient	58491.94	54592.66	93.33
	t-stat	15.36	11.69	

	Signifi.	***	***	
Total Cost	Coefficient	17016.12	18918.24	111.18
	t-Stat	5.59	5.59	
	Signifi.	***	***	
Pesticide Cost	Coefficient	4601.92	1920.19	41.73
	t-Stat	3.87	1.50	
	Signifi.	***		
Seed Cost	Coefficient	1301.82	2393.32	183.84
	t-Stat	2.31	3.86	
	Signifi.	**	***	
Price	Coefficient	2739.83	1493.40	54.51
	t-Stat	49.38	21.45	
	Signifi.	***	***	
Profit	Coefficient	44050.28	33016.56	74.95
	t-Stat	9.43	5.90	
	Signifi.	***	***	
Note: *** = significant at 99 percent, ** = significant at 95 percent, * = significant at 90 percent				

Findings for Andhra Pradesh are given in the table below. The findings indicate that BT Cotton gives a statistically significant increase in the yields of 46 percent which is higher than the full sample average. The impact on the value of output is also statistically significant and is found to be larger at 112%. However, the total cost increase is also large and statistically significant and is of 221%. This derives from increases in pesticide cost of 27 percent and substantial seed cost increase of 342 percent. The findings indicate that there is also a 51 percent increase in price (but this may be partly related to historical cotton prices). Despite the cost increases, the yield, value of output, and price advantages of Bt cotton lead to a statistically significant 96% increase in the profits, which is very substantial and larger than the estimated national (4 state) increase.

Table 7.2: Regression Results on the Impact of Bt Cotton on various cost and performance variables: Andhra Pradesh

		Variables		N=164
Dependent Variable		Constant	Bt	Percent Impact of Bt
Yield	Coefficient	1925.40	893.69	46.42
	t-stat	14.37	4.89	
	Signifi.	***	***	
Value of Output	Coefficient	56264.09	63131.22	112.21
	t-stat	11.64	9.83	
	Signifi.	***	***	
Total Cost	Coefficient	9771.18	21614.93	221.21

	t-Stat	3.31	6.07	
	Signifi.	***	***	
Pesticide Cost	Coefficient	10916.67	2922.62	26.77
	t-Stat	2.65	0.64	
	Signifi.	**		
Seed Cost	Coefficient	1133.98	3892.78	343.28
	t-Stat	1.44	4.17	
	Signifi.	NS	***	
Price	Coefficient	2787.42	1445.22	51.85
	t-Stat	27.46	10.44	
	Signifi.	***	***	
Profit	Coefficient	45492.94	43683.62	96.02
	t-Stat	8.69	6.12	
	Signifi.	***	***	
Note: *** = significant at 99 percent, ** = significant at 95 percent, * = significant at 90 percent				

Findings for Gujarat are given in the table below. The findings indicate that BT Cotton gives a statistically significant increase in the yields of 47 percent which is about the same as Andhra Pradesh. The impact on the value of output is also statistically significant and is found to be larger at 123%. However, the total cost increase is also large of 135%. This is not statistically significant since it is based on very few observations available for non-Bt cotton in the sample. The increase derives from increases in pesticide cost of 71 percent and substantial seed cost increase of 144 percent. The findings indicate that there is also a 55 percent increase in price (but this may be partly related to historical cotton prices recall). Despite the cost increases, the yield, value of output, and price advantages of Bt cotton lead to a statistically significant 90% increase in the profits, which is very substantial and is almost the same as that Andhra Pradesh.

Table 7.3: Regression Results by State on the Impact of Bt Cotton on various cost and performance variables: Gujarat				
		Variables		N=162
Dependent Variable		Constant	Bt	Percent Impact of Bt
Yield	Coefficient	1921.92	906.33	47.16
	t-stat	9.24	3.49	
	Signifi.	***	***	
Value of Output	Coefficient	53601.97	66333.79	123.75
	t-stat	6.03	6.15	
	Signifi.	***	***	
Total Cost	Coefficient	13087.50	17686.91	135.14
	t-Stat	0.83	1.10	

	Signifi.			
Pesticide Cost	Coefficient	2906.25	2071.25	71.27
	t-Stat	1.24	0.84	
	Signifi.			
Seed Cost	Coefficient	1000.00	1437.56	143.76
	t-Stat	0.29	0.41	
	Signifi.			
Price	Coefficient	2749.47	1501.96	54.63
	t-Stat	22.41	9.86	
	Signifi.	***	***	
Profit	Coefficient	46470.13	41679.21	89.69
	t-Stat	5.14	3.71	
	Signifi.	***	***	
Note: *** = significant at 99 percent, ** = significant at 95 percent, * = significant at 90 percent, NS = not significant				

Findings for Maharashtra are given in the table below. The findings indicate that BT Cotton gives a statistically significant increase in the yields of 16 percent which is much lower than Andhra Pradesh or Gujarat. The impact on the value of output is also statistically significant but much lower at 75%. However, the total cost increase is large and statistically significant and is of 153%. This derives from increases in pesticide cost of 159 percent, which is much larger than other states, and seed cost increase of 80 percent. The findings indicate that there is also a 66 percent increase in price (but this may be partly related to historical cotton prices recall). The cost increases, and the yield, value of output, and price advantages of Bt cotton lead to a statistically significant 24% increase in the profits, which is much lower than that seen in Andhra Pradesh and Gujarat.

Table 7.4: Regression Results by State on the Impact of Bt Cotton on various cost and performance variables: Maharashtra				
		Variables		N=162
Dependent Variable		Constant	Bt	Percent Impact of Bt
Yield	Coefficient	1959.38	312.38	15.94
	t-stat	7.28	0.99	
	Signifi.	***		
Value of Output	Coefficient	54703.26	41012.28	74.97
	t-stat	4.78	3.13	
	Signifi.	***	***	
Total Cost	Coefficient	23668.71	24852.93	105.00
	t-Stat	6.99	6.24	
	Signifi.	***	***	

Pesticide Cost	Coefficient	2478.13	3935.94	158.83
	t-Stat	2.01	2.86	
	Signifi.	**	***	
Seed Cost	Coefficient	1899.25	1514.03	79.72
	t-Stat	3.59	2.64	
	Signifi.	***	***	
Price	Coefficient	2530.36	1670.99	66.04
	t-Stat	18.69	10.51	
	Signifi.	***	***	
Profit	Coefficient	38767.62	9196.97	23.72
	t-Stat	3.76	0.77	
	Signifi.	***	***	
Note: *** = significant at 99 percent, ** = significant at 95 percent, * = significant at 90 percent				

Findings for Punjab are given in the table below. The findings indicate that BT Cotton gives a statistically significant increase in the yields of 30 percent which is much lower than Andhra Pradesh or Gujarat, but higher than Maharashtra. The impact on the value of output is also statistically significant and about the same as Maharashtra at 73%. The total cost actually shows a decrease at -19 percent. This derives from decreases in pesticide cost at -53 percent, and seed cost increase of 155 percent which is comparable to Gujarat. The cost changes are not statistically significant since they are based on very few observations available for non-Bt cotton. The findings indicate that there is also a 48 percent increase in cotton price (but this may be partly related to historical cotton prices recall). The cost decreases, and the yield, value of output, and price advantages of Bt cotton lead to a statistically significant increase in the profits of 70 percent, but this is lower than that seen in Andhra Pradesh and Gujarat.

Table 7.5: Regression Results by State on the Impact of Bt Cotton on various cost and performance variables: Punjab				
		Variables		N=164
Dependent Variable		Constant	Bt	Percent Impact of Bt
Yield	Coefficient	2118.00	641.60	30.29
	t-stat	11.86	2.92	
	Signifi.	***	***	
Value of Output	Coefficient	68005.80	49363.66	72.59
	t-stat	9.78	5.84	
	Signifi.	***	***	
Total Cost	Coefficient	40450.00	-7703.85	-19.05
	t-Stat	2.07	-0.39	
	Signifi.	**		

Pesticide Cost	Coefficient	11875.00	-6240.79	-52.55
	t-Stat	3.03	-1.53	
	Signifi.	***		
Seed Cost	Coefficient	1000.00	1550.42	155.04
	t-Stat	0.27	0.42	
	Signifi.			
Price	Coefficient	2865.71	1381.24	48.20
	t-Stat	32.45	12.72	
	Signifi.	***	***	
Profit	Coefficient	49048.24	34675.05	70.70
	t-Stat	5.95	3.37	
	Signifi.	***	***	
Note: *** = significant at 99 percent, ** = significant at 95 percent, * = significant at 90 percent				

The impact of Bt Cotton is represented by a single dummy variable in the above equations and results, which is consistent with the analysis of variance framework, but it would include the effects of all other inputs. In order to separate and capture the other input effects, additional analysis is carried out below which includes, apart from Bt, the effects of some of the major inputs. The independent variables included are Bt Dummy, Seed input cost, Fertiliser input cost, Pesticide input cost, Farm Power cost, Land Preparation cost, Harvesting cost, and Dummy variables for the states of Maharashtra, Andhra Pradesh, and Punjab (Gujarat being the base). The results indicate that even when other effects are included, the Bt cotton variable continues to have strong statistical significance in determining the different dependent variables of yield, value of output, total cost, and profit. The impact of Bt cotton on yield is found to be about 38 percent, and that on profits comes to 83 percent. Thus the present data confirms the strong positive impact of Bt cotton on yields and profits. Whereas the impact of seed input cost is not significant in any equation, the impact of fertilizer input cost is significant in the total cost equation. The pesticide input cost has a positive and significant impact on the yield, value of output, and total cost, indicating that pesticide use still has an impact, perhaps owing to the problems of other pests. However, its impact on profits is not significant. In other costs, farm power, land preparation and harvesting all contribute significantly to the total cost. In particular, land preparation and harvesting costs both have a significant negative impact on the profitability of cotton. This is perhaps due to the impact of the high and rising labor cost in cotton cultivation. The dummy variable estimates indicate that the profitability in Maharashtra and Punjab is lower than that in Gujarat, but for Andhra Pradesh, it is statistically no different from that in Gujarat.

Table 7.6: Regression results for the determinants of yield, value of output, total cost and profits in cotton

Dependent Variable		Constant	Bt	Seed Input Cost	Fertilser Input Cost	Pesticide Input Cost	Farm Power Input Cost	Land Prepara-tion Cost	Harvesting Cost	Dummy Maharashtra	Dummy Andhra Pradesh	Dummy Punjab
Yield	Coefficient	2019.375	763.22	-0.03	0.005	0.04	0.014	-0.059	0	-653.257	-233.29	-137.771
	t-stat	10.49	3.342	-0.446	0.274	2.175	0.551	-1.558	-0.008	-2.747	-0.844	-0.652
	Significance	***	***			**				***		
Value of Output	Coefficient	62674.87	55049.03	-0.191	0.094	1.43	0.561	-2.177	0.08	-25575.3	-13064.8	-17090.2
	t-stat	8.383	6.21	-0.074	0.124	2.025	0.57	-1.483	0.154	-2.766	-1.215	-2.133
	Significance	***	***			**				**		**
Total Cost	Coefficient	29.879	3110.787	0.554	1.218	1.21	2.308	1.587	1.21	2521.365	-13336.2	-630.259
	t-stat	0.029	2.512	1.526	11.499	12.27	16.801	7.737	16.682	1.952	-8.879	-0.563
	Significance		**		***	***	***	***	***	*	***	
Profit	Coefficient	62645.07	51938.49	-0.745	-1.124	0.22	-1.747	-3.764	-1.13	-28096.6	271.514	-16459.9
	t-stat	8.228	5.753	-0.282	-1.455	0.305	-1.744	-2.517	-2.137	-2.984	0.025	-2.017
	Significance	***	***					***	**	***		**

Note: Bt dummy=1 for Bt and 0 for Non-Bt cotton variety, *** = significant at 99 percent, ** = significant at 95 percent, * = significant at 90 percent (N=306)

Chapter 8: Perceived Performance and Satisfaction with Bt Cotton

This chapter examines the responses of the farmers on the perceived advantages and disadvantages of Bt cotton vs non-Bt cotton, the overall satisfaction, the impact on the local economy, and the changes they see in the recent years.

The results on the advantages and disadvantages are given in the table below. A majority of the farmers see advantage of BT cotton in the quality and availability of seeds, reduction of the pest incidence and problem, and the need to use pesticides. They also see advantage in the boll size, staple length, fibre colour and cotton price. Strong advantage is seen in yield and profit. It is also seen as suitable for early sowing. Disadvantages are seeing in seed cost and fertiliser need. No difference is seen in machinery need, irrigation and harvesting cost as well as in marketing and byproduct output.

Table 8.1: Advantages and Disadvantages of BT cotton *vis-à-vis* non-BT Cotton

Sl. No	**Item**	Strong Advantage	Advantage	No Difference	Disadvantage	Strong Disadvantage	**Mean**	N
1.	Availability of seeds	28.3	55.3	13	3.1	0.3	1.1	322
2.	Seed cost/price	3.1	15.2	6.5	57.6	17.6	-0.7	323
3.	Quality of seeds	37.7	51.1	9	1.9	0.3	1.2	321
4.	Pest Incidence/ Problem	14.4	53.4	11.2	19.7	1.2	0.6	320
5.	Pesticide need/cost	9	43.6	14	29.6	3.7	0.2	321
6.	Fertilizer need/cost	2.5	11.9	40.8	38.9	6	-0.3	319
7.	Labour need/cost	4.7	10.3	55.8	23.1	6.2	-0.2	321
8.	Machinery need/cost	1.9	3.4	85.4	8.1	1.2	0.0	321
9.	Irrigation need/cost	1.6	5.2	77.8	14.4	1	-0.1	306
10.	Harvesting cost	2.2	15	55.9	20	6.9	-0.1	320
11.	No of pickings	11	44.3	35.5	7.9	1.3	0.6	318
12.	Boll size	42.1	40.8	10.4	6.6		1.2	316
13.	Staple length	22.6	60.4	7	8.7	1.3	0.9	230
14.	Fibre colour	46.9	35.6	14.4	2.5	0.6	1.3	320
15.	Cotton price	17.3	40.9	29.4	5.6	6.8	0.6	323

16.	Market preference	12.4	37.5	46.1	3.4	0.6	0.6	323
17.	Easy marketing	12.3	34.2	52.2	1.3		0.6	316
18.	By-product output	2.7	10.8	75.7	7.2	3.6	0.0	311
19.	Yield	45.2	52	1.9	0.9		1.4	321
20.	Profit	45.9	39.1	5.6	3.1	6.2	1.2	320
21.	Livestock feeding	1.9	14.4	45.7	32.6	5.4	-0.3	313
22.	Suitable for early sowing	13.8	58.1	20	7.2	0.9	0.8	320
23.	Suitable for late sowing	4.2	25.3	26.3	37	7.1	-0.2	308
24.	OVERALL	51	30.7	14.1	1	3.1	1.3	292

The table below provides the findings of the changes seen by the farmers over recent years in the advantages of BT cotton. Farmers indicate that aspects which have become better include the availability of seeds, quality of seeds and the pest resistance/ problem. Various cotton quality aspects have also become better including boll size, staple length, fibre colour and the resulting cotton price. Yields and profits have become better. Some aspects which have become worse include pesticide cost, fertiliser cost, and seed cost. No change is seen in other costs as well as market preference and marketing ease.

Table 8.2: Changes over Time in Recent Years in Bt Cotton

Sl. No	Item	Change over the time			N
		Better	No change	Worse	
1.	Availability of seeds	84.4	10.1	2.1	322
2.	Seed cost/price	19	12.3	65.6	323
3.	Quality of seeds	65.6	23.3	7.4	321
4.	Pest Incidence/ Problem	47.5	23.3	24.8	320
5.	Pesticide need/cost	36.2	23.6	35.9	321
6.	Fertilizer need/cost	12	46.9	35.9	319
7.	Labour need/cost	11.7	58	26.4	321
8.	Machinery need/cost	5.2	80.7	8.3	321
9.	Irrigation need/cost	4.6	77.6	9.8	306
10.	Harvesting cost	14.4	57.7	20.9	320
11.	No of pickings	43.9	45.4	4	318
12.	Boll size	63.8	26.1	3.1	316
13.	Staple length	46.3	17.5	2.5	230
14.	Fibre colour	54.6	31.3	2.8	320
15.	Cotton price	49.1	28.2	12.9	323
16.	Market preference	27.9	58.3	4	323
17.	Easy marketing	28.5	57.4	1.5	316
18.	By-product output	3.7	21.8	4.3	311

19.	Yield	71.2	14.4	4.6	321
20.	Profit	64.7	11.3	12.3	320
21.	Livestock feeding	10.7	51.2	24.8	313
22.	Suitable for early sowing	44.2	38.7	5.5	320
23.	Suitable for late sowing	18.1	40.5	26.4	308
24.	OVERALL	40.2	9.8	2.8	292

The most important feature of BT cotton is its resistance to pests. The table below examines the changes in this observed by the farmers in recent years, as well as related aspects. A majority of the farmers disagree that boll worm infestation in BT cotton has increased over the years and that BT cotton is not resistant to adult boll worms, though some indicate that this is the case. Most of the farmers disagree that pest attack on other crops is higher when BT cotton is cultivated and secondary pests have become major pests in the presence of BT cotton. Many indicate, though, that new pests and diseases have started emerging in cotton crop in general. A large majority of farmers indicate that BT cotton has a positive impact on the environment as it requires less pesticides.

Table 8.3: Response on Pest resistance & related issues in BT cotton/ cotton

Statement	Strongly Agree	Agree	Partially Agree	Disagree	Strongly disagree	**Mean**	N
1. Bollworm infestation level in BT cotton has increased over the years	9.3	25.5	7.2	27.4	30.5	2.56	320
2. BT cotton is not resistance to large/adult larvae of bollworm	6.9	26.6	10.3	30.9	25.3	2.59	323
3. Pest/Insect attack on other crop is higher when BT cotton is cultivated	9.8	24	7.3	31.5	27.4	2.57	321
4. New pests and disease have started emerging in BT cotton crop	15.4	25.5	9.7	25.2	24.2	2.83	322
5. New pests and disease have started emerging in cotton crops in general	12.2	27.8	10.3	24.4	25.3	2.77	318
6. Previously	4.5	15.3	15.3	36.6	28.3	2.31	321

secondary pests have now become dominant							
7. BT cotton has positive impact on environment as it require less pesticide use	7.9	38.6	21.2	14.9	17.4	3.05	321

The table below examines farmer responses on the trends in BT cotton and non-BT cotton. Farmers indicate that the yield level of BT cotton has increased and pesticide use reduced. However, they indicate that the cost of pesticides used and the overall cost of cultivation has increased. Despite this, they indicate that the profitability of cotton and farm income per hectare as increased due to BT cotton. In the case of non-BT cotton some indicate that the yield levels have increased, but the majority indicate that pesticide use, cost and total cost of cultivation have increased, and the profitability and farm income have not changed or reduced.

Table 8.4: Trends in cotton cultivation - Change over the years							
Statement	**BT-cotton**						
	Strongly Agree	Agree	Partially Agree	Disagree	Strongly disagree	**Mean**	N
1. The yield level has increased	35.2	42.1	7.2	13.7	1.9	3.95	321
2. The pesticide use per acre has reduced	12.2	41.6	13.4	28.4	4.4	3.00	320
3 The cost of pesticide used per acre has reduced	8.2	24.3	12.9	38.5	16.1	3.29	317
4. Overall cost of cultivation per acre has reduced	6.9	22	13.8	44.3	12.9	1.95	318
5. Profitability of cotton cultivation per acre has increased	30.6	39.4	9.4	13.1	7.5	2.70	320
6. The farm income per acre has improved	38.6	31.3	11.4	10.4	7.9	2.23	316
	Non BT Cotton						
	Strongly Agree	Agree	Partially Agree	Disagree	Strongly disagree	**Mean**	N
1. The yield level has increased	2.1	30.9	39.4	20.2	7.4	2.66	94

2. The pesticide use per acre has reduced	5.4	9.7	8.6	26.9	49.5	2.40	93
3. The cost of pesticide used per acre has reduced	5.5	17.6	9.9	28.6	38.5	3.73	91
4. Overall cost of cultivation per acre has reduced	3.4	13.8	27.6	29.9	25.3	2.69	87
5. Profitability of cotton cultivation per acre has increased	1.1	27.5	27.5	27.5	16.5	3.83	91
6. The farm income per acre has improved	4.5	15.7	33.7	23.6	22.5	2.56	89

The table below reports on the responses of the farmers with respect to the issues and problems that are being frequently raised regarding BT cotton. It is interesting to see that farmers disagree with most of the contentions that are being raised. Whereas some farmers agree that BT cotton cultivation is a risky, the majority disagree that it is a risky business and not suitable for small farmers. More than 80% disagree that farmers are compelled to grow BT cotton since local varieties are not available and that BT cotton has lead to poverty and distress among the farmers. Over 85% of the farmers disagree that there has been an increase in the suicides among farmers due to BT cotton, or that there had been cases of pesticide poisoning among BT farmers. Over 90% disagree that cattle have died after eating BT cotton plants, and the majority do not believe that the seeds, oil or oil cake are unsafe for human consumption. 90% or more farmers do not find the government, non-government agencies, seed dealers or pesticide and other input dealers against the cultivation of BT cotton. The majority in fact indicate that the current policies are not in favour of BT cotton and that improvements are required, many also indicating that the market linkages are weak and need improvement.

Table 8.5: Response on Issues & Problems Currently Raised with Respect to BT cotton							
Statement	Strongly Agree	Agree	Partially Agree	Disagree	Strongly disagree	**Mean**	N
1. Cultivation of BT cotton is a risky business	12.7	26.6	4	15.2	41.5	2.54	323
2. BT cotton cultivation is not suitable for small farmers	4,0	21.7	2.8	39.0	32.5	2.26	321
3. Farmers are compelled to cultivate BT cotton as desi seeds are not available	1.9	5.9	4.4	39.9	48.0	1.74	322
4. Cultivation of BT cotton has led to poverty and distress among farmers	5.3	8.1	6.2	43.5	37.0	2.01	318
5. There has been an increase in the case of suicides among farmers	3.8	8.2	2.2	19.2	66.7	1.63	321
6. There has been cases of pesticide poisoning among the BT farmers in your area/village	1.6	9.3	5.9	29.9	53.3	1.76	321
7. You have heard that cattle has died after eating BT cotton leaves/plant	1.6	3.1	2.8	24.3	68.2	1.45	309
8. The oil cakes, seeds and oil from BT cotton seeds is not safe for consumption	7.8	14.6	10.7	30.4	36.6	2.27	315
9. Government is interfering in BT cotton cultivation	0	2.9	7.6	20	69.5	1.44	320
10. Non-government agencies / cooperatives are against BT cotton cultivation	1.2	2.2	3.8	18.4	74.4	1.38	322
11. Fellow farmers or villagers area against BT cotton farming	1.2	1.6	1.9	18.6	76.7	1.32	321
12. Seed Company/dealers are against BT cotton cultivation		1.9	1.2	14.6	82.2	1.23	319

13. Pesticide dealers/Fertilizer dealers are against BT cotton cultivation	0.9	2.5	0	14.1	82.4	1.25	322
14. Current policies are not in favour of BT cotton and needs improvement	23.3	31.4	16.1	16.5	12.4	3.50	316
15. Market linkages are weak in case of BT cotton	16.5	20.9	14.9	23.1	24.7	2.81	313
16. Inputs are not available in sufficient quantity when required	4.8	16	13.7	28.1	37.4	2.23	321

The table below gives the findings on the local impact of BT cotton technology as reported by the farmers. The farmers indicate that BT cotton has had a substantial positive impact on their village. The impact has been quite widespread and includes almost all the social groups in the village, including small farmers, women and the poor. To some extent large farmers, upper caste villagers, and farmers with irrigation have benefited more, but substantial beneficiaries include labour – wage earners too. Traders have also benefited substantially, and tribals have also benefited. Regarding the environmental impact the majority indicate that there has been no impact on humans, land, water, air, other crops and beneficiary insects. A few indicate negative as well as positive impact on humans, and negative impact on the land and animals, though what exactly is meant is not known. Regarding the impact on agriculture, there is a substantial positive impact indicated on cotton yields, output quality, profit and incomes.

Table 8.6: Local Impact of Bt Cotton Technology

Sl. No.	Impact on:	Impact of BT Cotton Technology					Mean	N
		Substantially positive	Positive	No Impact	Negative	Substantially Negative		
	Economic impact:							
1.	Village as a whole	39.1	52.8	1.9	4.4	1.9	1.23	320
2.	Upper caste	38.6	46.7	9	1.9	3.7	1.15	321
3.	Lower caste	25	55	13.1	4.4	2.5	0.96	320
4.	Women	37.3	45.2	15.6	1	1	1.17	314

5.	Large/medium Farmers	63.1	27.2	5	3.4	1.2	1.48	320
6.	Small/marginal Farmers	17.2	63.3	12.5	4.7	2.2	0.89	319
7.	Landless/ Poor	38.3	35.1	19	4.7	2.8	1.01	316
8.	Labour/wage earners	58.3	30.1	8.5	1.9	1.3	1.42	319
9.	Farmers with irrigation facilities	51.4	22.2	23.2	2.2	1	1.21	315
10.	Farmers without irrigation facilities	4.7	48.9	27.1	17.8	1.6	0.37	321
11.	Young farmers	12.1	52.6	28.3	5	1.9	0.68	321
12.	Livestock owners	2.5	18.2	45.9	28.9	4.4	-0.14	318
13.	Traders	68	25.6	4.4	0.9	0.9	1.59	316
14.	Tribal	38	40.8	19.2	1.2	0.8	1.14	250
15.	Reducing Migration	11.6	29.3	34.4	21.9	2.9	0.25	311
	Environmental impact:							
1.	Humans	0	20.8	54.2	25	0	-0.04	323
2.	Land	0.9	9	57.3	24.8	8	-0.30	241
3.	Water	0.4	2.5	95.9	0.8	0.4	0.02	240
4.	Air	0.4	1.7	95	2.9	0	0.00	108
5.	Non – BT Cotton crop	1.9	4.6	51.9	23.1	18.5	-0.52	234
6.	Other crops and plants	0.9	8.5	84.6	5.6	0.4	0.04	238
7.	Beneficial insects	1.3	17.2	61.8	19.7	0	0.00	228
8.	Cattle and other domestic animals	1.3	6.6	49.6	36.8	5.7	-0.39	238
	Impact on cotton crop:							
1.	Cotton yields	51.7	44.5	1.7	0.8	1.3	1.45	238
2.	Use of pesticides/insecticides	17.6	52.5	13	15.5	1.3	0.70	235
3.	Production cost	20	45.5	18.7	14	1.7	0.68	237
4.	Overall profit / income	51.1	39.7	6.8	0.8	1.7	1.38	235
5.	Output quality	60.4	32.8	4.3	2.1	0.4	1.51	323

The table below reports on the suggestions of the farmers for improving the cotton technology and is profitability. The huge majority of the farmers suggest more resistance towards bollworms and other emerging pests. Farmers also strongly suggest herbicide tolerant cotton and drought tolerant cotton. Higher yields are most strongly suggested, and a large number of request for field demonstrations and a lowering of seed cost.

Table 8.7: What would you suggest for improving BT cotton and its profitability?							
Suggestion	Strongly Agree	Agree	Partially Agree	Disagree	Strongly disagree	**Mean**	N
1. More resistance towards bollworm	28.7	47.4	16.2	3.1	4.7	3.92	321
2. More resistance towards other emerging insect/pests	54.3	40.1	4.7	0.3	0.6	4.47	322
3. HT (Herbicide Tolerant) cotton	50.5	39.1	6.3	2.5	1.6	4.34	317
4. Drought tolerant cotton	49.7	40.6	5.6	2.5	1.6	4.34	320
5. Higher yield	63.1	34.1	2.2	0.3	0.3	4.59	320
6. Better quality seeds	0.3	49.1	44.7	5.3	0.6	4.43	322
7. Reducing seed cost	39.9	29.1	13	14.6	3.4	3.88	323
8. Field demonstration	41.3	37.6	7.8	8.4	4.3	4.06	322
9. Seed packaging with less quantity	8.7	12.6	35.2	28.1	15.5	2.71	310

In the final analysis the farmers were asked regarding their overall judgements and opinions on BT cotton. The results are given in the table below. The farmers almost all strongly agree that BT cotton has a strong yield advantage over non-BT cotton. They also agree that BT cotton requires less pesticide than non-BT Cotton. However, most indicate that the seed cost and cultivation cost are high. Almost all indicate that the profitability of BT cotton is very high and the technology has improved the economic status of their household. Nearly 80% indicate that they are completely satisfied with BT cotton, and over 90% indicate that they would definitely grow BT cotton in the future.

Table 8.8: Overall judgments and opinions							
Statement	Strongly Agree	Agree	Partially Agree	Disagree	Strongly disagree	**Mean**	N
1. BT cotton has a strong yield advantage compared to non- BT Cotton	55.8	41.1	2.2	0.9	0.0	4.52	321
2. BT cotton requires less pesticides than non-BT cotton	21	60.5	7.2	10	1.3	3.90	319
3. BT cotton seeds cost less as compared to non-BT cotton seeds	3.8	7.8	2.8	63.1	22.5	2.07	320
4. BT Cotton costs less to	4.4	28.8	16.6	42.3	7.8	2.80	319

produce per unit area compared to non- BT Cotton							
5. The overall profitability per unit area of BT Cotton is very high	27.9	47.3	9.1	11	4.7	3.83	319
6. The economic status of your household has improved because of BT-cotton cultivation	41.1	38.9	9.1	7.2	3.8	4.06	319
7. You are completely satisfied with BT cotton	39.3	37.1	9	9.3	5.0	3.98	321
8. You will definitely grow BT Cotton in future	59.2	30.4	6.6	1.9	1.9	4.43	319

Chapter 9: Consumer Awareness, Perceptions and Attitudes on Biotechnology

Consumer awareness, perceptions and attitudes have played and will play a huge role in the acceptance of GM technologies. To understand the awareness, opinions and risk perception of consumers/ common people regarding GM foods and crops a survey was conducted of a sample of urban residents/ consumers in the four sample states. It includes people living in the largest city/ town of the sample districts in each of the four states covered in the study, but does not include metropolitan cities. Significant parts of the survey questionnaire were based on the work and approach of Knight and Paradkar (2008) discussed earlier.

The Table below describes the sample profile and shows that the respondents belong to the four states: Andhra Pradesh, Gujarat, Maharashtra and Punjab. Majority of the respondents belong to the middle-age group of 31 to 50, the average age being 37 years.

Table 9.1: Consumer Survey- Sample profile

State	Respondents (%) (N= 115)
Andhra Pradesh	28.70
Gujarat	19.13
Maharashtra	27.83
Punjab	24.35
Age	Respondents (%)
18	0.87
19-30	35.65
31-50	46.96
> 50	16.52
Average Age	37.46

Preliminary questioning showed that familiarity with genetically modified(GM) or genetically engineered (GE) foods/ crops was far from universal – most did not know what it was and had never heard about it. It did not serve much purpose asking them further questions, given the nature of the questionnaire. Only those who, after some description, could understand at least a little about the subject were interviewed. The responses of these people about their familiarity are summarized in the Table below. Only 9.7 percent indicated that they are very familiar, 40.7 percent were somewhat familiar, and 47.8 percent were not very familiar. Thus, the awareness level of the people regarding GM/GE appears to be quite low. Whereas 88.7 percent had heard of Bt cotton and 47 percent about Bt Brinjal, the majority have not heard of other GM crops.

<table>
<tr><th colspan="21">Table 9.2: Familiarity of respondents with GM/GE (%) N= 115</th></tr>
<tr><th></th><th colspan="5">Very familiar</th><th colspan="5">Somewhat familiar</th><th colspan="5">Not very familiar</th><th colspan="5">Had never heard the terms</th></tr>
<tr><td>How familiar are you with the terms “genetically modified"(GM) or “genetically engineered"(GE) foods/ crops?</td><td colspan="5">9.73</td><td colspan="5">40.71</td><td colspan="5">47.79</td><td colspan="5">1.77</td></tr>
<tr><th></th><th colspan="4">Bt Cotton</th><th colspan="4">Bt Brinjal</th><th colspan="4">Bt Maize</th><th colspan="4">GM Rice</th><th colspan="4">Ht Maize</th></tr>
<tr><td>Which of these terms have you heard of?</td><td colspan="4">88.70</td><td colspan="4">46.96</td><td colspan="4">37.39</td><td colspan="4">9.57</td><td colspan="4">0.87</td></tr>
</table>

Analysis of the sources of information in the Table below indicates that for 70 percent of people the source of information is newspapers and for 35 percent it is TV & Radio. Another important source is Government agencies at 37 percent. Friends & Relatives are indicted by only 15 percent of the respondents, and NGOs by only 3 percent. Experts, scientists and teachers come at less than 5 percent. Public debates generally on TV are indicted by 13 percent. Thus, newspapers and TV-Radio dominate as the source of the information.

Table 9.3: Source of Information on GM/GE	
Source	Response (%) N=115
Newspaper Articles	69.57
TV and Radio	34.78
Magazines	6.09
Internet	4.35
Scientific Journals	0.87
Government Agencies	36.52
NGOs	3.48
Friends and Relatives	14.78
Teachers	0.87
Doctors/Scientists	13.04
Expert Interviews	3.48
Public Debates	2.61

Regarding the awareness level, findings in the Table below indicates that only 11 percent strongly agree that they are well aware and 37 percent only partially agree. About 50 percent are unaware that GM foods are allowed in other countries. Less than 25 percent have tried to look up scientific or research findings about them.

Table 9.4: Response of Awareness Level									
Question/Statement	Response (%)								
	5	4	3	2	1	Mean	Std Dev	CV	N
1. You are well aware of GM food and its technology	11.30	17.39	36.52	27.83	6.09	3.00	1.08	36.03	114
2. You are aware that GM foods are allowed in countries like US and China	19.13	18.26	11.30	31.30	19.13	3.13	1.43	45.66	114
3. You have tried to read scientific and research findings on GM technology and its impact	7.83	8.7	8.7	30.43	42.61	2.07	1.27	61.12	113
Note: 5 = Strongly Agree, 4 = Agree, 3 = Partially Agree or Disagree, 2 = Disagree, 1 = Strongly Disagree									

Responses to questions regarding the available information and the development of the risk-perception are analyzed in the Table below. Over 50 percent indicate that the public does not have enough information about GM foods/crops, and over 70 percent think that the information available is not authentic. Over 50 percent agree that the uncertainty generates fear, and almost everybody agrees that the media fills the void of uncertainty. Further, nearly 90 percent agree that people are afraid of GM because of the scare created by the media. Over 90 percent agree that bad news sells more than good news and negative aspects are amplified by the media and when information moves from person to person. Over 90 percent agree that media over-estimates the risk of rare events. For most people, public opinion becomes more important than the opinion of the experts. A majority indicate that pro-organic campaigns raise even more doubts about GM foods, and over 70 percent indicate that they are inclined to take the risks in voluntary activities but not in things such as new technology in agriculture/ food. Findings indicate that the awareness is low, and the role of the media in development of the risk perception is very large. It indicates that people are willing to take the risks, but are more likely to do this on a voluntary basis.

Table 9.5: Response on Information, risk perception and its development

Question/Statement	Response (%)								
	5	4	3	2	1	Mean	Std Dev	Coefficient of Variation	N
1. Public does not have enough information about GM food/crops	28.90	24.60	16.70	23.70	6.10	3.46	1.30	37.46	114
2. The information about GM foods/crops available to you is not authentic/ realistic	5.30	35.10	28.90	18.40	12.30	3.03	1.12	36.90	114
3. Uncertainty generates fear	10.60	42.50	11.50	22.10	13.30	3.15	1.26	40.07	113
4. Media fills this void of uncertainty	41.20	26.30	14.90	14.00	3.50	3.88	1.20	30.91	114
5. People are afraid of GM foods because of the scare created by media	36.00	30.70	12.30	14.00	7.00	3.75	1.27	34.03	114

6. Bad news sells more than good news	65.80	26.30	3.50	3.50	0.90	4.53	0.80	17.69	114
7. Things are amplified (particularly –ve aspects) when information moves from person to person	57.90	36.80	2.60	2.60	0.00	4.50	0.68	15.15	114
8. Media over-estimate the risk of rare events	46.90	31.00	9.70	9.70	2.70	4.10	1.09	26.69	113
9. NGOs over-estimate the risk of rare events	13.80	37.60	13.80	22.90	11.90	3.18	1.27	39.91	109
10. Opinion of general public is more important to you rather than opinion of experts	22.10	25.70	9.70	24.80	17.70	3.10	1.45	46.86	113
11. The pro-organic campaigns are raising even more doubts over GM food	12.40	34.00	29.90	17.50	6.20	3.29	1.09	33.12	97
12. You are ready to take risk in voluntary activities (i.e. driving fast/street food)but not of new technology for agricultural production	34.50	37.30	13.60	11.80	2.70	3.89	1.09	28.14	110
Note: 5 = Strongly Agree, 4 = Agree, 3 = Partially Agree or Disagree, 2 = Disagree, 1 = Strongly Disagree									

The opinions and attitudes of the people about GM foods and crops were examined through a set of questions and the responses on these are analyzed in the Table below. The responses indicate that a large majority of the respondent are aware of the potential benefits of GM technology such as higher yields, less pesticides and better quality and nutrition. The majority also thinks that they would be cheaper. Many think that the resistance is politically motivated and that GM technology should be supported by the government. Many though are not clear about their threat to human life or their great usefulness. But over 80 percent think that the resistance to GM is due to poor awareness and information. This indicates that people are broadly aware of the benefits of GM technology but lack clear knowledge and are concerned about the risks. It indicates that much can be changed on this front by strong communication and awareness building especially by the government and the experts.

Table 9.6: Attitude / opinion towards GM crops									
Question/Statement	Response (%)								
	5	4	3	2	1	Mean	Std Dev	Coefficient of Variation	N
1. GM crops can be high yielding crops	43.2	45.9	9.0	1.8	0.0	4.31	0.71	16.51	111
2. GM crops can reduce the use of harmful pesticides on the crops	27.8	38.0	13.9	16.7	3.7	3.69	1.16	31.28	108
3. GM foods can be of better quality	26.4	32.1	27.4	10.4	3.7	4.08	4.15	101.59	106
4. GM foods may have better nutritional value	17.1	44.8	22.9	11.4	3.8	3.60	1.02	28.46	105
5. GM foods can be cheaper	24.3	31.5	18.9	19.8	5.4	3.50	1.21	34.69	111
6. GM foods can help in solving food problems of the country	42.0	35.7	4.5	14.3	3.6	3.98	1.17	29.38	112
7. GM foods can help farmers by increasing their incomes	51.4	38.7	6.3	1.8	1.8	4.36	0.83	19.01	111
8. GM foods should be supported by the government	36	31.5	11.7	15.3	5.4	3.77	1.24	32.87	111
9. The resistance over GM foods is politically motivated	13.3	44.9	19.4	19.4	3.1	3.46	1.05	30.27	98
10. There can be no threat to human life from the GM technology	14.2	26.4	25.5	18.9	15.1	3.06	1.28	41.83	106
11. GM technology can be extremely useful to the mankind	28.4	29.4	25.7	12.8	3.7	3.66	1.13	30.93	109
12. Resistance to GM foods/crops is due to poor awareness/ information	41.4	38.7	8.1	8.1	3.6	4.06	1.07	26.40	111
Note: 5 = Strongly Agree, 4 = Agree, 3 = Partially Agree or Disagree, 2 = Disagree, 1 = Strongly Disagree									

The Table presents finding on the awareness and perception of people regarding Bt Cotton. The findings show that most of the people are aware about the success of Bt cotton in India, and that it has helped increasing cotton productivities dramatically, and improve the economic status of cotton growing farmers. They are also aware about the reduction in pesticide use due to BT cotton. Most people are fine with consuming cottonseed oil made of Bt cotton, and wearing cotton clothes made of Bt cotton. Most have never come across issues of skin allergies due to Bt cotton clothes, but some have a preference for organic cotton. Thus, benefits of Bt cotton are known and accepted by most of the people/ consumers.

Table 9.7: Perception Regarding Bt Cotton Technology:

Question/Statement	Response (%)								
	5	4	3	2	1	Mean	Std Dev	Coefficient of Variation	N
1. Bt Cotton has been one of the most successful GM technologies in India	55.0	38.7	3.6	2.7	0.0	4.46	0.70	15.65	111
2. Bt Cotton has helped India in increasing its cotton productivities drastically	61.3	30.6	6.3	0.9	0.9	4.50	0.74	16.36	111
3. Bt Cotton has helped in improving the economic status of the cotton growing farmers	52.3	36.7	6.4	3.7	0.9	4.36	0.83	19.13	109
4. Pesticide use on cotton crop has decreased significantly as a result of Bt Cotton cultivation	34.3	35.2	17.6	10.2	2.8	3.88	1.08	27.91	108
5. The controversy around Bt cotton does not make much sense	27.1	31.8	17.8	11.2	12.1	3.50	1.33	37.87	107

1. You are fine with consuming cottonseed oil made of Bt cotton	17.2	34.3	19.2	21.2	8.1	3.31	1.22	36.75	99
2. You did not come across any issues with the usage of cottonseed oil made of Bt cotton	35.1	32.0	11.3	14.4	7.2	3.73	1.28	34.27	97
3. You are fine with wearing cotton clothes made of Bt cotton	58.9	28.0	2.8	5.6	4.7	4.31	1.09	25.19	107
4. You never came across issues of skin allergies due to Bt cotton clothes	49.0	27.9	4.8	11.5	6.7	4.01	1.27	31.76	104
5. It is not at all important for you to have organic cotton clothes	11.1	28.7	18.5	34.3	7.4	3.02	1.18	38.96	108
Note: 5 = Strongly Agree, 4 = Agree, 3 = Partially Agree or Disagree, 2 = Disagree, 1 = Strongly Disagree									

The table below examines the people's perception regarding potential risks of GM crops and foods. Even though most people do not strongly agree regarding the risks, a good number of people are concerned about the risks and long-term impacts if any. They are aware that GM foods are a not of natural origin, but most don't think they are harmful to the environment, or harmful to health. There is a fear though that GM technology will make people dependent on MNCs and seed companies. However, they don't consider GM technology against religion.

Table 9.8: Assessment Of Potential Risk Of GM Crops/Foods

Question/Statement	Response (%)								
	5	4	3	2	1	Mean	Std Dev	Coefficient of Variation	N
1. There can be risks to lives of people from GM foods/crops	4.5	24.5	21.8	30.0	19.1	2.65	1.18	44.32	110
2. GM foods/crops can cause unknown changes in the human body	11.3	32.1	21.7	27.4	7.5	3.12	1.16	37.16	106

3. GM foods/crops can have long term impacts rather than the short term	19.8	34.9	22.6	15.1	7.5	3.44	1.19	34.50	106
4. GM foods/crops can be harmful to environment	10.7	19.4	17.5	26.2	26.2	2.62	1.34	51.27	103
5. GM foods/crops may be produced in an unnatural way	51.9	23.1	6.5	11.1	7.4	4.01	1.31	32.62	108
6. GM foods/crops may be harmful to health	5.5	26.4	19.1	34.5	14.5	2.74	1.16	42.49	110
7. GM food is a way of making farmers dependent on MNC s for seeds etc.	31.2	36.7	11	13.8	7.3	3.71	1.25	33.71	109
8. GM technology is expensive	22	22.9	16.5	29.4	9.2	3.19	1.32	41.43	109
9. GM technology is against religion	0	0.9	1.8	19.1	78.2	1.25	0.53	42.42	110
Note: 5 = Strongly Agree, 4 = Agree, 3 = Partially Agree or Disagree, 2 = Disagree, 1 = Strongly Disagree									

The table below reports on findings regarding the attitudes and overall assessment on the acceptance of GM foods and crops. It shows that about one third of people may refuse to accept GM foods or crops in the present state of awareness, but the rest would accept them. Almost all respondents indicate the right to know how the food is produced and request mandatory labelling of foods so that people can decide. The majority would like to see labelling even if the government allows the GM foods. Almost all people are in favour of through testing of GM foods. Most of the people indicate that they would be willing to accept GM foods provided they are found safe in other countries, if the government has accepted them, most of the people are consuming them, and the technology is required so that there is enough food and starvation is avoided. The majority of the people appear willing to support GM as the next step in food technology.

Table 9.9: Assessment Of Level Of Acceptance Of Gm Food/Crops									
Question/Statement	Response (%)								
	5	4	3	2	1	Mean	Std Dev	Coefficient of Variation	N
1. I refuse to accept GM foods/crops	7.3	26.4	19.1	30.0	17.3	2.76	1.23	44.36	110
2. It is my right to know how the food is produced	75.9	20.5	0.9	0.9	1.8	4.68	0.71	15.24	112
3. There should be mandatory labelling of GM foods/crops	65.5	28.3	0.9	3.5	1.8	4.52	0.84	18.48	113
4. Labelling is important and can help people to avoid consuming GM foods/crops	32.7	52.2	8.8	4.4	1.8	4.10	0.87	21.13	113
5. Labelling is acceptable only if it does not increase the price	13	24.1	14.8	28.7	19.4	2.82	1.35	47.64	108
6. If Government has allowed it, there is no need of labelling	6.2	7.1	0	35.4	51.3	1.81	1.15	63.60	113
7. The government policies on GM food and its technology are not clear	22.6	29.8	23.8	21.4	2.4	3.49	1.14	32.55	84
8. There should be through testing of GM foods/crops for safety	58.2	29.1	7.3	2.7	2.7	4.37	0.94	21.43	110
9. You are doubtful while eating imported food such as chocolates and chips	7.3	28.2	10	24.5	30	2.58	1.36	52.83	110
10. You think GM food might not taste as good as the original food	29.4	30.3	19.3	13.8	7.3	3.61	1.25	34.60	109
11. I have reservations about it & will consume it only if majority of population is consuming it	25.5	41.8	7.3	20	5.5	3.62	1.22	33.69	110
12. Using new agricultural technology (i.e. GM foods) is better than death by starvation for poor countries	50.0	28.6	3.6	11.6	6.2	4.04	1.25	31.02	112
13. I am fine with GM foods/crops and will consume it if government allows it	38.2	31.8	10	15.5	4.5	3.84	1.22	31.88	110

14. If GM foods/crops are found safe in other countries (i.e. US) then they can be accepted	28.8	39.6	11.7	13.5	6.3	3.71	1.20	32.37	111
15. I support GM food; it's the next step in food technology	20.6	49.0	15.7	9.8	4.9	3.71	1.06	28.56	102
Note: 5 = Strongly Agree, 4 = Agree, 3 = Partially Agree or Disagree, 2 = Disagree, 1 = Strongly Disagree									

Summary

Consumer perceptions and attitudes seem to play a major role in the acceptance of GM technologies. Findings show that the familiarity with genetically modified (GM) is far from universal and most people do not know what it was/ had never heard about it. Asking even those who had heard showed that only 9.7 percent were very familiar and 47.8 percent were not very familiar. Analysis of the sources of information showed that newspapers and TV-Radio dominate as the source of the information. Over 50 percent indicate that the public does not have enough information about GM foods/crops, and over 70 percent think that the information available is not authentic. Over 50 percent agree that the uncertainty generates fear, and almost everyone agreed that the media fills the void of uncertainty. Nearly 90 percent agree that people are afraid of GM because of the scare created by the media. Over 90 percent agree that negative aspects are amplified by the media and when information moves from person to person, and that media over-estimates the risk of rare events. For most people, public opinion becomes more important than the opinion of the experts. Findings indicate that the role of the media in development of the risk perception is very large.

A large majority of the respondent are aware of the potential benefits of GM technology such as higher yields, less pesticides and better quality and nutrition. Many think that the resistance is politically motivated and that GM technology should be supported by the government. Over 80 percent think that the resistance to GM is due to poor awareness and information. Findings indicate that much can be changed on this front by strong communication and awareness building especially by the government and the experts. Most of the people are aware about the success of Bt cotton in India, and most people are fine with consuming cottonseed oil made of Bt cotton, and wearing cotton clothes made of Bt cotton and most have never come across issues of skin allergies due to Bt cotton clothes,

Even though people do not strongly agree about the risks, a good number of people are concerned about the risks and long-term impacts if any. They are aware that GM foods are a not of natural origin, but most don't think they are harmful to the environment, or harmful to health. There is a fear though that GM technology will make people dependent on MNCs and seed companies. However, they don't consider GM technology against religion. Findings indicate that about one-third of people may refuse to accept GM foods or crops in the present state of awareness, but the rest would accept them. Most respondents favour the right to know how the food is produced and request mandatory labelling of foods so that people can decide. The majority would like to see labelling even if the government allows the GM foods. Almost all people are in favour of through testing of GM foods. Most indicate that they would be willing to accept GM foods provided they are found safe in other countries and if the government has accepts them. Most agree that the technology is required so that there is enough food and starvation is avoided.

Chapter 10: Concluding Observations and Implications

Breakthroughs are urgently needed in Indian agriculture to increase productivities and in this context, biotechnology offers a huge new potential and perhaps even a new green revolution. Remarkable scientific advances in the recent decades have made it possible to identify genes, know their functions, and also transfer them from one organism to another. These advances in biotechnology are offering numerous possibilities such as the development of Bt cotton. The history of commercialized of biotech crops started in 1996 and in a short span of time has reached 160 million hectares in 2011. They are now grown in 29 countries covering over 60 percent of the world's population

Cotton is the most important cash crop in India and the country ranks first in cotton area and second in cotton production in the world. About 15 million farmers in the country across 10 states are engaged in cotton production. However, cotton yields in India are one of the lowest in the world, a major reason being susceptibility to severe pest attacks. Over 55 per cent of the pesticides sold in the country are used on cotton. Cotton farming was in serious trouble in India when transgenic Bt cotton arrived. After its approval in 2002 in India following much hesitation, Bt cotton has spread rapidly across the country, helping to raise production and incomes, and bring a second green revolution in some states. But Biotechnology has continued to be controversial, and new biotechnology innovations for agriculture have faced much resistance, and have yet to be officially approved.

In 2004-05, the Centre for Management in Agriculture (CMA), Indian Institute of Management, Ahmedabad (IIMA), had undertaken a coordinated study on the performance of Bt cotton in India, at the request of Ministry of Agriculture, Government of India. In light of continuing and new concerns, the Ministry of Agriculture has once again requested CMA to revisit the topic and conduct a fresh study on biotechnology and Bt cotton. The present study is being conducted by CMA, IIM, Ahmedabad in this context. The broad objective of the research is to make an assessment of the benefits and concerns of agri-biotechnology in India with a focus on Bt cotton.

Biotechnology, the Development of Bt Cotton, and Framework for Technology Adoption

Bt cotton was first developed by Monsanto and it is currently one of the most widely grown transgenic crops, now grown in numerous countries including United States, China, India, Australia, Argentina, South Africa and Indonesia. The history of commercialized of biotech crops started in 1996 and in a short span of time has reached160 million hectares in 2011. They are now grown in 29 countries, 19 developing and 10 industrialized, which covering over 60 percent of the world's population

What are the major advantages and breakthroughs that biotechnology can offer to agriculture in India, and are these important for India? One of the most important benefits that biotechnology can bring to many crops in India is the resistance to pests and diseases. Currently highly toxic pesticides are often used against these pests and diseases, and biotechnology offers a major advantage of reducing pesticide use and therefore the environmental harm. Another major advantage that biotechnology can offer is increasing crop yields and through this increase in production, exports and incomes. Biotechnology can also help improve output quality. This may include a nutritional enrichment, reduction in fats or harmful fats in the food, and reducing allergens, which cause allergic reactions. Biotechnology can provide herbicide tolerance which can be used along with herbicides to effectively control weeds. Advances in biotechnology can provide drought tolerance to crops, which will reduce consequences of droughts and help in reducing the use of water which is becoming an extremely scarce resource. Biotechnology can incorporate salt tolerance in plants helping large areas affected by salinity. Biotechnology can also help to reduce fertilizer use and runoff by improving the nutrient availability and absorption efficiency of plants in the soil. Biotechnology can also contribute to enhancement of the shelf-life of food, making food products last longer and, thereby reducing wastage. Biotechnology also offers the promise of creating new sources of renewable energy which are urgently required due to rising energy costs, and they can also help reduce biodegradable materials for manufacturing which could contribute significantly to reducing environmental harm.

Despite substantial potential and possibilities, biotechnology has faced resistance substantially because of the risk perception that people have about agri-biotechnology. However, in the US, it is estimated that between 70 percent and 75 percent of all processed foods available in the grocery stores may contain ingredients from genetically engineered plants. Breads, cereal, frozen pizzas, hot dogs and soda are just a few of them. Soybeans, cotton and corn dominate the 100 million acres of genetically engineered crops in the US. Soybean oil, cottonseed oil and corn syrup are used extensively in processed foods. Others such as squash, potatoes, and papaya, have been engineered to resist plant diseases. More than 50 biotech food products have been evaluated by the FDA and found to be as safe as conventional foods. The proof is also in their safe consumption for over two decades in the US as well as numerous other countries.

What kind of a role can news-media, NGO's and the government play in the creation of fear perceptions? There are food health fears that people have and the media fills the void of uncertainty. Alarmist predictions are made, and bad news sells more than good news. This results in social amplifications and the over-estimation of the risks of rare events. The view of experts generally differs substantially from the view of the public. Whereas the experts who have substantial scientific knowledge consider many agri-biotechnologies as safe, the public may still believe them to be risky. People are often willing to take substantial lifestyle risks but would be against even the slightest technological risk. Studies have shown that the risk perception depends on the personality of the hazard and the qualities of the danger. Familiarity and control can go a long way in reducing the perception of risk. The catastrophic potential of many technologies is almost insignificant and equal to most day-to-day activities – but this needs to be communicated effectively to people. The level of knowledge plays a major role in risk perception, and perceived risks need to be balanced with perceived benefits in effective communications. This can go a long way in the willingness to accept the risks.

Studies to understand the growth and fluctuations of fertilizer consumption in India, China and Sub-Saharan Africa have resulted in the development of a more comprehensive framework which can be used for explaining the growth of input use and markets in developing countries. The first element of the framework is the agronomic potential of an input which is its capacity to produce physical benefit such as an increase (or saving) in the quantity (or quality) of the output. The existence of an agronomic potential is however not enough, since farmers use inputs for profit and unless it generates an acceptable level of economic return: the agro-economic potential, which depends on factors such as the product prices and demand and input prices. A good agro-economic potential is also not sufficient and needs other factors for the creation of an effective market demand such as effective communication and other services. Further, demand must be met by supply through the creation of an adequate and reliable aggregate supply. Finally, with small farmers and the huge geographic spread of farms, an effective distribution system for inputs is also a must. Developments on all these fronts together effectively determine the growth path of any agricultural input.

Cotton Production and Bt Cotton in India

With cultivation of about 12 million hectares, India's cotton acreage is the largest in the world and India is the second largest cotton producer after China. The world annual production of cotton is estimated be about 100 million bales (one bale equals 480 lbs). China occupies the top position with a share of 29 percent of the global production, followed by India with a share of 21.7 percent, and USA has a share of 12.8 percent. Although India occupies the top position in terms of area under cotton, it ranks lower in production is due to low yields. The cotton yields in the country is hardly one-third that of China and 40 percent that of USA.

Cotton production in India doubled from 57 lakh bales in 1960/61 to 117 million bales in 1990/91 (bale=170kg), see Table 3.3. However, in the decade 1991/92 to 2001/02, the production growth rate decelerated to -0.422 percent, much of this due to yields, which show a growth rate of -2.442 percent in this period, indicating a problem with the technology. However, the area growth rate was 2.01 percent, indicating that the crop still found favor with the farmers. Since the introduction of Bt cotton in 2002, the performance shows a substantial turn around. The production growth rate shot up to 13.14 percent and yield growth rate to 9.57 percent. Even the area has grown at 3.17 since the introduction of Bt cotton and 5.13 percent in the last 6 years, with some deceleration in the yield growth rate.

Based on cotton production during the 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. 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. The area and production of cotton in Punjab is lower than in other sample states but the yields are generally the highest.

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. It was realized soon that 3 hybrids were too less and was a major limiting factor for a country of the size of India. Later, the GEAC approved large scale field trials and seed production of 12 more varieties of Bt cotton in 2005. From 2005, more hybrids and seed companies were granted approval, and by 2009, 522 Bt hybrids and 35 companies had been approved. This included Bollguard I and Bollguard II technologies. By 2010-11, the area under Bt cotton in India was about 9.4 million hectare, or about 85 percent of the cotton area. The data shows that despite the concerns voiced, the adoption by the farmers has been extremely rapid, which indicates that farmers must be experiencing substantial benefits from Bt hybrids as compared to earlier/ alternative technologies.

Profile of the Sample Data and Cotton Varieties Grown

In order to address the subject and objectives of the research, a primary sample survey of cotton farmers as well as consumers. The primary data collected pertains to the agricultural year July 2012 to June 2013. The top 4 cotton states: Gujarat, Maharashtra, Andhra Pradesh and Punjab were selected for the study sample. The next stage in the sampling was the selection of districts. Given the limitations of time and resources, it was decided to limit to one sample district in each state. The selection of districts was made on the basis of the recent area, production and yield data of the cotton growing districts in each state. The district with the highest cotton production was selected in each state: Guntur district in Andhra Pradesh, Rajkot district in Gujarat, Jalgaon district in Maharashtra, and Bhatinda district in Punjab. The villages within each district were selected to cover cotton including Bt cotton cultivation and provide a diversity of agro-ecological settings. Finally, the farmers were selected in each village through a random process and effort was made as far as possible to have both Bt and Non-Bt farmers in the sample, and if not, to have Bt farmers who could reflect on their non-Bt growing experience. Effort was also made to cover both irrigated and unirrigated farms, as well as small, medium and large farms. The ability to do this depended on the presence, size and access to each of these strata in the survey locations. A highly detailed questionnaire was developed for the study based on the objectives, research questions and the behavioural framework presented above. In each state, a sample of 100 was planned consisting of 80 farmers and 20 consumers. A total of 326 farmers and 115 consumers were covered, with roughly about 25 per cent from each state.

An important aspect of the study was to observe and report on the cotton varieties (including hybrids), both Bt and non-Bt, grown by the farmers. The Table below gives the names of the most common varieties reported grown by the sample farmers in each state. The profile indicates that there is a huge diversity in the reported varieties. Only a few varieties were found common across the states. Mallika is reported in the states of Andhra Pradesh, Gujarat, and Maharashtra, The variety Jadoo is reported in Andhra Pradesh and Maharashtra. In Gujarat, a few non-BT varieties are also reported. Thus, there is a huge difference in the variety preference of the farmers across states. Very few varieties are suitable across all the states and very few varieties seem to perform well across the states. This is indicative of the need for a large selection of available varieties. In Andhra Pradesh, the BT variety Mallika of Nuziveedu Seeds is reported by as many as 41 per cent of the farmers, the BT variety Jadoo of Kaveri Seeds is reported by 24 per cent of the farmers, the BT variety Bhaskar of Tulasi Seeds by 12 per cent of the farmers, and the Bt variety Jackpot of Kaveri Seeds by 10 per cent of the farmers. In Gujarat, the most common variety is the Bt variety Vikram of Vikram Seeds reported by 25 per cent of the farmers. This is followed by the non-confirms/non-Bt variety Prabhav of unknown origin grown by 10 per cent of the farmers, and the Bt Mallika variety of Nuziveedu Seeds grown by about nine per cent of the farmers. Thus there is a much greater diversity of varieties reported in Gujarat. In Maharashtra, the Bt variety Mallika of Nuziveedu Seeds is reported by 28 per cent of the farmers. This is followed by the Rashi-2 Bt variety of Rashi Seeds grown by 19 per cent of the farmers. The Bt varieties Brahma of Monsanto, Ajit-155 of Ajit Seeds and Ankur-2 of Ankur Seeds are grown by about nine per cent of the farmers each. In Punjab, the Bt variety 6588 of Mahyco is reported by 17 per cent of farmers, followed by the Bt varieties 6488 of Ankur Seeds, Nikki of Mahyco, Raghav of Nuziveedu, and 3028 of Ankur Seeds, reported by about eight per cent of the farmers each. Further to this, the Bt varieties Pancham of Mahyco and 7007 of Bayer are reported by about seven per cent of the farmers each. As in case of Gujarat, a huge number of different varieties of Bt cotton are grown in Punjab.

Examination of the physical/ agronomic features of varieties most grown by the farmers indicate that Bollworm resistance is a very important feature and the most grown varieties are generally strong on bollworm resistance. Most of them show lesser resistance to other pests but those that are reasonably good are preferred. The yields under irrigated condition is another very important characteristic in the preference of farmers, and the most grown varieties all show excellent performance on this feature. The quality of the fibre and market acceptance are two other prominent characteristics of the preferred varieties. In economic features high profitability appears to be the strongest feature of the most preferred varieties, indicating the great importance of economics in the decision making.

Pest Resistance and Factors Affecting Bt Cotton Technology Adoption

The most important targeted advantage offered by Bt cotton technology is pest resistance particularly against boll worms. The results indicate that Bt cotton appears to show substantial resistance/ substantially lower incidence in the case of boll worms including American, Pink and Spotted bollworms, particularly Pink bollworm. Bt cotton also shows resistance towards foliage feeding pests such as leaf rollers and caterpillars. However, Bt cotton shows a greater incidence of sucking pests particularly mealy bugs, aphids & jassids, and white fly. Bt cotton also shows a higher incidence of the disease of alternaria leaf spot. Thus, Bt cotton appears to tackle the problems of boll worms and leaf feeding insects which are major pests, but it shows a higher incidence for sucking pests and alternaria leaf spot. Has there been a change in the pests incidence in Bt cotton over the years? The results indicate that many farmers do not see any change. However, in the case of bollworms, 20-30 percent of farmers have experienced an increase but almost an equally large percentage of farmers have experienced a decrease. However, increases in incidence are seen in the case of sucking insects of aphids and jassids, and mealy bugs, and also in the diseases of alternaria leaf spot, and grey mildew.

Resistance to pests is only one of the factors influencing the adoption of Bt technology by farmers. As discussed above, the process of technology adoption is much more complex. Results on the factors of agronomic potential indicate that BT cotton has been good pest resistance and is responsive to fertilisers and irrigation. Almost all farmers indicate that BT cotton yields more than non-BT cotton. However, there is little difference in the by-product yield and BT cotton is not as drought and salinity tolerant as non-BT cotton. On the whole the agronomic potential of Bt cotton appears to be strong except for the issues of drought and salinity resistance. On the agro economic potential results indicate that there is good demand for BT cotton and the price is also higher. Almost all farmers indicate that BT cotton is substantially more profitable than non-BT cotton, indicating a strong agro-economic potential, and this is based on the private market and not government support. The results on factors affecting creation of effective demand indicate that the cotton farmers are willing to take risks and be opinion leaders or other farmers, showing that they are enterprising. Almost all of them are aware of the benefits of BT cotton and the package of practices to follow. However, many farmers are not aware about the right varieties and brands to use. Some farmers do not have sufficient access to credit but their locations are well-connected with markets. Results on aggregate Supply and distribution situation indicate that a large number of companies supply BT cotton seeds and numerous varieties are available in sufficient quantity when needed. Farmers indicate that large number of dealers nearby are ready to sell BT cotton seeds. However many feels that the dealers charge a high price for BT cotton seeds and often do not provide credit. The dealers provide guidance on the kind of seeds to use and most farmers are satisfied with the quality of the seeds. However the dealers do not take back unused seeds and do not compensate farmers in the case of crop failure. The findings indicate that the adoption process for BT cotton has worked very well. The only concern is the limited knowledge that farmers have about the varieties and brands suitable for their areas and farms.

The findings on information sources indicate that seed dealers are the most common source of information, and also the most important. The next most important source is fellow farmers. This seed company and other input dealers also play a small role. However, the government sources such as extension workers and call centres do not play much of a role as far as information on BT cotton is concerned. Mass media such as newspapers and television also play only a limited role. The main advantages conveyed include yield advantage, pest resistance and profitability. Findings on disadvantages or negative information are given below. They indicate that by and large nobody conveys such information, and of this the most important source is fellow farmers, and not newspapers, mass media or NGOs. Very little negative information is conveyed, and this mainly relates to the risk and the highest seed cost, rather than harm to human beings and the environment.

Costs, Yields and Profitability of Bt Cotton

Insights into the economics of Bt cotton and its comparison to non-Bt cotton are very important to understand the nature and cost-benefits of the technology. The findings indicate that there is a substantial increase in the seed, fertiliser, harvesting, and marketing costs. As a result the total cost increases by 72%.

However, the yield increases by 33% and the revenue by 79%. As a result there is a substantial increase of 83% in the profits. The findings on perception also indicate that farmers perceive a substantial increase in the yields and particularly in profits with the adoption of BT Cotton. This economic advantage explains the rapid adoption of BT Cotton and its popularity with the farmers. For Andhra Pradesh the results indicate that there is a substantial increase in the seed, fertiliser, farm yard manure, and harvesting costs leading to an increase in the total cost of 205%. However the yield increases by 52% and the total revenue by 99%. Thus, profits increased by 70% with the adoption of BT Cotton. The farmer perception substantiates the great advantage that BT Cotton has been yields and profits, leading to the widespread adoption of BT Cotton in Andhra Pradesh. For Gujarat the findings indicate that there is a substantial increase in the seed, fertiliser, farmyard manure, and marketing costs with the adoption of BT Cotton. However, other costs increases are limited and the overall costs increases by 50%. The yields increase by 30% and the revenue by 326% leading to a substantial increase in profits of 139%. The impact of BT Cotton on profits in Gujarat appears to be among the highest in the States, explaining the widespread adoption of BT Cotton. For Maharashtra the results indicate that there is a substantial increase in the fertiliser, pesticide, harvesting and marketing costs in the shift from non-BT to BT Cotton. As a result the total cost increases by 94%. The increase in the yield is 46% and the revenue by only 20%. As a result the profits in Maharashtra increased by 44%. This is among the lowest in the sample states, though the perceived increase in yield, revenue and profits is highly positive. This appears to show a gap between perception and reality in BT Cotton in the State of Maharashtra. For Punjab are given in the table below. The findings indicate that there is a substantial increase in the fertiliser, farmyard manure, weeding, and marketing costs, but a reduction in the pesticide and harvesting costs. Overall, this leads to a 66% increase in the total cost. That yield increases by 32% and the revenue by 44%. The overall increase in profits is by 34% which appears to be the lowest among the sample states. However, the perceptions about the yield and property increases are very high, indicating a gap between perception and reality. Thus in terms of profitability, BT Cotton does not seem to offer a very high advantage in Punjab.

There is a considerable increase in the seed cost but this varies from over 300% in Andhra Pradesh to just 57% in Maharashtra. Fertiliser costs showing huge increase in all states and even farmyard manure shows a large increase in most states. Pesticide costs do not show much change, except in Punjab where they show a decrease. Two other costs will show the change for harvesting costs and marketing costs. On an all India average, total cost shows a 71% increase, but this ranges from as high as 205% in Andhra Pradesh to just 50% in Gujarat. The highest yield increase is seen in Andhra Pradesh followed by Maharashtra. Revenue increased is most substantial in Gujarat at over 300% in the least in Maharashtra at just 20%. The profit increase is the greatest in Gujarat at hundred and 140% followed by Andhra Pradesh at 70%. The lowest increase is shown in India at 34%. A comparison of the levels of costs, yields, revenues and profits in BT Cotton per hectare cross the States indicates that Andhra Pradesh has among the highest costs in seeds, fertilisers, pesticides, irrigation and farm power. On the other hand Gujarat shows some of the lowest costs such as in seeds, pesticides, irrigation and farm power. The total cost is also the lowest in Gujarat at Rs. 33466 per hectare and the highest cost is shown by Punjab at Rs. 57373 per hectare. However, the yield and revenue are also the highest in Punjab leading to the highest per hectare profit in Punjab of Rs. 104759. This is followed by Gujarat at Rs. 75466 per hectare, and the lowest being in Maharashtra at Rs. 69077 per hectare which is just slightly lower.

Econometric Analysis of Bt Cotton Performance

It is important to establish the statistical significance of major findings in order to confirm them through the data and for this econometric analysis is important and is carried out through regression analysis. The findings indicate that BT Cotton is statistically significant in increasing the yields, and on an average has an impact of 35% increase in the yields. The impact on the value of output is also statistically significant and is found to be 93%. However, the total cost increase is also large and significant and is of 111%. This derives from increases in pesticide cost and seed cost of 42 percent and 184 percent respectively and are statistically significant. The findings indicate that there is also a 54 percent increase in price, but this may be partly related to past cotton prices. Despite the cost increases, the yield, value of output, and price advantages of Bt cotton lead to a statistically significant 75% increase in the profits, which is very substantial.

Findings for Andhra Pradesh indicate that BT Cotton gives a statistically significant increase in the yields of 46 percent which is higher than the full sample average. Despite the cost increases, the yield, value of output, and price advantages of Bt cotton lead to a statistically significant 96% increase in the profits, which is very substantial and larger than the estimated national (4 state) increase. Findings for Gujarat indicate that BT Cotton gives a statistically significant increase in the yields of 47 percent which is about the same as Andhra Pradesh. Despite the cost increases, the yield, value of output, and price advantages of Bt cotton lead to a statistically significant 90% increase in the profits, which is very substantial and is almost the same as that Andhra Pradesh. Findings for Maharashtra indicate that BT Cotton gives a statistically significant increase in the yields of 16 percent which is much lower than Andhra Pradesh or Gujarat. The cost increases, and the yield, value of output, and price advantages of Bt cotton lead to a statistically significant 24% increase in the profits, which is much lower than that seen in Andhra Pradesh and Gujarat. Findings for Punjab indicate that BT Cotton gives a statistically significant increase in the yields of 30 percent which is much lower than Andhra Pradesh or Gujarat, but higher than Maharashtra. The cost decreases, and the yield, value of output, and price advantages of Bt cotton lead to a statistically significant increase in the profits, but this is lower than that seen in Andhra Pradesh and Gujarat.

Perceived Performance and Satisfaction with Bt Cotton

The results on the advantages and disadvantages are given in the table below. A majority of the farmers see advantage of BT cotton in the quality and availability of seeds, reduction of the pest incidence and problem, and the need to use pesticides. They also see advantage in the boll size, staple length, fibre colour and Cotton price. Strong advantage is seen in yield and profit. It is also seen as suitable for early sowing. Disadvantages are seeing in seed cost and fertiliser need. No difference is seen in machinery need and irrigation and harvesting cost as well as in marketing and byproduct output.

The findings of the changes seen by the farmers over recent years in the advantages of BT cotton indicate that aspects which have become better include the availability of seeds, quality of seeds and the pest incidence. Various quality aspects have also become better including boll size, staple length, fibre colour and the resulting Cotton price and profits. Some aspects which have become worse include pesticide cost, fertiliser cost, and seed cost. No change is seen in other costs as well as market preference and marketing ease.

The most important feature of BT cotton is its resistance to pests. What are the changes in this observed by the farmers in recent years? A majority of the farmers disagree that boll worm infestation in BT cotton has increased over the years and that BT cotton is not resistant to adult boll worms, though others indicate that this is the case. Most of the farmers disagree that pest attack on other crops is higher when BT cotton is cultivated and secondary pests have become major pests in the presence of BT cotton. Many indicate though that new pests and diseases have started emerging in cotton crop in general. A large majority of farmers indicate that BT cotton as a positive impact on the environment as it requires less pesticides.

On the trends in BT cotton and non-BT cotton, farmers indicate that the yield level of BT cotton has increased and pesticide use reduced. However, the indicate that the cost of pesticides used and the overall cost of cultivation has increased. Despite this, the indicate that the profitability of cotton and farm income per hectare as increased due to BT cotton. In the case of non-BT cotton some indicate that the yield levels have increased, but the majority indicate that pesticide use, cost and total cost of cultivation have increased, and the profitability and farm income have not changed or reduced.

The study also examines the responses of the farmers with respect to the issues and problems that are often being currently raised regarding BT cotton. The farmers disagree with most of the contentions that are being currently raised. Whereas some farmers agree that BT cotton cultivation is a risky, the majority disagree that it is a risky business and not suitable for small farmers. More than 80% disagree that farmers are compelled to grow BT cotton since local varieties are not available and that BT cotton has lead to poverty and distress among the farmers. Over 85% of the farmers disagree that there has been an increase in the suicides among farmers due to BT cotton, or that there had been cases of pesticide poisoning among BT farmers. Over 90% disagree that cattle have died after eating BT cotton plants, and the majority do not believe that the seeds, oil or oil cake are unsafe for human consumption. 90% or more farmers do not find the government, non-government agencies, seed dealers or pesticide and other input dealers against the cultivation of BT cotton. The majority in fact indicate that the current policies are not in favour of BT cotton and the improvement, many also indicating that the market linkages are weak and need improvement.

On the suggestions of the farmers for improving the cotton technology and is profitability, the study finds that a huge majority of the farmers suggest more resistance towards bollworms and other emerging pests. Farmers also strongly suggest herbicide tolerant cotton and drought tolerant cotton. Higher yields are most strongly suggested, and a large number of requests for field demonstrations and a lowering of seed cost.

In overall judgements and opinions on BT cotton, the farmers almost all strongly agree that BT cotton has a strong yield advantage over non-BT cotton. They also agree that BT cotton requires less pesticide than non-BT Cotton. However, most indicate that the seed cost and cultivation cost of high. Almost all indicate that the profitability of BT cotton is very high and the technology has improved the economic status of their household. Nearly 80% indicate that they are completely satisfied with BT cotton, and over 90% indicate that they would definitely grow BT cotton in the future.

Consumer Awareness, Perceptions and Attitudes on Biotechnology

To understand the awareness, opinions and risk perception of consumers/ common people regarding GM foods and crops a survey of the consumers was conducted of a sample of urban residents in four states. 115 respondents were covered across four states: Andhra Pradesh, Gujarat, Maharashtra and Punjab.

Preliminary questioning on familiarity with genetically modified (GM) or genetically engineered (GE) foods/ crops showed that most people did not know what it was and had never heard about it. Only those who, after some description, could understand at least a little were interviewed. Only 9.7 percent indicated that they are very familiar, 40.7 percent were somewhat familiar, and 47.8 percent were not very familiar. Thus, the awareness level of the people appears to be relatively low. Analysis of the sources of information indicates that for 70 percent of people the source of information is newspapers and for 35 percent it is TV & Radio. Another important source is Government agencies at 37 percent. Friends & Relatives are indicted by only 15 percent of the respondents, and NGOs by only 3 percent. Experts, scientists and teachers come at less than 5 percent. Public debates generally on TV are indicted by 13 percent. Thus, newspapers and TV-Radio dominate as the source of the information.

Over 50 percent indicate that the public does not have enough information about GM foods/crops, and over 70 percent think that the information available is not authentic. Over 50 percent agree that the uncertainty generates fear, and almost everybody agrees that the media fills the void of uncertainty. Further, nearly 90 percent agree that people are afraid of GM because of the scare created by the media. Over 90 percent agree that media over-estimates the risk of rare events. For most people, public opinion becomes more important than the opinion of the experts. A majority indicate that pro-organic campaigns raise even more doubts about GM foods, and over 70 percent indicate that they are inclined to take the risks in voluntary activities but not in things such as new technology in agriculture. Findings indicate the awareness is low, and the role of the media in development of the risk perception is very large. It indicates that people are willing to take the risks, but are more likely to do this on a voluntary basis.

The opinions and attitudes of the people about GM foods and crops indicate that a large majority of the respondent are aware of the potential benefits of GM technology such as higher yields, less pesticides and better quality and nutrition. Many think that the resistance is politically motivated and that GM technology should be supported by the government. Many though are not clear about their threat to human life or their great usefulness. But over 80 percent think that the resistance to GM is due to poor awareness and information. This indicates that people are aware of the benefits of GM technology but lack clear knowledge and are concerned about the risks. It indicates that much can be changed on this front by strong communication and awareness building especially by the government and the experts. The findings show that most of the people are aware about the success of Bt cotton in India, and that it has helped increasing cotton productivities dramatically, and improve the economic status of cotton growing farmers. They are also aware about the reduction in pesticide use due to BT cotton. Thus, benefits of Bt cotton are known and accepted by most of the people.

Regarding potential risks of GM crops and foods, even though most people do not strongly agree regarding the risks, a good number of people are concerned about the risks and long-term impacts if any. They are aware that GM foods are a not of natural origin, but most don't think they are harmful to the environment, or harmful to health. There is a fear though that GM technology will make people dependent on MNCs and seed companies. However, they don't consider GM technology against religion. Regarding the attitudes and overall assessment of the acceptance of GM foods and crops shows that about one third of people may refuse to accept GM foods or crops in the present state of awareness, but the rest would accept them. Almost all respondents indicate the right to know how the food is produced and request mandatory labelling of foods so that people can decide. Almost all people are in favour of through testing of GM foods. Most of the people indicate that they would be willing to accept GM foods provided they are found safe in other countries, if the government has accepted them, most of the people are consuming them, and the technology is required so that there is enough food and starvation is avoided. The majority of the people are willing to support GM as the next step in food technology.

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