Chapter – 1

Introduction

Agriculture in India is the largest sector of economic activity and has a crucial role to play in the country’s economic development in various ways. In India agriculture is in fact looked as a way of life, though its contribution in the Indian economy is reducing still it is the major source of providing employment to about 65% of the rural poor. The main characteristic features of Indian Agriculture are as follows:

1. Relatively small size of field.
2. The fertility of soil is poor.
3. Almost 75% of the agriculture is dependent on rain.
4. Uncertain, ill distributed and limited annual rainfall.
5. Occurrence of extensive climatic hazards like drought, flood etc.
6. Similarity in types of crop raised by almost all the farmers of a particular region.
7. The rate of adoption of newer agricultural technologies is very poor.
8. Losses due to insect pest and diseases are high.
10. The quality of produce is poor.
11. Inadequate market facility for the produce.
12. Assured rates for produce is less.
13. Cost of cultivation has increased
14. Government subsidies on the inputs have decreased.
15. Value addition to the agriculture produce is nil or very less.

Problems of Farmers:

Owing to the above-mentioned characteristics of the agriculture the country farmers are facing a number of problems. The ultimate result of these problems is pitiable life style of the common farmers that sometimes leads to their suicide as seen in Maharashtra, Andhra Pradesh and Karnataka.
India has about 108 million hectares of rain fed area, which constitute nearly 75% of the total arable land. As water is the most important factor of crop production, inadequacy and uncertainly of rainfall often cause partial or complete failure of the crop, which leads to period of scarcities. A proverb is very common amongst the farmers of India that less grows that sown, less reaped than grown, less stored than harvested and less used than harvested as at every stage, from sowing to actual consumption by the users, there are losses. Many of the factors resulting in losses can be prevented by adopting proper agronomical practices and other care.

The major controllable enemies of the farmers are insect-pest, diseases, weeds etc. These enemies can be easily removed by using appropriate recommendations suggested by agronomists for particular crops and farmers can reap more than his present production.

The green revolution that was started in 1967 has contributed significant improvement in agricultural sector. Swaminathan (1985) stated that, “slowly but surely the yellow color of seedlings of various crops started turning green due to increased development of chlorophyll as a result of better nutrition and this change in color is popularly referred to as Green revolution.” The green revolution was the result of a package of four measures- a) use of high yielding varieties of seeds (wheat and paddy), b) increased use of fertilizers, c) improved water supplies, and d) better agricultural practices. Now a days we need biotechnology as a tool to feed the World (Swaminathan, 1985; Borlaug, 2001). Due to green revolution, agricultural production has considerably increased and food problem of over exploited population in India was solved up to certain extent. As the new variety of seeds was responsible for high yield, green revolution was also known as high yield variety programme (Lakshmi Devi, 1971; Jain, 1997). To get maximum yield, use of fertilizers at proper time and doses was found to be necessary. Irrigation was found to be another necessary pre-condition for the success of green revolution. Further, the pests easily affect the new varieties and so there must be proper use of pesticides. Pest is an organism that causes damage resulting in economic loss to a plant of animal. The expression of “pest” is used very broadly to insect, other invertebrate like nematodes, mites, snails and slugs etc. that causes damages to crop. Our farmers deserve praise in making this programme a grand success.

After the success of GREEN REVOLUTION a need has been felt for post green-revolution that requires more production from less size of holding and the cost
of cultivation and other inputs including fertilizers and pesticides needs to be used at a very low level. This need has come up in the back drop of reduction in the culturable land, increase in the population and environmental pollution caused due to overuse of fertilizers and pesticides.

Since 1970, agricultural development has been changed from traditional farming methods to more modern and intensive practices using irrigation facilities. Continuous use of chemical fertilizers and adoption of faulty irrigation methods, slowly changed soil status to salinity creation, ultimately the production in long run has reduced. It has resulted in leaching of chemicals into the surface and groundwater. Due to increasing demand for cash crops the practice of monoculture cropping pattern (e.g. wheat, paddy, sugarcane etc.), have further deteriorated soil and water qualities.

Continuous application of chemical fertilizers leads to loss of soil potential by inhibiting the soil microflora, Increase in the cost of chemical fertilizers and their harmful effects on environment have drawn world attention to apply biofertilisers in the fields. Soil health enhancement could be achieved by applying biofertilisers. The eco-friendly fertilizers can make a significant contribution towards the sustainable development (Venkataraman, 1961; Swaminathan, 1985, 2007).

Despite the success of the green revolution owing to the characteristics of Indian Agriculture the farmers of the country are facing a number of problems; the ultimate result of the problems is pitiable life style of the common farmers that sometimes leads to their suicide as seen in Maharashtra, Andhra Pradesh and Karnataka. India has about 108 million hectares of rain fed area, which constitute nearly 75% of the total 143 million hectors of arable land. In such area crop production becomes relatively difficult at it mainly depends upon intensity and frequency of rainfall. The crop production, Therefore in such area is called reified farming as there is no facility to give any irrigation, the annual rainfall between 400 mm to 1000 mm which is unevenly distributed, highly uncertain and erratic. As water is the most important factor of crop production, inadequacy and uncertainly of rainfall often cause partial or complete failure of the crop, which leads to period of scarcities.

Due to smaller size of the holding the farmers cannot adopt newer technologies and in many parts of the country losses due to insects, pests, diseases and weeds amounts to more than 30% of the total produce. Also due to lesser availability of the storage for produce the post harvest losses also reaches sometimes to 10%.
The major controllable enemies of the farmers are soil nutrients, water for irrigation and insect-pest, diseases, weeds etc. These enemies can be easily removed by using appropriate recommendations suggested for particular crops and farmers can reap more than the present production. It is a well known fact that insects being sexually reproducing organism with very short life cycle are widely distributed throughout the world and becomes more problematic in tropical climate. Due to high genetic variability and ability to adapt to different climatic and environmental conditions it is impossible to eradicate them.

The losses caused by different pest. Insect diseases etc. is given below:-

**Table 1.1 Losses caused by insect, pests and diseases in India during 2006-2007**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Type of Enemies</th>
<th>Loss caused in production (%)</th>
<th>Loss in Corers (Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Insect</td>
<td>20</td>
<td>1200</td>
</tr>
<tr>
<td>2</td>
<td>Pest</td>
<td>7</td>
<td>420</td>
</tr>
<tr>
<td>3</td>
<td>Diseases</td>
<td>26</td>
<td>1560</td>
</tr>
<tr>
<td>4</td>
<td>Weeds</td>
<td>33</td>
<td>1980</td>
</tr>
<tr>
<td>5</td>
<td>Rodents</td>
<td>6</td>
<td>360</td>
</tr>
<tr>
<td>6</td>
<td>Miscellaneous</td>
<td>8</td>
<td>480</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>100</strong></td>
<td><strong>6000</strong></td>
</tr>
</tbody>
</table>

(Source: www.ikisan.com)

The Tab. 1.1 indicates that during the year 2006-07 the losses due to various biological enemies of the farmers was to tune of Rupees Six Thousand Crore and hence requires immediate attention.

Insecticides valued at US $ 660 million are used annually on all crops in India, of which more than half are used on cotton. Cost of the 21,500 metric tons (active ingredient) of insecticides used on cotton in India 2001 was US $ 340 million (Manjunath, 2004).

Biotechnology has some answers to the problems that have come up after the success of green revolution. “Biotechnology is the integrated use of biochemistry, microbiology and engineering of the capabilities of micro-organism or cultured tissue, cell or a part there off” (Gupta, 2003). Biotechnology as word indicates is the product of interaction between the science of Biology and technology, this relationship between science and technology has been observed to be complex, so that not only
science has influenced technology, but the technology has also influenced science. Because of this complex relationship and its major impact on the human welfare is observed. Using the biotechnology means various simple and complex technologies and developed for improvement in human life like diagnosis of diseases, pharmaceutical drugs, gene technology, industrial microbiology, protein engineering, transgenic animal and plants, in agriculture sector etc.

In agriculture sector genetic engineering, micro propagation, production of haploids, somatic embryogenesis, production of secondary metabolites etc. have been utilized on commercial scale to improve the quality and quantity of product. Also the technology is widely used to reduce the cost of cultivation and reduce the use of insecticides and pesticides by way of offering genetically modified crops like Bt Cotton. Many of the technologies are used on wide scale while others are at experimental level. There are number of factors including its cost that prevent large scale use of such technologies and hence are out of the reaches of the common farmers of the country.

Of the various factors affecting productivity and production from the soil, soil microflora, nutrients present in the soil and water for irrigation play very important role. Also crop management and crop protection are important factors determining the total production and the economy of agriculture.

Low agricultural production efficiency is closely related to a poor co-ordination of energy conversion which in turn is influenced by crop physiological factors, the environment and other biological factors including soil microorganisms. The soil and rhizosphere micro flora can accelerate the growth of plants and enhance their resistances to disease and harmful insect by producing bioactive substances. These microorganisms maintain the growth environment of plants and may have secondary effect on crop quality. A wide range of results are possible depending on their predominance and activities at any one time. Nevertheless there is a growing consensus that it is possible to attain maximum economic crop yields of high quality at higher net returns, without the application of chemical fertilizers and pesticides until recently, this was not through to be a very likely possibility using conventional agricultural methods. However, it is important to recognize that the best soil and crop management practice to achieve a more sustainable agriculture will also enhance the growth, numbers and activities of beneficial soil microorganisms that in turn can
improve the growth yield and quality of crops (National Academy of science, 1989; Parr et. al., 1992).

The quality of soil enables it to provide essential chemical elements in quantities and proportions for the growth of specified plant (Brady and Weil, 1999). The fertility of the soil can be maintained by biological and chemical methods. Plant nutrient are chemical elements that are mostly absorbed by plant roots as inorganic chemical dissolved in water. There are at least 16 essential chemical elements required for plant growth, carbon, hydrogen and oxygen obtained in large amounts from air and water make up the bulk of plant dry matter in products of photosynthesis, but usually are not included as ‘Nutrient’ elements. The plant nutrients elements fall into two categories, macronutrients and micronutrients. Macronutrients are Nitrogen (N), Potassium (K), Phosphorus (P), Calcium (Ca), Magnesium (Mg), Sulfur (S) etc. required in large amount and micronutrients those are required small or trace amounts like Iron (Fe), Zinc (Zn), Manganese (Mn), Copper (Cu) Boron (B), Molybdenum (Mo) and Chlorine (Cl) are obtained from the soil (Bierman and Rosen, 1999). These major and minor nutrients can be supplied in the form of manures and fertilizers to obtain optimum yield.

Plants roots require certain condition to obtain these nutrients from the soil. First, the soil must be sufficiently moist to allow the roots to take up and transport the nutrients. Sometimes correcting improper watering strategies will eliminate nutrient deficiency symptoms; second the pH of the soil must be within a certain range for nutrients to be release-able from the soil particles. Third the temperature of the soil must fall within a certain range for nutrient uptake to occur. The optimum range of temperature, pH and moisture is different for different plant species. Thus, nutrients may be physically present in the soil but not available to plant (Hosier and Bradley, 1999).

To tackle the problems that are not within the control of human being like disease and insect resistance, resistivity of the crop to water and other types of stress; genetic engineering has potential.

**Use of Genetic Engineering in Agriculture:**

Genetic engineering, also called genetic modification is the manipulation of an organism genome by human intervention using modern DNA technology. It involves
the introduction of foreign DNA or synthetic genes into the organism of interest, the introduction of new DNA does not require the use of classical genetic methods.

The organism generated through the introduction of recombinant DNA is considered to be a genetically modified organism. The first genetically engineered organisms were bacteria in 1973 and then mice in 1974, insulin producing bacteria were commercialized in 1982 and genetically modified food has been sold since 1994 and insect resistance and herbicide tolerant crop have been commercialized.

The first field trials of genetically engineered plants occurred in France and the USA in 1986, tobacco plants were engineered to be resistant to herbicides. The People’s Republic of China was the first country to commercialize transgenic plants introducing a virus-resistant tobacco in 1992. In 1994 Cal gene attained approval to commercially release the Flavr Saver Tomato, a tomato engineered to have a longer shelf life. In 1994, the European Union approved tobacco engineered to be resistant to the herbicide Bromoxynil, making it the first genetically engineered crop commercialized in Europe. In 1995 Bt potato was approved safe by the Environmental protection agency, making it the first pesticide producing crop to be approved in the USA. In 2009, 11 transgenic crops were grown commercially in 25 countries, the largest of which by area grown were the USA, Brazil, Argentina, India, Canada, China, Paraguay and South Africa (James Clive, 1996-97, Burdening et. al., 2000, Mackenzie, 1994, Lawrence Journal world, 1995).

**History of Genetically Modified Crops:**

For several thousand years, farmers have been altering the genetic makeup of the crops they grow. Human selection for features such as faster growth, larger seeds or sweeter fruits has dramatically changed domesticated plant species compared to their wild relatives. Remarkably, many of our modern crops were developed by people who lacked an understanding of the scientific basis of plant breeding this is known as plant breeding. After understanding the principles of genetic transfer, technique of hybridization was standardized and using this technique a large number of hybrid high yielding varieties having number of beneficial characteristics were developed. This technique revolutionized the crop production in the world.

The next stepping stone came when James Watson and Francis crick cracked the genetic code at Cambridge in 1953, identifying the double helix structure of DNA
that was common for all the living organisms. Since then the engineering of genes has been practiced in wide variety of organisms including microbes, plants and animals.

Using the traditional methods of hybridization it is not possible to cross a fish with a vegetable as animals and plants have long been separated in evolution and therefore, are incompatible. But laboratory researchers have produced a “frost-resistant” tomato by introducing into its genetic code a gene obtained from fish that protects a flounder from the cold. Transgenic technology provides the means to make even more distant “crosses” than were previously possible. Thus organisms that have until now been completely outside the realm of possibility as gene donors, can now be used to donate desirable traits to crop plants. These organisms do not provide their complete set of genes, but rather donate only one or a few genes to the recipient plant. For example a single insect resistance gene from the bacterium *Bacillus thuringiensis* can be transferred to a corn plant to make Bt corn.

Transgenic plants were first created in the early 1980s. By four groups working independently at Washington University in St. Louis, Missouri and the University of Wisconsin. On the same day in January 1983 the first groups announced at a conference in Miami, Florida, that they had inserted bacterial genes into plants, the fourth group announced at a conference in Los Angeles, California in April 1983 that they had inserted a plant gene from one species into another species.

The Washington university group, headed by Mary-Dell Chilton, had produced cell of *Nicotiana plumbaginifoli* a close relative of ordinary tobacco that were resistant to the antibiotic kanamycin (Framond et. al., 1983). Schell et. al., (1983) working in Belgium had produced tobacco plants that were resistant to kanamycin and methotrexate a drug used to treat cancer and rheumatoid arthritis. Farley et. al., 1983 a, at Monsanto had produced petunia plants that were resistant to kanamycin. The Wisconsin group headed by John Kemp and Timothy Hall, had inserted a bean gene into a sunflower plant.

In the Nineties, biotechnology moved out of the laboratory into farms and shops and became a boom industry. In 1990 the first GM food, a yeast, was approved in the UK in 1992 the first food to be made from a GM ingredient a vegetarian cheese went on sale in the UK and three years ago supermarkets started selling GM tomato puree ([www.gmcrops.ewebsite.com](http://www.gmcrops.ewebsite.com)).
Cotton Growing in India:

In India cotton is being cultivated since ancient times and it was the home of best quality lint in the world. At present it is the major cash crop grown in more than nine states covering an area of 8.68 million hectare (Barik, 2010). There are four cotton species grown in India, of which two are diploid (Gossypium arboretum and Gossypium herbaceum) and the other two tetraploid (G. hirsutum and G. barbadense). In addition, hybrids generated from crossing tetraploid species G. hirsutum (hirsutum x hirsutum) are also cultivated in the central and southern cotton-growing zones. The diploid species referred to as the ‘Desi’ variety accounted for 25–30% of the production. This variety has low productivity and is not responsive to good agronomic practices in terms of yield. In addition, its fiber is rough and short. However, the negligible cost of desi cotton seeds accounts for its popularity amongst the poorer farmer. The tetraploids account for the remaining more than 70% of the cotton production in India (varieties developed by selection 50% and hybrids 50%). These varieties provide fine quality fiber, which is used by the textile industry. Although hybrid seeds are costly, their yield can be as high as 800 kg/ha, depending on the agronomic conditions. However, this too is lower than the 1200 kg/ha yield obtained in the US4 (Barwale et. al., 2004). There is reduction in the area under desi cotton throughout the country including Maharashtra at a very fast rate due to introduction of Hybrid and High yielding varieties.

Cotton Yield and Production:

Available data on the area, production and productivity of cotton in India reveals that there was increase in the area under cotton cultivation from 5.58 million hectar (MH) during 1950-51 to 9.13 MH in 2001-02 sowing 61% increase. During the same period the increase in the production was to the tune of three times more whereas the productivity has gone up from 88 kg lint/h to 186 kg lint/h with a maximum of 265 kg lint/h during 1996-97 cropping season.

The increase in the productivity is attributed mainly to the increase in the area under irrigation from 8.2% during 1950-51 to 33.1% in 2001-02, introduction of new Hybrid-4 variety in 1971 and use of fertilizers and pesticides. Despite the fact that there was increase, this figure is well below the 943 kg/ha for China and even the current world average of 584 kg/ha. Moreover, better agronomic practices and the introduction of high-yielding hybrid varieties based on cotton-breeding techniques
resulted in China being able to increase its yield from 225 kg/ha in 1962 to 420 kg/ha in 1965, and 810 kg/ha in 1990. In China, the cotton-breeding technique was successful because of two reasons; an improved cotton variety seed are well distributed and such seeds were grown on soil rich in humus.

As has been stated above India has more area under cotton than any other country in the world, but cotton lint yield has been among the lowest. India’s 22 million acres represents about one quarter of the world’s total cotton area and occupies 5 per cent of India’s cultivated area (for comparative data, (James, 2002b). Farmer suicides in India’s cotton belt, especially in 1998 in Warangal district of Andhra Pradesh, underlined the risk of growing cotton. Debts sometimes overwhelmed farmers caught in a cost price squeeze. Farmers most at risk are those with fewest resources. To the extent risk-reducing innovations are scale-neutral; there is considerable potential to improve the condition of small producers (Du Puis and Geisler, 1988).

Among the most serious risks to cotton farmers in India are unmanageable pests, particularly the ‘American’ (green) bollworm (*Helicoverpa armigera*). Pesticides are costly and not always effective; resistance has developed in major pests.

**Agrochemical Consumption by Cotton:**

Cotton yield in India is mainly affected by the problems due to insects and pests. Cotton is a crop to which 45% of the pesticides and 58% of insecticides used in India are applied (Report on Indian Agriculture, 1997). The major culprits are ‘bollworm complex’ and ‘jassids’. Sixty per cent of the insecticide spray is used to control the damage caused by a single group of insects referred to as Lepidopterans (Singh, 1999).

These include the *Heliothis* sp., *Helicoverpa armigera*, *Spodoptera* sp., *Pectinophora* sp. and *Earias* sp., which are collectively referred to as the ‘bollworm complex’. To a lesser extent white fly and aphids also affect the cotton crop. Although insecticides are effective in controlling jassids, the damage caused by bollworm (*Heliothis spodoptera* is the major insect in Andhra Pradesh) infestation can be controlled only in the early stages after which it causes extensive damage. However, a large variety of insecticides and pesticides products are being sold by many local and multinational companies to minimize and control the damage caused by insects and
pests in India. These product categories include organophosphorus, organochlorine, carbamates, pyrethroids, etc. Monocrotophos is widely used and accounts for 22% of the cotton insecticides market, as are endosulphan, chlorpyriphos, quinalphos, cypermethrin, fenvalerate and acephate. Other products introduced in the Indian market include triazophos, profenophos and lamdacyhalothrin. Recently multinational companies such as Syngenta (Novartis and Zenessa) have introduced insecticides like Curacron® (profenofos is an active ingredient) and Polytrin® (profenofos + cypermethrin is an active ingredient). Even though many insecticides and pesticides are available in the market, the problem of insects and pests continues. The major difficulties faced by farmers in effective utilization of this agrochemical are lack of quality spraying equipments, unawareness of integrated pest and insect management practices and cost associated with these agrochemicals, adulteration of insecticides and pesticides and over-spraying. Besides, build-up of pest resistance and resurgence of secondary pests have become serious problems, mainly due to indiscriminate use of pesticides by farmers, lured by marketing strategies of Indian and multinational companies (Singh, 1999).

Cotton Growing in Maharashtra:

Maharashtra is a major cotton-growing state accounting for the largest area under cotton cultivation (33.18% of the total area under cotton cultivation in India) in India, agro-ecologically falling into the central zone with the states of Gujarat and Madhya Pradesh. Area under cotton was about 3.1 million hectares in 2001 (Barik, 2010). The Asiatic types of cotton have been cultivated in Maharashtra for thousands of years, and Maharashtra, especially the Khandesh region has historically been an important centre of cotton production and trade.

Attempts to introduce the New World species G. hirsutum were made in the eighteenth century. The world’s first hybrid cotton Shankar-IV (or H-4) was released in 1971 by Gujarat’s Cotton Research Station in Surat. Thus, along with the Gujarat’s farmers the farmers from the adjoining Khandesh region of Maharashtra were among the first to experiment with hybrid cottons. Cottons are grown with intensive agro-chemical inputs; many farmers believe that heavy applications of pesticides and inorganic fertilizers threaten soil exhaustion.

Farmers are pressured to intensify production on what land they have through new management strategies and technologies. Seed choice is fundamental to crop risk;
unreliable seed supply and adulteration plague Indian cotton farmers. There is frequently a large gap between demand for certified seed and supply (Sindhu, 1999). Shortage of certified seeds necessitates seed trading with fellow farmers and unauthorized seed sellers and traders (Lalitha, 2003). Cotton farmers typically buy hybrid seeds from recognized companies for reliability and to avoid loss of ‘hybrid vigour’, despite the lower cost of saved seeds. Compared to traditional indigenous (desi) seeds, hybrid seeds also require more industrial approaches to farming—more chemical fertilizers and pesticides, with attendant risks. Despite the fact that the area under irrigation for cotton crop is smallest in the entire country at 4.2% of the total area under irrigation in the entire country more and more farmers in Maharashtra grow hybrid and high yielding varieties that require irrigation. Maharashtra is one of the most importance cotton growing states in the country. In Kharif 2007, it covered about 34% of total cotton area and contributed 17% of the total production in the country. The state produces approximately 25 lack bales per year.

In Maharashtra growing area is classified in four major zones viz. Vidarbha, Marathwada, Western Maharashtra and Khandesh or Nasik regions. All the four regions have their own peculiarity regarding area, production and productivity. During kharif 1995-96 Maharashtra produced 29.94 lakh bales of cotton from 30.85 lakh ha. with a productivity if 165 kg lint/ha. That was lower than the national average of 242 kg lint/ha. There was reduction in the area under cotton cultivation by one lakh ha during 2001-02 still the production had increased to 34.25 lakh bales and the productivity was 195 kg lint/ha.

During 2001-02 the total area under cotton cultivation was 3.1 million ha. of which major share was of Vidarbha region amounting for 51% of the total area of the state but contributed 47% in the state production and its productivity was 9% less than the state average. On the other hand in Khandesh region the area under cotton was 16% of the total area of the state whereas it contributed 21% in the production and its productivity was 1.31 times more than the state average (Barik, 2010).

The diffusion-adoption literature on agricultural technologies overflows with examples of ‘treadmill’ behaviors. That is, structural pressures lead to adoption of state-of-the-art technologies to avoid ceding ground (often literally) to even earlier adopters (Cochrane, 1965). Today, this competition for ‘adopter rents’ is not limited to the farmer next door. In a world of receding protective tariffs and continued subsidies for farmers from richer countries, Indian cotton farmers find themselves
competing with cotton farmers from around the globe. There is thus pressure from
within-the stressful agricultural environment of Maharashtra and from external
movements in prices and yields to experiment with new solutions elsewhere in the
country and abroad.

Problems of cotton growers in India and Maharashtra:
The main losses in cotton production are due to its susceptibility to about 162
species of insect pest or number of diseases. Among the insect, cotton in India
coasting annual losses at least US $ 300 million. The cotton bollworm complex
comprises American bollworm, and foliage feeder leaf worm etc, damage cotton
bolls.

In India, including Maharashtra, many farmers commit suicide daily. Majority
of such farmers are cotton growers. These are the small and marginal farmers
adopting rainfed agriculture.

Genetic Engineering for Rescue of Cotton Grower:
To answer the problems of cotton growers, especially regarding the attack of
bollworm a genetically modified variety was developed that is now commonly known
as Bt cotton. Bt cotton was among the first transgenic crops to be used in commercial
agriculture. A gene from the soil bacterium Bacillus thuringiensis has been transferred
to the cotton genome. This gene codes for production of a protein that is toxic to the
cotton bollworm, a severe impact pest in most cotton-growing regions of the world
(Bennett and Kambhapati, 2004). Bacillus thuringiensis is a spore forming bacterium
that produces crystal protein (cry-proteins) that are toxic to many species of insects.

Bacillus thuringiensis can be found almost everywhere in the world. It is
distributed in the soil sparsely but frequently worldwide. Bacillus thuringiensis has
been found in all types of terrain, including beaches, desert and tundra habitats.
Thousand of Bacillus thuringiensis strains, producing over 200 cry proteins that are
active against an extensive range of insects and some other invertebrates (Chaudhari,
2003). Using the technique of genetic engineering the cry protein producing gene/s is
transferred to cotton to produce transgenic plants called Bt cotton.

The Monsanto of USA possesses the world patent on the use of genetically
modified cotton crop. As per the claims of the company it is superior to many of the
locally available cotton varieties as regards to the quality and yield of the lint. It is
resistant to bollworm attack for the first 90 days. Also it requires lesser number of sprays of insecticides to control the attack of bollworm (Monsanto, 2000). At present Bt cotton is grown worldwide and is considered to be the major factor in increasing cotton production throughout the world including China and India.

Commercial cultivation of Bt cotton in India started 2002. Approximately in 30.22-lac acres Bt cotton was cultivated in India including Khandesh region of Maharashtra (Nandurbar, Dhule and Jalgaon District). In season Kharif 2004, Maharashtra had the largest area of Bt cotton planted in the country (from 54000 acres in Kharif 2003 to 5.25 lack acres by Kharif 2004 as per Monsanto India quoted in financial express).

About 97% of the cotton crop in Maharashtra is estimated to be grown under rain fed condition and grown mostly crop in Maharashtra is estimated to be grown under rain fed condition and grown mostly cotton soil. Hybrid covers about 73% of the cotton area of the state. The main cotton region of the state included Khandesh, Vidharbha and Marathwada and Deccan canal area.

According to MAHYCO the partner of Monsanto in India there was 40% higher yield of Bt hybrids (13.20 q/ha) over their non Bt counterpart (10.45 q/ha).The bollworm damage to the bulbs was significantly less as compared to non Bt cotton (10% at 61-90 days planting). The overall pesticide requirement for controlling bollworm was reduced drastically the Indian council for agriculture research (2005) conducted studies that were mainly concerned on cost benefit analysis of Bt-Cotton, revealed that the there was yield increase over non Bt cotton recorded to the magnitude of 90% and increase in the gross income was to the tune of 67%.

Quim and Zilberman (2003) reported that hybrid receive 3 times less sprays against bollworm than non-Bt hybrid. But the number of sprays against the sucking pets was same in both. The Ac Nielsen ORG-MARG (2003) survey found that there was increase in the profit of Bt cultivation by 78% as compare non Bt. Also on an average there was increase in the yield by 29% and decline in the use of Pesticide by 60% (www.ikisan.com2000).

Bt cotton had a bumper yield last year (2009-10), but this (2010-11) year there is shock to farmers. The Bt cotton has suffered a setback following an attack by pest and/or diseases. According to the agriculture department there will be reduction in the yield by approximately 2 to 30.5% less.
Bt Cotton:

Crop production is a result of complex interaction between a number of factors including good weather, timely sufficient rains, soil fertility, crop protection, better seed variety etc. Change in any one factor can result in reeducation in production. These factors are crop specific and vary not only according to crops but also varieties of crop. Despite these well known facts of late, there have been several media and industry reports in the past few years highlighting the remarkable increase in cotton productivity in India only due to Bacillus thuringiensis in the form of Bt cotton varieties (Financial Express, 2007). Bacillus thuringiensis is ubiquitous, soil bacterium first discovered in 1901 by Ishiwata, a Japanese microbiologist (Kumar 1996). Later it was found that some Bt strain (cry+) were highly toxic to larvae of certain insect species which are also plants pest. Bt was first sold as a spray formulation in 1938 in France for the management of European corn borer. Subsequently research has revealed that Bt carries proteinaceous crystals that causes mortality in those insect which carry receptor proteins in gut membranes that bind to Bt proteins.

Introduction of Bt Cotton in India and Maharashtra:

Bt cotton was introduced officially in India during 2002-2003. National Research center for crop Biotechnology reported about how cotton production was stagnant before Bt cotton’s advent and how production has double after introducing GM crop in India (The Hindu, 2008). Such reports were supported by comparison of cotton production of 270-280 lack bales during 2007-2008 compared to 136 lack bales during 2002-03 (Mehta et al., 2008). This increase in the production of cotton in the entire country was attributed to various genetically modified cotton varieties commonly known as Bt cotton. Presence of genes from Bacillus thuringiensis in these varieties was attributed the sole cause of increased production scientifically this is not true. The cry genes produce proteins that are harmful to the insects. Thus it provides protection to the plant and has nothing to do with the productivity. In any case as a result of increased popularity of the Bt cotton varieties there have been marked increase in the area under cotton in general and Bt cotton in particular in the cotton producing state like Gujarat, Punjab, Uttar Pradesh, Karnataka, Maharashtra, Tamil Nadu, Andhra Pradesh etc.
The latest estimate for the cotton production for the year 2008-09 by various agencies put the production at of cotton in India at 233 lack bales. Untimely rains and plant disease ate reported to be the reasons for the 10% reduction in production Maharashtra and Andhra Pradesh governments. For instance, has admitted decrease in the yields to the tune of 40% from projected production figures due to various reasons including untimely rains.

It is surprising to note that when increase in the production of cotton is considered the single factor responsible for it was Bt cotton varieties, however, when it comes to decrease in the production, the entire complexities involved in yield of a crop are brought in this indicate there is something is wrong. A look at the figures to the cotton area, production and yield in India is presented Tab. 1.2.

After introduction of Bt-Cotton in the country in 2002-03, the increase in area under cotton was to the tune of 18.60%, production increased by 62.01% and the yield per hectar increased by 31.83%. These figures and facts indicate that though there is increase in the average per hectar yield of cotton there is comparative decrease in the production of cotton. This argument will become clearer if we look at the figures from Gujarat major cotton producing developed state where Bt cotton was introduced first in the country. Its share in the total cotton production has gone up from 29% at the time of Bt cotton introduction to 39% by 2007-08.

The farmers of Maharashtra cannot afford to be conservative. Severe risk introduced by inadequacy of existing methods of pest control was manifest in September 2001, when a massive bollworm infestation struck Maharashtra and Gujarat, devastating hybrid cotton varieties. An exception in such a situation was seen for the farmers who adopted – Navbharat 151 (NB151), an unapproved Bt variety produced by a Ahmedabad based seed company. After conducting trials under the aegis of Indian Council for Agricultural Research, from 1st January 2002, the government of Maharashtra granted permission to MAHYCO-Monsanto Biotechnology to sell three Bt varieties, provisionally for a three-year period under the brand name Bollgard (MECH-12, MECH-162, and MECH-184).

In 2002–03, against a background of wide-spread crop failure produced by ‘bollworm rampage’ (Joshi, 2001) and now-legal transgenic cotton cultivars, farmers of Maharashtra farmers had new planting options before them: Bollgard varieties; illegal non-Bollgard Bt Navbharat 151; offspring of NB 151 the so-called ‘loose’
seeds of uncertain parentage; 6 and emergent branded (e.g. Vaman) Bt varieties locally but illegally produced (Jayaraman, 2004).

Also the period of 2002-03 saw a sharp decline in yield growths in traditional cotton at the same time Bt cotton crop spread to 61% of total area of cotton cultivation in India. The subsequent year, which witnessed a slower expansion of GM cotton, saw impressive increases in yield growth steep yield increases in cotton 2004-05 are in fact is attributed to excellent weather condition (Meyer et. al., 2007). More out the increase in cotton productivity observed in the different state of India is due to increase of irrigation harvesting programs on the other hand rainfall was also good during 2004-05 to 2006-07. Parameters like irrigation facilities, good monsoon, and use of drip, low pest pressure, black soil and farmers experience are contributing in the success of cotton crop in the country.

After introduction of Bt cotton in the country in the year 2002-03 sharp increase in the productivity was recorded. It was 302 kg lint/h during 2002-03 whereas during 2006-07 it was 501 kg lint/h indicating an increase of more than 60%, whereas during the same period the area under cotton cultivation has increased by only 26%.

Similarly in Maharashtra there was increase in the productivity and production after introduction of Bt. The productivity prior to introduction of Bt was 195 kg/ha in 1999-2000. In 2003-04 it reduced to 191 kg/ha but later on there was increase in the productivity in 2004-05 (311 kg/ha) which again decreased to 213 kg/ha in 2005-06 and later on steadily increased to 336 kg/ha.

The area, production and productivity of cotton in various regions of Maharashtra is given by Barik, 2010). From the data presented therein it is apparent that there is steady increase in the area under cotton cultivation except during 2004-05 that shows decline in area over earlier season of 2003-04. However, in the Khandesh region there is decline in the area with the exception of 2004-05 which showed exponential increase in the area which in the next season declined in the same fashion. Though Khandesh represents the lowest area under cotton cultivation in the state its productivity is highest. It was highest prior to introduction of Bt cotton in the state and the region and remained so. Also in the Khandesh region there is recorded steady increase in the productivity and after the introduction of Bt (2005-06) it increased very fast (56.4%) over the productivity recorded in 2001-02 (Barik, 2010).
Within these four regions Khandesh is a very peculiar region that has geographical borders adjoining Gujarat and therefore, it is assumed that this region is quicker in adopting newer technologies from the neighboring Gujarat. Also this region has highest population of tribal that still uses older techniques for cultivation. The area, production and productivity of cotton in four districts of the region are presented in the following Tab. 1.2.

Table 1.2 District wise area, Production and Productivity of Cotton
(Area in “00” ha, Production “00” bales of 170 Kg, each and Productivity in Kg/ha)

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td></td>
<td>Area</td>
<td>Production</td>
<td>Productivity</td>
<td>Area</td>
<td>Production</td>
</tr>
<tr>
<td>1</td>
<td>Nasik</td>
<td>72</td>
<td>47</td>
<td>111</td>
<td>141</td>
</tr>
<tr>
<td>2</td>
<td>Dhulia</td>
<td>665</td>
<td>903</td>
<td>213</td>
<td>733</td>
</tr>
<tr>
<td>3</td>
<td>Nandurbar</td>
<td>362</td>
<td>409</td>
<td>192</td>
<td>349</td>
</tr>
<tr>
<td>4</td>
<td>Jalgoan</td>
<td>3836</td>
<td>5148</td>
<td>228</td>
<td>3934</td>
</tr>
</tbody>
</table>

(Source: Barik, 2010)

If we compare the area, production and productivity of Cotton in various districts of Khandesh given in Tab. 1.2, it is clear from the table that Jalgaon district has highest area, production and productivity. In the cropping season of 2006-07 Nandurbar district had lowest area, production and productivity. This happened despite the fact that Bt cotton was cultivated in the district.

Controversies related to Genetically Modified Crops:

In addition to the problems recorded from the fields of Maharashtra there are number of controversies assigned to the Genetically Modified (GM) crops worldwide. The promoters of GM technology argue that introduction of GM crops will help in conservation of biodiversity through reduction in application of pesticides. They are also of opinion that extensive cultivation of GM crop will reduce pressure on the land other natural resources and it will reduce deforestation activity for agriculture purpose. Whereas the opponents are of the view that introduction of transgenic particularly herbicide tolerant ones will encourage increased application of herbicides in the agricultural field. This will have adverse effect on the environment as well as biodiversity. In addition squeeze in varietal diversity and gene pollution will also
adversely affect our rich biodiversity since biodiversity is the key to our food security. Any reduction in it will adversely affect our food security.

The promoters of GM technology also argue that introduction of GM varieties capable of producing more nutrients and vitamins like golden rice will help to mitigate mal-nutrition problem in the under nourished people. Technologies are now also available to produce GM varieties that can produce therapeutically proteins and drugs in the plant systems and it may help in solving our health related problem. Whereas the opponents are of the view that the introduction of foreign gene in the food crop system will lead to production of a foreign protein that may cause Allergy, Cancer, Stomach ailment and other ailments.

Moreover, they also claim higher return due to reduction in the cost of production which can make food grains affordable to poor people. Because of its high degree of uniformity it can facilitate mechanization in agriculture and better market.

But GM is cost intensive and our resource poor farmer cannot afford it. Besides the market accesses of GM foods it will have less appreciation in the market seeds of GM crop have been patented and so it will be monopoly of multinationals that will indirectly control the price of seed and their availability.

Promoters of GM technology claim that spread of GM crops will boost our agricultural production significantly through their high yielding ability and resistance against biotic and abiotic stresses. It will also ensure our food and nutritional security through development of nutritionally rich food grains like beta-carotene rich golden rich.

Whereas the opponents of the technology claim that there is no significant gain in the productivity of the GM crop in comparison to some of the best high yielding varieties/hybrids available in the country. They argue that cultivation of few GM varieties with narrow genetic base in large scale will make crops more vulnerable to diseases and pest due to genetic uniformity. Large scale cultivation of transgenic will also bring reduction in biodiversity though squeeze in varietal and crop diversity. There is risk of transfer of introduced foreign gene into other varieties and non target species and it may lead to gene pollution and contamination of our genetic resources. In cotton pollination takes place by either of the ways depending upon the availability of pollinator. In absence of pollinator it is self pollinated and in presence of pollinators it gets cross pollinated. During the domestication of cotton in India, four main types of cotton species were selected and grown throughout the country they are
Gossypium hirsutum, G. barbadense, G. arboreum and G. herbaseum. The farmer is also known as American variety from which hybrids have been developed and these hybrids were grown as commercial crop before the introduction of Bt cotton. G. arboreum and G. herbaseum are diploid species whereas the other two are tetraploid. The transgenic cotton varieties developed by Monsanto are basically Gossypium hirsutum varieties and hence are compatible with the native hybrids.

The Gossypium hirsutum L. is one of the four cultivated species for the production of the cotton fiber (Lee, 1984). This species contributes to 90% of the world cotton production. The Safety of GM Varieties for the environment has been one of the main concerns addressed in the case adoption of GM cotton in India. The gene flow from cultivated species to these relatives has receiving larger attention, due to possible adverse effect on the biodiversity.

Gene flow is the exchange of alleles among individuals, populations or species. The effect of the alleles migration among populations of a species depends on the migrating proportion of individuals and on the difference in the allele frequencies of the two populations. Gene flow can happen through seed dispersion or pollen movement. It can be classified as vertical when it involves individual or populations of the same species; or horizontal when it involves the species that are philogenetically distant.

Cotton flowers are large and complete, facilitating insect visitation. Pollen is dispersed through the anthers after the flower opens, remaining viable from approximately 12 to 24 hours. Cotton plant pollen is relatively large, 81 to 143 microns, viscous, spherical shaped, covered with a great amount of spicules and practically and practically not wind pollinated. Due to its size and formation of small clusters, wind pollinated pollen has not been reported for the genus Gossypium. Thus for cross pollination to occurs, pollinating insects are needed.

A factor that increases the capacity of attraction of cotton to the pollination is the presence of the five sets of nectarines, a floral and four extra floral ones. The floral nectar is formed by a ring of papilliform cells on the base of the inner face of the calyx. The reduction of cross pollination rate as one goes inside the receptors plot. The highest percentage of cross pollination originated seeds has always been verified in the plants near the pollen source, drastically reducing as distance increases, apparently in an exponential way.
Llewellyn and fit (1996) and Xanthopoulos et. al., (2000) observed that the amount of cross pollination varied, being higher in those in which pollination is presumably most intense. Thus, the direction towards which the source plot and the receptors plot lie must be taken into account. The only study aiming at the evaluation of the Gene flow from transgenic cotton plants in Brazil was carried out by Freire (2002a). All the analyses conducted in this study showed that a relative small numbers of conventional cotton rows, such as borders, were sufficient to contain the pollen from the interior of the transgenic plant plot.

The separation of the pollen source and pollen receptors plots by barriers of other cultures taller than cotton or by non cultivated areas, also reduce the amount of cross pollination. The greater the barrier between the source and the receptor plots is, the greater the reduction of cross pollination. Therefore, to prevent cross pollination it is advised to plant at least two rows of refuge cotton varieties (Borem et. al., 2003). However in practice the farmers do not plant such refuge cotton and thus increasing the chances of cross pollination and increase the risk of transfer of Cry genes from Bt cotton to other varieties.

Also cultivation of transgenic will encourage more application of fertilizers and chemicals and cultivation of herbicide tolerant GM varieties will boost herbicide application in the field. Increase in application of these agrochemicals will ultimately lead to environmental pollution. Apprehensions are also made that cultivation of diseases and pest resistant transgenic will lead to development of resistance in the pest and may hasten their co-evolution. Similarly transfer of herbicide tolerant/resistant gene from transgenic to associate weed species may lead to development of super-weeds causing serious problem in future for their control (Singh, 2010).

**Problem with Bt Cotton Cultivation:**

Apart from the findings of MEC report in 2006 there are other reports from government and non-government organizations regarding the truth in the claims the company and other problems associated with the introduction of GM crops. India is a key battle line in the global war over GM crop and both sides interpret the suicide as supporting their position. Monsanto attribute the suicide to crop destruction by pesticides resistance bollworm and now they offer GM “Bollgard-2” cotton. Vandana Shiva, one of the world’s top anti GM activist, attribute the cause for suicide of the cotton growers, to globalization, commercialization of agriculture and intensive
technologies. She contended that GM crop would worsen poverty or indebtedness by concentrating power promoting ecologically unstable monoculture or discouraging traditional seed sowing (Shiva V, 2010).

Cotton is the classic “Pesticide treadmill” crop. Farmers spend heavily on pesticide that are applied desperately and indiscriminately to combat a plethora of increasingly resistance pest. Monsanto emphasizes the predation from the “American bollworm” against which Bollgard is effective.

There are other issues like quality of the seeds. Today biotechnological crop fail because they get quality “spurious seed”, where inferior cotton seed are packaged as popular brands and marketed at lower rates. Farmer needs much higher regulation at the point of scale, but India’s regulatory mechanism focuses at the other end of the seeds system i.e. approval or certification. This year, unapproved Bt seeds was found growing in many region of India.

The farmers, who faced the greatest risk from the development of the insect resistance to Bt, are neighboring farmer who grow Corn, Soya bean, Jowar etc. Once resistance to appear in insect population, Corn, Jowar or Soya bean growing farmer will not be able to use Bt in its microbial insecticide form for control of pest moving in from adjacent neighboring transgenic field. Moreover, Bt crop also target natural species, this species is importance because they maintain agro ecosystem e.g. Lepidoptera.

Yet again controversy has been set off by the Ministry of Environment and Forests (MOEE) and scientific studies by some civil society group reported / proved that the Bt cotton crop had failed in south India. The Secundarabad based Center for Sustainable Agricultures (CSA) conducted a study (2002-05) in collaboration with grassroots researches, revealed the following controversy;

1) **Lower Yield**: While yield from Bt cotton for small farmers 650 kg per acre; it was 535 kg is under rain-fed condition in 2005. The same farmer got 150 kg more yield from non-BT hybrids under same condition is the Bt cotton. Thus the non-Bt yield is nearly 30% more than the Bt yield and it is also 10% less expensive.

2) **No reduction in pesticide uses the insecticide as**: The pesticide and insecticide use for control Bollworm as insect near about same ration in both.
3) **No higher profit**: The last 3 years average revealed that the Non-Bt farmer in 60% more an acre than Bt farmers.

4) **No education cost of cultivation**: Farmer not only had to spend 3 to 4 times more for the MAHYCO-Monsanto Bollgard seeds, but had to take extra care to manure, irrigate, and look after the Bt crop. Thus, many farmers especially in the rain-fed areas spent at least 2,000 more an acre compare to the non-Bt hybrid. On an average the Bt farmers more cultivation cost than non-Bt farmers.

5) **Environment impact**: A special kind of root rot was being spread by Bollgard, or Bt cotton farmers could not grow other crop after Bt because is affected to soil (Kumar, 2005).

**Problems with Bt Cotton in Maharashtra:**

Looking at the wide spreads complaints regarding Bt cotton, in 2002-03, the Maharashtra State Government had conducted another detailed study in various cotton growing areas and pointed out that on an average 3-5 spray were needed both for Bt cotton and non-Bt cotton to control bollworm. Later on the government of Maharashtra had constituted committee to look in the problem more seriously. On the basis literature, field visit, personal communication with farmers, monitoring some plot of cotton farmer in Vidarbha region, the committee had submitted its report in 2005-06. The major findings of the report are:

1. There are marginal differences in bollworm infection on Bt cotton (5-7%) over non-Bt cotton (7-10%).
2. The non-Bt cotton plants produce more squires and more fruit and more borne on non-Bt plants than Bt cotton plots.
3. The incidence of sucking pests like white fly, mites and jassids were lesser on non-Bt cotton than Bt cotton.
4. The cost for control of pests and insects was more in Bt cotton than in non Bt as given in following Tab. 1.3:
Table 1.3 Pesticide use in crop in Maharashtra

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Particulars</th>
<th>Bt cotton</th>
<th>Non-Bt cotton</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>For sucking pest and bollworm control</td>
<td>689.00</td>
<td>683.00</td>
</tr>
<tr>
<td>2</td>
<td>Chemical used for disease control and growth regulation</td>
<td>371.00</td>
<td>168.00</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>1061.00</strong></td>
<td><strong>851.00</strong></td>
</tr>
</tbody>
</table>

(Source: Maharashtra Kharif Report, 2005-2006)

All the facts mentioned above shows that the Bt is no way superior to the local non-Bt varieties selected for the study.

Finally the committee in its Maharashtra Kharif Report, 2005-2006 has shown that the cost of cultivation for non Bt cotton is substantially less than Bt; the yield of non-Bt cotton is marginally lower than Bt cotton, there is significant difference in the cost of cultivation between Bt cotton and non-Bt cotton. Non-Bt cotton has also marginally better price for the farmers than Bt cotton and family net income high non-Bt cotton as compared to Bt cotton (Tab. 1.4).

Table 1.4 Cost Cultivation of Bt and Non Bt cotton in Maharashtra

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Particulars</th>
<th>Bt Cotton/acre</th>
<th>Non Bt Cotton/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Average cost of cultivation in Rs.</td>
<td>6184.11</td>
<td>4132.16</td>
</tr>
<tr>
<td>2</td>
<td>Yield in quintal</td>
<td>6</td>
<td>5.60</td>
</tr>
<tr>
<td>3</td>
<td>Average rate per quintal in Rs.</td>
<td>1900</td>
<td>1970</td>
</tr>
<tr>
<td>4</td>
<td>Average gross income in Rs.</td>
<td>11400</td>
<td>11032</td>
</tr>
<tr>
<td>5</td>
<td><strong>Net income in Rs.</strong></td>
<td><strong>5216</strong></td>
<td><strong>6900</strong></td>
</tr>
</tbody>
</table>


Recently a study was conducted by Maharashtra Evaluation Committee (MEC-3), instituted by Government of Maharashtra in 2003, that presented its report in 2006. The committee made following observations regarding the total cost of cultivation, the yield and net incomes of the sample farmers growing Bt cotton and non-Bt cotton. The MEC report states that the yields of non-Bt cotton are marginally lower than Bt cotton. However, there is significant difference in the cost of cultivation. It was 23.5% lower in non-Bt Cotton than Bt cotton. Also non-Bt cotton
has fetched marginally better prices than the Bt cotton. As a result non-Bt cotton farmer have obtained 68% more net income than Bt Cotton farmers.

The Committee (MEC-3) also analyzed the economics for irrigated and non irrigated Bt cotton and non-Bt cotton farmers separately. The finding show that the Bt cotton responded better to irrigation than its non Bt counterpart. It is also interesting to note that for irrigated Bt crop pesticides worth Rs. 427/- per acre were to be added as compared to unirrigated Bt crop. On the other hand for non Bt cotton grown under irrigation more pesticides worth Rs. 220/- needed as compared to unirrigated non Bt counterparts.

In addition to observations recorded above the committee observed that out of 26 farmers who had grown Bt cotton in previous year only one farmers reported “High Bollworm control” while rest experienced only “partial control” (96%).

The study also shows that there was negative impact of Bt cotton cultivation on soil productivity. Almost all the farmers reported reduction in the crop yield after cultivating Bt cotton. Also recorded in the report of the committee are the facts that the Bt cotton growers applied 2 more doses of fertilizer (10:26:26 Sufala) in Bt cotton than non Bt cotton and the Farmers also applied micro nutrients like boron, zinc, sulphate, magnesium etc. for Bt whereas farmer growing non-Bt cotton never applied any micro-nutrients. Moreover, the farmers responded that since the cost of the seed cost was very high, they do not want to take a chance with the crop. This resulted in the potential reduction in the area under Bt cotton crop.

Due to all the factors mentioned above the input cost for Bt cotton had increased. Many farmers reported that Bt cotton requires High Inputs, but gives only Low output. They reported high incidence of ‘Lalya’ disease and pointed out that Bt cotton cannot with stand harsh climatic condition. It is interesting to note that the Bt cotton was stress intolerant both in the case of low rains and excessive rains (MEC Report 3-2006).

Thus the MEC-3 report presented negative aspects of Bt cotton that were recorded from the farmers of Maharashtra.

Recently another study was conducted in Vidharbha region of Maharashtra (Domato, 2009), to determine the effect to Bt cotton on the microbial population of various soil microorganisms. The result indicates a significant decline in total microbial biomass in the Bt soil. If current trends continue the researcher estimated
that 6.7 million hectares of land on which Bt transgenic crop is planted in India will be in danger of becoming sterile and unable to grow anything within the next 10 years.

Also in their survey conducted in Bt cotton growing areas of Vidharbha, Navdanya, 2009, found significant micro flora disturbances; specifically, a 17% decrease in Actinomycetes and 14% reduction in beneficial bacteria in the Bt cotton soil as compare to non Bt cotton soil (Control). Actinomycetes are necessary for breaking down cellulose and humus and mineralizing and immobilizing nutrients. Without this vital breakdown, the soil begins to die which increases the probability of diseases in the plant and decreases the overall vital nutrient of the soil. Moreover in the study soil enzymes (i.e. dehydogenase, nitrogenase and acid phosphatase) were found to be significantly reduced in the Bt cotton soil as compared to the non Bt cotton soil specifically the researcher found a significant reduction of 10.3% in dehydogenase, 22.6% decrease in nitrogenase and 26.6% decrease in acid phosphatase. Soil enzymes, which make nutrient available to plants, are an integral and necessary component of soil metabolism.

The present researcher during his preliminary study in Khandesh region of Maharashtra (Marathe, Gohil and Somani, 2010) observed that the non Bt-cotton crops, grown in fields adjacent to Bt cotton fields, had more incidences of sucking and boring pests that normally infect cotton. This reduces crop production and increases the cost of cultivation of crops in the adjoining fields. Moreover, there are incidences of diseases like Lalya, Milibug, Mavatudtuda, Telya, etc. in Bt cotton crop which otherwise were not reported earlier in the non Bt cotton.

Another problem that was faced by the farmers was the increase in the prices of Bt Cotton seed, Fertilizer, Pesticide etc. that resulted in the increase in the cost of cultivation and on the other hand there was reduction in the selling price of cotton in the market.
**Objectives of the Present Study:**

Khandesh region of Maharashtra is adjacent to the major cotton growing area of Gujarat. The farmers here are quick to adopt the technologies adopted by farmers of Gujarat including Bt cotton seeds. Bt cotton was introduced in Khandesh during 2001-02 in the form of Navbharat 151. During the initial phase there was increase in the area and productivity of cotton but later on there was decline in the area and productivity and also other problems that arose after the introduction of Bt cotton in the area. Looking at the problems and issues recorded for Bt cotton crop elsewhere in India and in Maharashtra it was planned to undertake a detailed study on the biological evaluation and socio-economic impact assessment of introduction and cultivation of Bt cotton in Khandesh region.

**Specific Objective of the Study:**

1) To assess the performance of Bt cotton as compared to the performance of non Bt cotton in the field of farmers with respect to yield and input. Also the cost benefit ratio of cultivation will be calculated.

2) To record specifically the incidences of various diseases and pest on Bt cotton and non Bt cotton.

3) To look at other issue with Bt cotton cultivation including any human health problems.

4) To assess the effects of Bt cotton cultivation on the physico-chemical properties of soil and on the yield of other crops grown after harvesting Bt cotton.

5) To assess the changes in the microbial flora of the soils on which Bt and non Bt cotton was cultivated.

6) To assess the incidences of insect pest on the crops grown in neighboring field of Bt cotton.

7) To assess the genetic erosion in the native cotton gene pool (parameters for identification for genetic adulteration will be developed).