Chapter-6

Indian Experiences in GM Crop (Bt Cotton) Adoption

This chapter discusses the Indian experiences in introducing GM crops. Since the only approved GM crop in the country is Bt cotton, the chapter looks at the various environmental factors which had an effect on its adoption in the country. Chapter uses secondary data to explore these factors and to pinpoint their influence on the marketing strategies adopted by the technology promoters in the country. As discussed in the last chapter, legal environment is the first interface of any technology crossing borders; the regulatory framework for GM crops in Indian context is discussed in section 6.1.

Section 6.2 summarizes the events which marked the advent and kick started the journey of Bt cotton in the country. Section 6.3 explains the trends in area, production and yield of cotton since the launch of Bt technology across various zones. This section highlights the contribution of Bt cotton to the total cotton production and productivity since its launch. The factors affecting adoption across these zones are filtered out. The competitive and marketing scenario of the country which affected Bt dispersal and adoption is explained through the concept of PLC in Section 6.4. Section 6.5 summarizes all the external environmental factors affecting the adoption of Bt cotton in the country and marketing strategies used to tackle them. Finally, section 6.6 provides a brief conclusion.

6.1 Significance of GM cotton and its regulation in India

India is an agrarian economy and cotton is an important cash crop. Cotton provides livelihood to over 60 million people in India through cultivation, processing, trade and textiles. Cotton cultivation in the country accounts for 5% of the land under cultivation but uses around 50% of the pesticides produced in the country (Lalitha and Viswanathan, 2010). Bt cotton is an innovation which has promised to strengthen the position of India.
on the cotton front. Bt cotton was approved for commercial cultivation in the country in the country on March 25, 2002.

In India, manufacture, import, use, research and release of GMO’s as well as the products made by the use of such organism is governed by Environment Protection Act 1989(EPA) and the Rules 1989. India is a party to Cartagena biosafety protocol in 2001 and hence is committed to safe handling of GMO’s.

The regulatory authorities responsible for the implementation of Rules 1989 are ministry of environment and department of Biotechnology (DBT) through six designated authorities. They are -

- Recombinant DNA Advisory Committee (RDAC),
- Review Committee on Genetic Manipulation (RCGM),
- Genetic Engineering Approval Committee (GEAC),
- Institutional Biosafety Committee (IBSC),
- State Biotechnology Coordination Committees (SBCC),
- District level Coordination Committees (DLCC) and
- Monitoring and Evaluation Committee (MAC).

There is a three tier process in India for getting approval for GM crops to be commercially produced. Individual research institutes need to take permission from Review Committee of Genetic Manipulation under DBT for carrying out field trials after laboratory experiments. This committee if satisfied will grant limited permission for greenhouse trial and final trial under the supervision of scientists nominated by DBT and other state agencies like State Agriculture University, State Agriculture Department, ICAR (Indian Council of Agricultural Research) institutes. The final approval for commercial trial and use will come from GEAC.

### 6.2 Advent of Bt cotton in India

Bt-cotton was developed in India by Mahyco-an Indian company established in 1964. It is a well established name in the Indian seed industry. Currently, it is engaged in the research, production, processing and marketing of wide variety of products in numerous
crop species including cereals, oilseeds, fiber and vegetables. Mahyco has a national presence with its network across the country.

Mahyco developed Bt cotton containing the Bollgard Bt gene, \textit{cry IAc} was licensed from \textbf{Monsanto}- a multinational company which has been operating in India since 1949 and is a market leader in agricultural chemicals. It was approved by Government of India for commercial cultivation in March 2002. This approval was preceded by a large number of laboratory studies and field trials carried out during 1996 - 2001 to demonstrate the safety and benefits of Bt-cotton as per regulatory requirements.

As per regulatory procedure, Mahyco sent its application to the Dept of Biotechnology (DBT), Government of India, in March 1995 seeking permission for introducing this technology. On obtaining approval, Mahyco received 100 grams of Bt-cotton seeds (variety Cocker 312) containing the Bollgard Bt gene, \textit{cry IAc}, from Monsanto, USA, in March 1996. These seeds were first tested in India under greenhouses for germination, vigor and their efficacy against the Indian cotton bollworms. These were used in the greenhouse breeding programs and 40 elite Indian parental lines were introgressed with \textit{cry IAc} gene by crossing with the Bt gene donor parent obtained from Monsanto.

Mahyco had already developed several cotton hybrids suitable for different agro-climatic regions and these were popular with the farmers. Some of these ruling conventional hybrids were converted into Bollgard (this is the brand name of Bt-cotton developed by Monsanto) using the converted parental lines and tested for their performance and safety.

In the year 1998, Mahyco- Monsanto tied up and in the same year, the first field trials were permitted by Indian Dept. of Biotechnology’s Review Committee on Genetic Manipulation (RCGM). News broke that the trials of Bt cotton were being carried out by Monsanto without permission of regional governments and without consent of local communities and in November 1998, farmers from southern states of Karnataka burnt down the field where Bt cotton was being tested. The operation ‘cremate Monsanto’ was launched on the grounds of deception by the farmer of experimental field who claimed that the fact was dubiously hidden that the seeds were genetically modified.
The illegality of the field trials was challenged in Supreme Court. In 1999, January 8, RCGM expressed satisfaction over trial results at 40 locations and in June-Nov 1999, permission was granted to various field trials. Again in May, 2000, Mahyco asked GEAC for the release of large scale commercial field trials and hybrid seed production of indigenously developed Bt cotton hybrids. This permission was granted by GEAC in July 2000 for large scale field trials on 85 hectares and seed production on 150 hectares. This permission was backed by the data which led regulators to infer that Bt cotton was safe. DBT made a committee to independently monitor and evaluate large scale field trials. On June 18, 2001 there was a meeting between Greenpeace and MMB to discuss Bt cotton with scientists, Ministry of environment and farmer’s representatives. Farmers demanded Bt cotton to be commercialized. GEAC extended the field trials by another year in June 19, 2001. Mahyco complained about delays in clearance of their Bt-cotton varieties, even though they adhered to all the standards required and repeated field trials.

The round of difficulties in the prelaunch period of the technology began with the discovery of illegal unlicensed spread on more than 10,000 acres of land in Gujarat. These hybrids were produced by another Indian company, Navbharat Seeds (Ahmadabad) and contained Monsanto’s cry1Ac gene (Sadashivappa and Qaim, 2009). This generated bad word of mouth for the technology. These controversies settled when ICAR (Indian council of agriculture research) submitted a positive report to MOE (Ministry of Environment) on field trials on Feb 20, 2002 and on March 25, 2002; GEAC approved the commercial cultivation of the three varieties of BT cotton. The seed companies are required to ensure that a refuge (of conventional cotton) around Bt-cotton fields has to be planted. This refuge will act as a barrier to pollen flow, and to prevent the buildup of resistance among insects.

Thus there were a number of illegal issues that surrounded the initial launch of the technology in India. According to supporters, the issue of taking approval from the authorized body was a procedural irregularity. The Review Committee, which had authorized the import of Bt seeds in 1995, was empowered only to grant clearances for
contained genetic experiments in laboratories or greenhouses. Only Genetic Engineering Approval Committee (GEAC), an inter-ministerial body, could give permissions for the field trials. The mistake done by the technology promoter MMB is attributed to the ambiguity and overlapping in the roles and duties of the government regarding approval of GMO’s. However, according to critics, this was an intentional move by MMB to escape into the country without attracting public attention.

Thus there were a number of controversies that were created/tackled by the technology promoter Monsanto at the initial launch of the GM cotton technology in India. These controversies caused a delay in the launch of the technology. However, the hurdles have been crossed and the technology has been well adopted in the India.

In order to make count of other factors affecting the adoption in India, the analyses of trends in overall cotton production and the diffusion of Bt cotton across various zones is undertaken.

6.3 Cotton production in India across various zones

The cotton production in India is undertaken by Northern, central and southern zone across nine states in the country. In 2010-11, Northern zone occupied 12% of the area under total cotton in the country and contributed to the 12.5% of the cotton production; southern zone occupied 22% area of the total area under cotton in the country and contributed to 22% of the production and Central zone had 65% area under cotton and production percentage of 64.5%. The commercial cultivation of Bt cotton was approved in 2001-02 in Southern and Central zones but in 2005-06 in Northern zone. The ten years since the launch of technology in the country have seen an increase in the area, production and productivity of cotton.

Table 6: Cotton production and productivity in India

<table>
<thead>
<tr>
<th>Statistics</th>
<th>2001-02</th>
<th>2010-11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (Lakh hectares)</td>
<td>87.3</td>
<td>111.42</td>
</tr>
<tr>
<td>Production (Lakh bales)</td>
<td>148</td>
<td>313</td>
</tr>
<tr>
<td>Yield (KG per hectare)</td>
<td>308</td>
<td>517</td>
</tr>
</tbody>
</table>

Source: based on statistics provided by Cotton Corporation of India
These statistics for India include data for other regions of the country which occupy around 1% of total area under cotton since 2001-02. Today Bt cotton contributes to about 88.44% of area under total cotton cultivated in the country in 2010-11. In 2010-11, there is 92.5% of adoption of Bt hybrids in Northern, 87% in central and 91.59% in southern zone of the country.

Table 7: Cotton production and productivity in northern zone

<table>
<thead>
<tr>
<th>Statistics</th>
<th>2001-02</th>
<th>2010-11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (Lakh hectares)</td>
<td>15.57</td>
<td>13.57</td>
</tr>
<tr>
<td>Production (Lakh bales)</td>
<td>21.75</td>
<td>39</td>
</tr>
<tr>
<td>Yield (KG per hectare)</td>
<td>237</td>
<td>489</td>
</tr>
</tbody>
</table>

*Source: based on statistics provided by Cotton Corporation of India*

Despite a decline in the area by 12.8% there is an increase in the production by 80% in 2010-11 compared to 2001-02. During this period, the yield across the zone has more than doubled. Much of this has been attributed to the launch of Bt cotton in 2005-06. The adoption of Bt hybrids is 95% in Haryana, 96% in Punjab and 82% in Rajasthan (ALCOSA newsletter, May2011).

Table 8: Cotton production and productivity in southern zone

<table>
<thead>
<tr>
<th>Statistics</th>
<th>2001-02</th>
<th>2010-11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (Lakh hectares)</td>
<td>17.93</td>
<td>24.51</td>
</tr>
<tr>
<td>Production (Lakh bales)</td>
<td>38.75</td>
<td>68</td>
</tr>
<tr>
<td>Yield (KG per hectare)</td>
<td>367</td>
<td>472</td>
</tr>
</tbody>
</table>

*Source: based on statistics provided by Cotton Corporation of India*
This zone has seen an increase in are by 36.6%, production by 75% and productivity by 28.6% since 2001-02. The adoption of Bt cotton in AP is 99%, while it is 74% in Karnataka and 77% in Tamil Nadu (ALCOSA newsletter, May2011).

Table 9: Cotton production and productivity in central zone

<table>
<thead>
<tr>
<th>Statistics</th>
<th>2001-02</th>
<th>2010-11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (Lakh hectares)</td>
<td>52.9</td>
<td>72.15</td>
</tr>
<tr>
<td>Production (Lakh bales)</td>
<td>86.75</td>
<td>202</td>
</tr>
<tr>
<td>Yield (KG per hectare)</td>
<td>279</td>
<td>476</td>
</tr>
</tbody>
</table>

*Source: based on statistics provided by Cotton Corporation of India*

Since the launch of Bt cotton in 2001-02, the area (36%), production (132.8%) and productivity (71%) of cotton has risen in the zone. The adoption of Bt cotton is 81% in Gujarat, 91% in Maharashtra and 92% in Madhya Pradesh (ALCOSCA newsletter, May2011).

Comparison of the three zones reveals that the production and productivity across all the three zones has risen. Area under cotton has seen a rise in central and southern zone but the same has shrinked under northern zone. In order to filter out the factors responsible for these overall trends the state wise analysis is undertaken.

**Northern zone**-it comprises of Punjab, Haryana and parts of Rajasthan and UP. 95% of crop is under assured irrigation in Punjab and Haryana. In southern districts of Rajasthan, there is a sizable area under rain fed cotton. The earliest sowing of cotton in the country takes place in this zone commencing from April/May and sometimes extending up to the first week of June. Cotton picking usually commences in September-October and may go up to November. Harvest is completed before the onset of severe winter. Soils are sandy to clayey alluvial soils are low in drainage. Hence, over irrigation leads to water logging which affects the plant growth. Late unseasonal rains in the zone interfere in the timely and proper drying and opening of bolls. This posed a problem for the farmer as the water
table rose and prevented farmers from getting high yields. This also resulted in salinity, alkalinity of soils. Late unseasonal rains in the zone interfere in the timely and proper drying and opening of bolls. The trends could be mapped as-

**Figure 4: Yield, Production and Area under cotton (Haryana)**

Note: Area is in Lakh hectares, production in Lakh Bales of 170 KG each and yield in KG per hectare

*Source: based on statistics provided by Cotton Corporation of India*

Bt cotton was launched in 2005-06 sowing season in this state. Since then, productivity has improved from 379 to 484. The area under cotton production has been declining since last ten years. The area under cotton since the launch of Bt has also declined. There are a number of reasons quoted for the same. In 2005, the cotton belt of the state comprising districts of Sirsa, Hisar, Fatehabad, Bhiwani, Jind, Jhajjar, Rohtak and parts of Mahendragarh and Rewari were hit by attacks of American bollworm on the cotton crop
and the area under the cotton crop declined. In 2006-07 water shortage in Haryana was the reason for low acreage under cotton. In 2007-08, the agricultural scene in Haryana was dominated by paddy-wheat rotation. Less of rainfall in the same year was also one of the factors responsible for the drop in area under cotton. The drop in the area under cotton in 2008-09 was due to the attack of mealy bug on the cotton crop in 115 villages across the state. This was confirmed by a survey conducted in Haryana by State Agriculture Department and CCS HAU (Chaudhry Charan Singh Haryana Agriculture University) Hisar in August, 2007.

There was a marginal increase in the area in the year 2009-10 compared to the year preceding it. It could be due to the increase in the prices of cotton lint all over the world. This area has again shrunk in 2010-11. The state has around 95% of adoption of Bt cotton in 2010-11.

**Figure 5: Yield, Production and Area under cotton (Punjab)**

Note: Area is in Lakh hectares, production in Lakh Bales of 170 KG each and yield in KG per hectare

*Source: based on statistics provided by Cotton Corporation of India*
As shown by the graph, there has been a fall in the area in the total cotton production in 2010 compared to year 2001-02. Area under cotton production shows mixed trend of growth and decline in last ten years. When Bt cotton was launched in 2005-06, the area under cotton increased for next two seasons but started declining after 2007-08. This was mainly due to the attack of mealy bug in 2007-08, which discouraged farmers to plant cotton and had a negative impact on the production and productivity. The bug affected four major cotton-growing districts of Punjab- Bathinda, Muktsar, Faridkot and Ferozepur. It was reported that the farmers sprayed pesticides worth over Rs. 500 Crore in the season to save their crop from mealy bug. The bug was considered as deadlier than American bollworm.

In 2010-11, the area under cotton rose. There was a hope that water shortage will be reduced. The reason for the same could be the announcement of a fund of Rs 1, 410 Crore for Indira Gandhi Nahar project (IGNP). This fund is expected to be used to repair the main canal as well as its lined distribution system to prevent leakage of water. Hence the water shortage also affects the cultivation of cotton in terms of land area under it.

**Figure 6: Yield, Production and Area under cotton (Rajasthan)**

Note: Area is in Lakh hectares, production in Lakh Bales of 170 KG each and yield in KG per hectare

*Source: based on statistics provided by Cotton Corporation of India*
In last ten years the land under cotton has been showing a mixed trend. Since 2005-06, when Bt cotton was launched, there is an increase in the productivity by 15% and decline in the area under cotton by 29%. Water shortage is the major problem of the state. In 2006-07 seasons, there was a shortage of Bt cotton in the state, therefore many farmers purchased illegal seeds from the retailer. This might have resulted in the fall of productivity in 2007-08.

In addition to the above, outbreak of mealy bug in 2007-08, though affected only some of the patches in Rajasthan, discouraged the farmers to plant cotton further. But the area under cotton increased in Rajasthan in 2009-10. This might be due to the increase in the global cotton prices. In 2010, around April 20, Even as cotton sowing in irrigated fields in Punjab and Haryana began farmers in Rajasthan had to delay sowing due to decreasing water table and non availability of canal water from the India Gandhi and the Gang canal. This might have been the reason for the decline in the area under cotton in 2010-11 (Sally and Tiwari, 2010).

Thus this zone faces a number of problems which affect the cotton crop. The major ones are related to the geographic conditions. Other factors like the cotton prices and investments by the government also affect the cotton cultivation in the zone. In 2005-06 seasons it was reported that agents of spurious seed-selling firms established their network in the cotton belt of Punjab, Haryana and Sriganganagar district of Rajasthan. Government took measures at state level to curb the same. This zone saw the emergence of mealy bug pest in 2007-08 which resulted in the fall in the area in its corresponding year. In response to the increase in the cotton prices in 2009-10, there was an increase in the area under total cotton cultivation in Haryana and Rajasthan and decrease in the fall of land area under cotton in Punjab. Price controls have not been adopted in this zone.

**Central zone**: Central zone comprises primarily rainfed tract of MP, Maharashtra and Gujarat. The zone is dominated by black soils which are quite suitable for growing cotton, especially rain fed cotton because of their high retention capacity of soil moisture. Because of this, they are actually called black cotton soils. The zone has quite suitable
weather conditions that facilitate cotton farming. Though the farmers are resource poor and cannot invest much of into the irrigation. Usually, cotton sowing in the zone commences with the onset of south-west monsoon in June-July. The irrigated cotton is planted a little earlier in May-June. Cotton producing states of this zone Maharashtra and Gujarat are the leading states with highest area under cotton. Gujarat is also the highest producer of the cotton in India.

Figure 7: Yield, Production and Area under cotton (Maharashtra)

![Graph showing yield, production, and area under cotton for Maharashtra from 2003-2012.](image)

Note: Area is in Lakh hectares, production in Lakh Bales of 170 KG each and yield in KG per hectare

*Source: based on statistics provided by Cotton Corporation of India*
Maharashtra has shown an overall expansion in the area (32%), production (140%) and productivity (82%) of cotton in 2010-11 compared to the launch year of Bt cotton (2001-02). Besides the geographic factors like floods and excessive rainfall, outbreak of epidemics like chikungunya which impact the availability of the labor, also affect cotton crop statistics. Adoption of Bt cotton in the state was affected by the existence of cotton monopoly scheme where the guaranteed price for cotton farmers was high enough than market price. Though this provided incentive for higher production but there was no incentive for the farmers to improve upon the cotton quality. Moreover, the prevalence of fake and spurious seeds in the market affects the performance of Bt technology and interferes with its adoption across this state. In 2004, fake seeds worth Rs 2 Crore were reported to sell in the region. In 2006-07, Illegal Bt seeds amounting Rs. 81.76 Lakh were seized by their state officials and the police cases were launched against the suppliers.

Figure 8: Yield, Production and Area under cotton (Gujarat)

Note: Area is in Lakh hectares, production in Lakh Bales of 170 KG each and yield in KG per hectare

Source: based on statistics provided by Cotton Corporation of India
Compared to the year when Bt cotton was launched in the state (2001-02), there is an increase in the area by 56%, while the production has approximately tripled and the productivity has doubled. About 22% of cotton area in the State is irrigated. In the year 2005, there was a sowing of fake spurious seeds in the state up to 80% of total area under cotton. This might have been the reason for the loss in productivity in 2006-07. There were many initiatives taken by the state government to create awareness regarding authorized Bt seeds-formation of flying squad for surprise checking at ginning centers, godown of seed producers, processing centers and other premises, preventing the sale of unauthorized and other spurious seeds. Creating awareness among the farmer’s for purchasing the Bt seed from the recognized sources only, providing the agronomical know how regarding cultivation of cotton and critical points to look after it through mass media viz. Radio, T.V., newspaper, periodicals etc.

**Figure 9: Yield, Production and Area under cotton (Madhya Pradesh)**

Note: Area is in Lakh hectares, production in Lakh Bales of 170 KG each and yield in KG per hectare

*Source: based on statistics provided by Cotton Corporation of India*
Though this state has seen a decrease in the production and productivity of cotton since 2001-02, according to ALCOSA newsletter, May 2011, there were inaccurate statistics in the initial years of the decade. The state faces the prevalence of fake seeds and in June 2006, government decided to form committees to prevent fake Bt cotton seeds trading in the state. In 2006-07, price controls were imposed by the state government but were withdrawn upon defeat against the case by MMB in the High Court.

Thus the overall productivity in the central zone started declining since 2007-08 and continued till 2009-10. In 2010-11, there is has been a rise in production and productivity across the zone. This might have been due to the increase in the cotton prices in 2009-10 that more acreage is coming under cotton. The farmers in this zone have replaced other crops with cotton cultivation. For example- Gujarat farmers have moved away from sowing groundnut and pulses to growing cotton. In Maharashtra, farmers are withdrawing from soybean and sunflower and cultivating cotton. The major problem faced by the technology in this zone besides geographic and climatic factors is the prevalence of fake and spurious seeds and the price controls which discourage the investments in development of new technologies.

**Southern zone** comprises of Andhra Pradesh, Karnataka and Tamil Nadu. Unlike the two other zones, South cotton zone is not a cohesive one in agro-climatic conditions as also a few other respects. Soils in the zone are varied and have black, red and mixed ones. The seasons of cotton farming also vary from State to State. The bulk of sowings commences in August and goes on up to October and sometimes early November depending on the receipt of monsoon rains. Small pockets in some States like Karnataka take up sowing in April - May with the help of early rains also. This zone has AP which is the third largest state in the country in terms of area under cotton in 2010-11.
Figure 10: Yield, Production and Area under cotton (Andhra Pradesh)

Note: Area is in Lakh hectares, production in Lakh Bales of 170 KG each and yield in KG per hectare

Source: based on statistics provided by Cotton Corporation of India

Since 2001-02, there is an increase in the area (78%), productivity (11.2%). The production of the state has almost doubled since that year. This state has good irrigation facilities (40-45% of irrigated cotton) due to Nagarjunasagar dam Project (ALCOSCA newsletter, May 2011). The problem of unauthorized seeds has been prevalent across the state. After 2006-07, the area under cotton has been significantly rising in the state. It may be due to the price controls exercised by the state government. AP is the first Indian state to implement seed price controls in 2006-07. In 2005, AP government filed a petition with the Monopolies and Restrictive Trade Practices Commission (MRTPC) seeking to have MMB and its licensees declared monopolists and to reduce Bt cotton seed prices. Early in
2006, the Commission agreed and stated that the state government should set the price of Bt cotton. MMB appealed against this price-control order set by the MRTPC to the Supreme Court, but the issue is still pending five years later. Meanwhile during 2006, the planting time for cotton was approaching, so the seed companies negotiated with the AP government to set the price of hybrid cotton seed containing the BGI event at Rs. 750 per packet inclusive of technology fee. The AP government sent a letter about the ‘new (controlled) prices’ to other state governments, which adopted the same price policy. Now these price caps have spread to important cotton-growing states throughout the country, including Maharashtra and Gujarat, and have influenced prices in the rest of India.

Figure 11: Yield, Production and Area under cotton (Karnataka)

Note: Area is in Lakh hectares, production in Lakh Bales of 170 KG each and yield in KG per hectare

Source: based on statistics provided by Cotton Corporation of India
The production (43%) and productivity (55%) has increased despite fall in the area under cotton (7.8%) since the launch of Bt in 2001-02. This state has 15-30% area under irrigated cotton. However, the area under cotton has seen a rising trend since 2007-08. This might be due to the price controls for Bt cotton seeds. The prices of Bt cotton seeds were fixed at Rs. 750 for a 450 gm packet as against the Monsanto Bt Cotton India Limited’s Rs. 1,450 for the same quantity of seed. In response to the increase in the cotton prices, there was a substantial rise in the area under cotton in 2009-10 and is continuing in 2010-11.

In this state, Tungabhadra and a few other small scale projects provide irrigation for cotton in a few thousand hectares. In order to control illegal seed sales in the state, Seed Inspectors were instructed to conduct surprise raids to the seed dealer shops and draw Bt cotton samples for quality analysis. These might be the additional reasons for the rise in area under cotton.

**Figure 12: Yield, Production and Area under cotton (Tamil Nadu)**

Note: Area is in Lakh hectares, production in Lakh Bales of 170 KG each and yield in KG per hectare

*Source: based on statistics provided by Cotton Corporation of India*
As the graph shows, despite the fall in the area under cotton by 39%, there is an increase in the productivity by 64% since 2001-02. Tamil Nadu’s cotton production has shown mixed trends. There have been periods of increase, decrease and stagnation in all the three parameters on the graph. Expansion of area under cotton is slow because of land availability, higher cost of cultivation etc.

The total area under cotton has been rising since 2009-10 but the production and productivity have declined.

South zone also showed a loss of productivity since last two years. The major challenges were unauthorized seeds being sold in the market, difficulty in obtaining authorization for new varieties due to poor performance, fixing of the seed price as per government orders. The price controls are not adopted by the state government in Karnataka and Tamil Nadu though the zone has been a pioneer in initiating and implementing price controls in AP.

Since 2008-09 there was an increase in the area and production of cotton but there was a constant fall in the productivity in India. In 2010-11 all the three parameters rose for the cotton production. The above analysis of Bt cotton across various states pointed towards the political, legal, geographic and market related factors which affected the spread of technology in the country. In order to look into the market related factors like the number of companies in the market, share of Indian players, new technology in Bt cotton, competition at stages of spread of technology, product lifecycle of Bt cotton in India is mapped.

6.4 Product life cycle

6.4.1 The concept of PLC

Like in case of other innovations, the growth and trends in the life of Bt cotton can be traced through its PLC. PLC refers to the life cycle of a product where it undergoes the stages of introduction, growth, and maturity and finally declines. All the four stages are marked by different levels of sales, profits and marketing strategies being used by the producer/marketer. The concept of PLC applies to a generic category of
product and not specific brands. Product life cycle describes industry sales and profits for a product idea within a particular product market. The sales and profits of an individual brand may not, follow the life cycle pattern. Thus the concept talks about the total sales of a product by all the competitors in the industry. A life cycle can be graphed by plotting aggregate sales volume for a product category over time, usually years. Variations in industry life cycle model have been developed to handle the development of product, market and industry. To some degree the collective action of the firms offering competitive products in the same category affect the shape of sales and profit curves for a product category. Even single companies can have an impact. A giant firm may be able to shorten the introductory stage by broadening the distribution or increasing the promotional effort supporting the new product. The concept of life cycle is however related to a specific market. There are various cases in the product life cycle example maturity is elongated so as to prevent the product from declining as far as possible. A product may be at maturity or growth stage in a specific country but it might be at introduction stage in another. Thus a product may exhibit different stages of PLC across different countries. Here, the study talks about the Bt cotton in Indian context. In order to place Bt cotton in the framework for marketing of innovations and to trace its product life cycle, it is important to graph its growth in terms of sales of seeds since its introduction in India and draws its life cycle.

6.4.2 PLC of Bt cotton in India

The sale of Bt cotton seeds in the country since its launch is depicted by the following graph. The stages of lifecycle are also marked below-
Introduction stage- As discussed, Bt cotton was introduced in the country by Monsanto through its subsidiary MMB Limited. The first Bt hybrids combined the Bt gene from Monsanto with hybrid cotton cultivars from Mahyco. The joint venture Mahyco Monsanto Biotech (MMB) also expressed its willingness to license Bt technology to the companies agreeing to meet their financial and other contractual requirements. The introduction was marked by-

1. High price of seeds-the Prices of Bt cotton in the year of introduction were Rs. 1600 for a packet of 450 gm of Bt seeds and 120 gm of non-Bt seeds (which farmers are supposed to sow as ‘refuge’ to minimize the potential for development of Bt-resistant insect races in the long run) in comparison to 300-500 Rs for a packet of conventional hybrids (Pray and Nagarajan, 2010).
2. Higher technology fee charged by the promoter- Monsanto charged 1250 per packet as the technology fee. MMB was able to charge a substantial technology fee because the product promised to solve the problems of cotton cultivations and MMB was the only player. Only three Bt cotton hybrids of Mahyco (Mech-162, Mech-184 and Mech-12) were given the approval in 2002. In 2004, the Genetic
Engineering Approval Committee (GEAC) of the Ministry of Environment and Forest (MOEF) had approved one more Bt cotton hybrid of Rasi Seeds for cultivation in Central and Southern zone.

3. The first year of Bt cotton production saw a number of product failures like in AP, MP, Maharashtra, Karnataka and Gujarat (Krishnakumar, 2003). There are many studies based on the field survey that give mixed results during this period (Sahai and Rehman, 2003; Qayam and Sakkhari, 2003; Naik et al., 2005). Bt cotton was reported as a reason for farmer suicides across many states.

4. These marketing strategies in the introduction stage helped the company to penetrate the market-
   a. During the launch of Bt cotton seeds in southern zone, MMB distributed free pesticides with Bt cotton seeds. Launch of Bt cotton in AP was done by giving a feast to the farmers. On that day, bookings for the season’s supply were made by the dealers and company representatives.
   b. In central zone, advertisements in the newspapers, posters and televisions were carried out with popular actors like Nana Patekar. In Maharashtra, local religious guru Sant Satyapal Maharaj served as an opinion leader for Bt cotton.
   c. The promotion was targeted at the channel partners too. The Bt Cotton companies gave gold and silver prizes to the top retail seed seller and top wholesale merchant for their sales in 2004.

5. This stage saw the emergence of illegal unauthorized Bt cotton seeds and fake seeds in many states. Authorities in these regions launched a campaign against illegal sale of Bacillus thuringiensis (Bt) cotton seeds to farmers. It was advised that the farmers should buy seeds which are certified and approved by the government.

6. Hence at this stage there were three hybrids across two states and one company with one event containing cry1Ac gene developed by Mahyco for Bollgard1. Area under Bt cotton rose from 0.5% to 1.3% to reach 5% of total area under cotton cultivation in 2003-04.
Growth stage- the sales of Bt cotton started gaining momentum (take off) when in year 2005, it was approved for commercial cultivation in northern India. Takeoff is the point of transition from the introduction to the growth stage of the PLC. It is the first dramatic and sustained increase in product category sales. After takeoff, the sales base became high which implies that the increases in unit sales were quite substantial. In this stage –

1. The competition became intense with-
   a. Increase in the number of hybrids approved from 4 in 2004 to 20 in 2005 and 274 in 2008 (Pray and Nagarajan, 2010).
   b. Increase in the number of companies Bt seeds to 30 in 2008
   c. The area under Bt cotton grew to 80% in 2007-08.
   d. New Bt genes and new events started appearing in 2006. MMB sourced two genes cry1Ac and cry2Ab from Monsanto and developed Bollgard II (BGII). The other two events approved for the sale in the same year were Event-1 (third event) which was developed by JK Seeds featuring the cry1Ac gene, sourced from IIT Kharagpur, India the GFM event (fourth) which was developed by Nath Seeds, sourced from China, and features the fused genes cry2Ab and cry1Ac. In contrast to the above four events, which were all incorporated in cotton hybrids, notably the fifth event known as BNLA-601 was approved for commercial sale in an indigenous publicly bred cotton variety named Bikaneri Nerma(BN) expressing the cry1Ac gene.

In 2008, central Institute of Cotton Research (CICR) in Nagpur developed desi (local) Bt cotton seeds for distribution to farmers it was developed after ten years of research by CICR. It was approved for commercialization in 2009. This is the first indigenous Bt cotton event developed by the Central Institute of Cotton Research (CICR) – one of the premier public sector institute of the Indian Council of Agricultural Research (ICAR) – along with University of Agricultural Sciences, Dharwad, Karnataka. The approval of the Bt cotton variety BN will help farmers in varietal growing areas which were
previously disadvantaged because they were unable to benefit from the insect resistant Bt cotton hybrids cultivated widely across all three cotton growing zones. Hence the number of events approved also climbed up from 1 in 2004 to 5 in 2008. The commercial deployment of these 4 events in hybrids and 5th event in both variety and hybrids was made in the country.

e. During this period a number of companies like sygenta, Metahelix and indo American Hybrid seeds claimed to be working on their own technology.

2. In 2006, there were price controls exercised by the government of many states across central and southern zones. In year 2008-09, Maharashtra, Gujarat and Madhya Pradesh fixed the maximum retail price of Rs 650 a packet for BG-I hybrids and Rs 750 for BG-II packets, while Andhra Pradesh mandated a uniform Rs 750 rat. In Tamil Nadu, Punjab, Haryana and Rajasthan, BG-I was priced at Rs 750 and BG-II at Rs 925-950. Reduced prices meant that while farmers were initially planting only one packet of seeds for every acre, now raised it to 1.5 packets in the northern States and to 1.2 in other parts. The trait fee charged by Mahyco-Monsanto Biotech India Ltd (MMB) — the licensor for ‘Bollgard’ — also came down to Rs 140-150 a packet.

3. To control illegal fake Bt seeds, There were awareness campaigns launched by Monsanto and state governments. In MP, government formed committees to prevent the trading of fake seeds. In northern zone, flying squads set up at the state and districts levels to break the network of those involved in such activity.

4. In the beginning of this stage, 2005, there was a mix of marketing and promotional strategies which were used-

a. Testimonial advertisements-featuring farmers who have cultivated and benefitted by Bt cotton seeds adoption were shown in the posters and hoardings. Seed companies used booklets of success stories that included Bt Cotton farmer photos and stories about their high yields and profits. The Companies were distributing these booklets to the farmers through seed dealers.
b. Village Meetings and Feasts: The companies conducted meetings in select villages and brought farmers from neighboring villages by arranging vehicles etc. Here, they provided food for the farmers too. To gain credibility, the village head and influential farmers are also brought into the meetings where they put out their messages on the benefits of Bt Cotton.

c. A variety of media was used for advertising—the companies launched advertisements in local newspapers, through cable television, in videos in private buses and even videos in haats (rural weekly markets). They also used vinyl (digital) hoardings and cloth banners. Four wheelers with advertisements and film songs go around the villages, publicizing Bt Cotton amongst farmers.

d. Discount Schemes for Advance Bookings: The companies sell the seeds with a discount of around hundred rupees, for farmers who have booked seeds in advance. They also conduct some lottery draws for the pre-booked farmers - the prizes distributed are two-wheelers and school bags.

e. Free Gifts: The companies distributed a school bag each for 5 packets of Bt Cotton as a free gift.

f. Handbills: The companies distribute handbills in temple festivals and village bazaars.

g. In Punjab, the government pushed the Bt cotton seeds by promoting their benefits.

**Slowdown**—Slowdown is the point of transition from the growth stage to the maturity stage of the PLC. The slowdown signals the beginning of a period of level, slowly increasing, or temporarily decreasing product category sales. In case of Bt cotton in India it started between 2008-09 when the rate of increase in the sale of seed was lower than the growth years.

1. The competition became intense with the number of approved hybrids reaching 522 by 35 seed companies in 2008-09 to 619 in 2009-10.
2. The number of events also rose to 6 with In July 2009; Metahelix received approval to sell its new Bt gene.

3. The sixth new event, MLS-9124, was developed indigenously by Metahelix Life Sciences and features a synthetic cry1C gene. Metahelix Life Sciences became the first Indian private company to develop a commercial gene - cry1C on its own and got approval for its two Bt cotton hybrids. In this novel method, the single gene, cry1C, was expected to provide protection against two major pests (bollworm and spodoptera) which account for more than 60 percent of the pests that damage cotton crop. At present there is a commercial deployment of five events in hybrids and one event in both variety and hybrids in India.

4. In 2009, seven years after the launch of Bt cotton by Monsanto, first home bred varieties came into existence. Bikaneri Nerma-Bt,-an in-bred variety and a hybrid, NHH 44-Bt – both developed by the Indian Council of Agricultural Research’s Central Institute for Cotton Research (CICR). These were based on event BNLA-601 expressing the cry1Ac gene. Bikaneri Nerma-Bt held out hope for farmers in view of it being an in-bred variety, which can be stored and multiplied by farmers themselves and the seeds, were priced at Rs 200 per 2 kg bag.

5. Area under Bt cotton has declined to 88.4% in 2010-11 compared to 91% 2009-10

6. The prices for Bt seeds packets have declined from Rs 1600 for a packet of 450 grams (2003) to 650-750 for BG-1 and BG-2 respectively in most of the regions and 750-925 for north in year 2009. In 2010-11, these prices have risen to Rs.825 in BG-1 and 1000 for BG2 in northern zone, Rs 830 for BG1 and 930 for BG2 in central and southern zone.

The increase in the competition in the market and increase in the adoption of Bt cotton is summarized through table 10 and 11.
Table 10: List of Bt cotton events approved for cultivation in India

<table>
<thead>
<tr>
<th>Event Name</th>
<th>Event Number</th>
<th>Source/Company/Institution</th>
<th>Genes</th>
<th>Year of approval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bollgard1</td>
<td>MON 531</td>
<td>Monsanto</td>
<td>cry 1Ac</td>
<td>2002</td>
</tr>
<tr>
<td>Bollgard2</td>
<td>MON 15985</td>
<td>Monsanto</td>
<td>cry1Ac and cry2Ab</td>
<td>2006</td>
</tr>
<tr>
<td>Event-1</td>
<td>Event-1</td>
<td>IIT, Kharagpur</td>
<td>Truncated cry 1Ac</td>
<td>2006</td>
</tr>
<tr>
<td>GFM Cry1A</td>
<td>GFM Cry1A</td>
<td>Chinese Academy of Sciences</td>
<td>cry1Ac+cry2Ab</td>
<td>2006</td>
</tr>
<tr>
<td>Dharwad Event</td>
<td>Dharwad Event</td>
<td>UAS, Dharwad</td>
<td>Truncated cry 1Ac</td>
<td>2008</td>
</tr>
<tr>
<td>9124</td>
<td>9124</td>
<td>Metahelix</td>
<td>cry 1C</td>
<td>2009</td>
</tr>
</tbody>
</table>

Source: compiled from various sources

Table11: Expansion in the area under Bt cotton in India since its launch (per cent)

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>1.3</td>
<td>5</td>
<td>14.79</td>
<td>43</td>
<td>68</td>
<td>80</td>
<td>89</td>
<td>91</td>
<td>88.4</td>
</tr>
</tbody>
</table>

Source: based on statistics provided by Cotton Corporation of India and ISAAA Reports 2001-2010

The above discussion evidences the success of marketing strategies in inducing adoption of Bt cotton in the country. Growing stability and maturity of prices, burgeoning varieties, indigenous technologies and advent of homegrown companies into the arena further support this point. Next section provides the summary of the challenges faced by the technology in the country and the marketing strategies which were used to tackle them.
6.5 Factors affecting adoption in India and the marketing strategies used

6.5.1 Challenges affecting the adoption of Bt cotton in India

The above data clearly points to the fact that there were multifaceted challenges to the diffusion and adoption posed by the environmental variables (contextual and publics). But the data reveal These are summerized as-

1. **Geographical** - In India across all the states, agriculture is dependent upon the vagaries of nature. In addition to these the unique and diverse geographical and climatic conditions represent an inbuilt challenge to cotton cultivation including Bt cotton. These factors determine the performance of Bt cotton technology. Variations between regions (pest pressure, agro-ecological conditions) and farmers (pest control patterns) influence spatial differences in performance (Qaim et al. 2006). Market related challenges- these hurdles came in the way of marketing of Bt cotton seeds in India-
   a. The efforts for marketing of Bt technology at the initial launch stage were more or less carried by MMB in the country. The technology was launched by the sole promotion efforts of MMB. The company invested heavily in the campaings and devised diverse strategies to promote Bt cotton seeds to farmers as well as dealers and distributers. But these efforts were criticized by the NGO’s and farmer associations. The marketing strategies used were labelled as- aggressive, false and misleading.
   b. Some of the players in the market were selling illegal, fake and unauthorized seeds. Fake and poor quality seeds have low yield and affect the word of mouth negatively. Unauthorized seeds reduce the total profit earned by the authorized players who have gone through the regulatory process to get approvals. These seeds being lower in price are readily accepted by the market like in Haryana, due to poor quality of seed supplied by a national company the crop was infested with white fly insects leading to a loss in yield. This generated a negative word of mouth for the technology.
2. **Competitive environment**- Increase in the number of hybrids, companies producing Bt cotton seeds and rise in the number of approved events point towards the heating up of competitive scenario. Moreover the advent of home bred variety and in-bred varieties further promise to alter the rules of competition.

3. **Social environment and other stakeholders**- Social environment manifests itself in the form of other stakeholders who are directly or indirectly linked the innovation diffusion. Bt cotton technolgy faced a lot of opposition from media (Gentleman 2006), personalities (Lean 2008), and by a number of civil society organizations (e.g., Sahai 2005) on the grounds that it is linked to the farmers suicides in the country. But according to Gruere, Bhatt and Sengupta, 2008, Bt cotton is not a necessary or sufficient condition for the occurrence of farmer suicides. Therefore, it should not be blamed for the resurgence of farmer suicides in the field.

The positive impact of social environment and publics can be seen through farmer demonstrations that had had success cultivating it MoEF (Ministry of Environment and Forests 2003). This generated positive word of mouth for the technology. Media also helped in diffusion of the technology by providing various vehicles for disseminating the information and spreading awareness.

4. **Political and legal environment**-this environmental variable acted both ways-at some situations it boosted promoters of technology by providing incentive while in others it de motivated them.

The political and legal environment of India provided support to the technology through approval of hybrids, the launch of awareness campaings for the farmers, Minimum Support Price, technology mission on cotton, contract farming, irrigation facilities, making special arrangements at state and district level to control illegal Bt cotton. 

The major barriers erected by this environment in the country are- the technology was not allowed to be commercialized in the northern zone of the country and its launch was restricted to the central and southern zones only. the condition of the
refuge crop represented a constraint in the technology adoption by farmers of small fields (Raghuram, 2002).

The condition of five rows of conventional cotton which are required to be sown along the border of every field irrespective of the size of the plot. Though government has made efforts to spread awareness of the technology at state and district level, the farmers remained more or less dependent on the private companies for the information regarding these varieties (Grue, Bhatt and Sengupta, 2008). Even the agricultural extension services which were provided were located at distant places. According to Shridhar 2006, seed and fertilizer Company agents have been the sole interface between the technology and the farmers. There are price controls for Bt cotton seeds, levied by the state governments across central and southern zones. These price ceilings may demotivate the players from making hefty investments in research and development (Sadashivappa and Qaim, 2009; Pray and Nagarajan, 2010).

5. **Technological and Marketing environment**- Bt Cotton market saw development in terms of new hybrid being developed and events approved for transgenic cotton. Further there was an increase the number of companies entering the arena. Thus where on one hand the performance of technology improved, on the other hand competition got heated up in the market. This rise in the competition pushed the demand due to reduced prices and higher visibility and increased availability of the product. These developments in the environment increased farmers’ confidence and helped in the adoption of GM cotton technology.

6.5.2 **Marketing strategies to overcome the challenges and achieve adoption and diffusion in the country**

There were a number of marketing strategies which were built upon the factors impacting adoption in the country. These are summerized as-
1. Private players especially MMB realized that the onus of convincing the farmers to buy Bt cotton seeds lies is more or less on them and hence invested heavily in the promotions. Except for in northern state where a lot of support was provided by the government, MMB has been incidental in initiating trials in southern and central zones. Across many states, private companies alone or in collaboration with government started training and awareness programmes for the farmers to help them differentiate between the certified and uncertified varieties. In order to comply with the legal requirement of refuge seeds in India, the technology promoters packaged the Bt seeds (450 grams) with the Non Bt seeds (150 grams).

2. Looking at the socioeconomic condition of the farmers, the launch strategies included a number of free offers and discount offers like-free pesticides with Bt seed packets and promotions like providing feast to the farmers. Moreover the prices of Bt were reduced though it was done through government intervention. The same helped in getting a better penetration in the market.

3. In order to tackle the opposition by social groups and influence the opinion of farmers, the company made local people as their brand ambassadors.

4. Looking at the mix of geographical factors pertaining to a particular zone, the customized Bt cotton varieties were developed and launched.

6.6 Conclusion
Hence it can be concluded that the technology promoters have been successful in dealing with the environmental variables through their marketing strategies in India. The increase in number of companies, hybrids, events and area under Bt cotton serve as an evidence for the same. Thus marketing strategies of the promoters were incidental in inducing adoption of Bt cotton at the macro level. In order to look at the impact of the personal characteristics of the farmers on the adoption of Bt cotton in the country, the primary survey of the major cotton producing states across northern zone in the country was undertaken. The details of the same have been given in the next chapter.