Chapter – 2

Review of Literature

The present investigation deals mainly with the biological evaluation and impact of Bt cotton cultivation on socio-economic conditions of farmer. Also during the study aspects like genetic contamination (adulteration), impact on soil bacterial micro flora and on soil nutrients were researched. In order to get insight of these aspects in cotton cultivation in India and elsewhere in the world, extensive literature survey was made. Following are some of the relevant research work that the researcher could get hand upon from various libraries and through internet. The literature cited here is duly acknowledged and presented in the form of references at the end of the thesis.

Cotton Cultivation in India and Maharashtra:

Recently Ministry of Environment and Forest, Government of India (2011) had published Biology of Gossypium sp. (Cotton) where in history of cotton cultivation in India and the introduction of Bt cotton is reviewed. Barwale et. al., (2004) from Maharashtra Hybrid Seed Company studied the performance of Bt cotton during six years of experimentation during which time agronomic environmental and biosafety data was reported. Both the studies concluded that Bt cotton is safe for environment as well as reduce the load of insecticide.

Problems of Cotton Growers:

Voluminous literature is available that describes problems of cotton growers in India and especially in the cotton growing regions of Gujarat, Andhra Pradesh and Maharashtra. The major problem of Cotton growers is the control of bollworm that causes lot of destruction of the crop (Mayee et. al., 2002). After the introduction of Bt cotton other sets of problems are developed they are dealt with by Subramani (2012) who reported that sucking pests, mealy bug, para wilt, thrips, mired bugs, jassids and pink bollworm are main problem of cotton growers. Another major problem of Bt cotton growers are seed price, because Bt seeds are more expensive than conventional seeds Baragona Steve (2012).
Strauss (2005) from South Africa had reported that the Bt cotton was not proved to be sustainable in terms of reducing pesticide use or in terms of improving income for farmers. Also secondary pest are becoming major problem for small farmers.

Monitoring and Evaluation Committee (MEC) (2005) from Andhra Pradesh had reported that Bt cotton was severely affected by leaf curl TSV (Tobacco Streak Virus) and Jassids. Also growth of Bt crop was stunted with limited vegetative growth and plant did not grow above 3 feet height, Bt hybrids have very few sympodial branches and the number of bolls found to be in the range of 10-30. Recent studies from Gujarat and elsewhere have reported resistance developed by the bollworm to the Bollgaurd variety and the Monsanto-Mahyco had released another variety Bollguard-II (Monsanto 2011).

**Genetic Engineering for Agricultural Development:**

Framond *et. al.*, (1983) introduced the direct cloning of cassettes into T- DNA, which are subsequently transferred into the plant genome with the vir genes residing are on a separate helper plasmid. Schell and co-worker (1983) from Belgium had produced GM tobacco plants that were resistance to Kanamycin and Methotrexate a drug used to treat cancer and rheumatoid arthritis. Clive *et. al.*, (1996-97) describe the global review of the field testing and commercialization of transgenic crop, often referred to as release by regulators that have been tested word wide from 1986 to 1995; secondly review the status of approvals and pending application to grow transgenic crop on a commercial basis.

Debora Mackenzie (1994) from Brussels reported first transgenic tobacco plant with extra gene that makes it resistance to herbicide to be commercialized but Bruening and Lyons (2000) introduced the flavor saver tomato and it was the first genetically engineered crop product to be commercialized.

**Bt Cotton and its Benefits:**

Barik (2010) had given cotton statistics of India and reported fluctuation in the area, production and productivity of cotton. He has also mentioned increase in the cotton production in India due to introduction of Bt cotton. Chaudhari (2003) reported habitat of *Bacillus thuringiensis* and thousand of *Bacillus thuringiensis* strains produce approximately 200 cry proteins that are active against an extensive range of
insects and other some invertebrates also. Monsanto (2000) claimed, that the Monsanto GM variety superior than the many other local variety regarding to quality and yield of the lint with it is resistance to bollworm attack for the first 90 days and it require lesser number of sprays of insecticides to control the attack of bollworm.

Quim and Zilberman (2003) reported that Bt hybrid require 3 times less sprays against bollworm than non-Bt hybrid. But the number of sprays against the sucking pests 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%.

Financial Express (2007) reported that in Kharif 2004 Maharashtra had the largest area under Bt cotton cultivation in India with increase in cotton production in India due to Bacillus thuringiensis in the form of Bt cotton. The Hindu (2008) stated that the production of cotton double after introducing GM Cotton.

Controversies related to GM Crops in General and Bt Cotton in Particular:

Singh (2010) mentioned the controversies related to genetically modified crops. He reported increased use of pesticide for control of sucking pests in Bt cotton crop. Manjunath, (2004) reported that insecticide valued at US $ 660 million are used annually on all crops in India, of which more than half are used on Bt cotton. The slower expansion of GM cotton saw impressive increases in yield. Steep growth in increase in cotton yield during 2004-05 was attributed to excellent weather condition (Meyer et. al., 2007).

Socio-economic Impact of Bt Cotton:

Looking at the success of Bt cotton, the Finance Minister of India (2007) had urged to biotechnology industry to replicate the success of Bt cotton in other food crops to boost farm yield. Kumar et. al., (2009) mentioned in the status report of Bt cotton in India, any technological innovation takes time to stabilize and become widely acceptable. The pace at which Bt cotton has been accepted and adopted in India has been phenomenal. Along with the government policy, scientific support has been quit forthcoming. Need of good public awareness program, well regulated seed distribution system and conductive market for the produce was emphasized.

Khadi et. al., (2007) reported increase in the yield of cotton but reduction in overall quantity of insecticide substantially limited to some parts of country like Gujarat, while in rest of the states many insect pests such as mirid bugs, tobacco caterpillar, Spodoptera litura was found to increase to damaging cotton fields.

Heong (2010) summarizing various reported on the performance of Bt cotton in India concluded that Bt cotton could not fulfill the expectations and instead has led to adverse socio-economic impact for many small farmers. Similarly Loganthan et. al., (2009) in their study of cotton farmer from Tamil Nadu reported that high seed cost and incidence of pest and diseases are the major problem of the Bt cultivating farmers.

Terri Raney (2006) in his review article opined that farmers in developing countries can benefit from transgenic crop became high level of national institutional capacity is required to ensure that farmers have access to suitable innovations on competitive terms. Also a certain level of national research and regulatory capacity are prerequisites along with effective management and input supply systems, especially for seeds But for the poorest farmers in the poorest countries, where institutional condition are weak.

Dev and Rao (2007) describe the socio-economic impact of Bt cotton cultivation in selected districts of Andhra Pradesh. They compared performance of Bt cotton and non Bt cotton farmers using parameters like socio-economic, irrigation, area, production, cost of cultivation etc.

**Genetic Contamination (adulteration):**

Borem et. al., (2003) had at length discussed the Bt gene escape in cotton in Brazil, where in it was stated that there are chances of gene escape from Bt to non Bt cotton varieties. The chances are dependent on various factors that govern cross
pollination and also the compatibility of cotton varieties. The Brazilian Federal Science and Technology Department (2003) had also expressed concern about horizontal and vertical gene transfer from Bt cotton varieties (www.ctnbio.gov.br, 2003). They have recommended planting refuge lines surrounding Bt cotton crop to avoid gene escape. But in India a large number of studies including the ones carried out by Ministry of Environment and Forest, Government of India (2011) and Center for Environment Education (2010) and studies cited there in reports that there is no risk of vertical gene transfer from Bt cotton to other non Bt cotton varieties grown in India. However, there are chances of horizontal gene transfer to soil microbes including Bacillus thuringiensis (Mendelsohn et. al., 2003). On the other hand, there are hue and cries from the non Governmental Organizations and other Public Institutions regarding the possible threat of gene transfer from Bt cotton varieties grown in India resulting in the contamination of biodiversity (Nair, 2012; Shiva V., 2010).

**Soil Nutrients and Microflora:**

Parr and Hornick (1922 a) showed that to maintain soil productivity without crop rotations and addition of animal manures, farmers had to increase their inputs of chemical fertilizers and pesticides. Intensive tillage and the lack of appropriate conservation practices often resulted in excessive soil erosion and a decline in soil productivity and pollution of surface water and ground water by agrochemicals.

Manicam and Venkataraman (1972) reported that continuous application of chemical fertilizer over a long period may affect biological properties of soil. The concept of effective microorganisms (EM) was developed by Higa (1991); Higa and Wididana, (1991a), effective microorganisms consist of mixed cultures of beneficial and naturally occurring microorganisms that can be applied as inoculants to increase the microbial diversity of soils and plant.

National Academy of Science (1989) and Parr et. al., (1992) suggested that best soil and crop management practices rendered to achieve a more sustainable agriculture will also enhance the growth, numbers and activities of beneficial soil microorganism that can improve the growth, yield and quality of crops.

Singh (1999) explained the role of soil micro flora in soil condition and in stimulating plant growth. He reported that microorganisms are beneficial in increasing the soil fertility and plant growth.
Brady and Weil (1999) described the nature and properties of soil for the growth of specified plant. Bierman and Rosen (1999) focused on nutrient cycling at the center of soil nutrient management.

Hosier and Bradley (1999) reported that the plant root require certain conditions to uptake the nutrient from soil (Optimum pH, temperature and moisture). Microbes play an important role in maintenance of soil fertility, Bierman and Rosen (1999) reported that the fertility of the soil can be maintained by biological and chemical methods. They also mentioned that macronutrient and micronutrient was essential for plant growth and development.

Sun et. al., (2006) studied the nutrient content of the soil after 30 days of transgenic Bt rice planting and by the end of the growth season of transgenic Bt cotton and found that there was no significant difference in the content of soil nutrients but suggested that there was a little disturbance in the cycle and balance of soil nutrients after a short period of transgenic Bt crops planting.

Sarkar et. al., (2008) have investigated significant reduction in dehydrogenase activity, soil respiration and nitrogen mineral in the rhizosphere of Bt cotton soil from New Delhi.

Anne Sewell (2012) reported that Bt cotton hybrids pointing to drastic depletion of soil nutrients due to its repeated cultivation. Crop failures and lesser yields from the use of transgenic seeds are causing suicides among Indian farmers. Harpal Singh (2012) mentioned over use of chemical fertilizer in Bt cotton field responsible for loss of soil fertility.

Aladakatti et. al., (2012) investigated the effect of nutrient omission in Bt cotton and its effect on soil organic carbon (OC) and available nutrients. Awasthi (2008) of Indian Agriculture Research Institute (IARI), reported in their recent study that Bt cotton affects negatively on soil microbial population as well as nitrogen concentration of soil.

Wude Yang et. al., (2012) investigating the accumulation of Bt protein in the rhizosphere soil of variety Bt Xincail reported that it reached a peak at 56.14 ng.g\(^{-1}\) during the flowering period. However, they also reported that the Bt protein would not continuously accumulate in the soil. The rhizosphere soil of such Bt variety was more suitable for the growth and proliferation of bacteria and fungi and it had no significant impact on the number of actinomycetes. But had some inhibitory effects on alkaline phosphates activity in rhizosphere soil and it might promote
dehydrogenase activity during the blooming period. They also reported no significant impact on the contents of organic matter, total nitrogen and available phosphorus during the flowering period.

Mina and Chaudhary (2012) studied the impact of five Bt cotton varieties and their respective isogenics non Bt cotton on soil enzymes. Their result showed that dehydrogenase, alkaline phosphates and urease activity were higher in rhizosphere of Bt isolines as compare to Non Bt isolines of all varieties indicating more microbial activities. Also there was no adverse effects on dehydrogenase, alkaline phosphatase and urease activities in the rhizosphere of Bt soils.

Domato (2009) studied the effect of Bt cotton cultivation on the microbial population of various soil microorganism. The result indicates that significant decline in total microbial biomass in the Bt cotton field soil indicating less population of microbes in the soil. Navdanya (2009) in their study from Vidarbha region of Maharashtra showed decrease in 17% actinomycetes and 14% beneficial microbial population as well as decrease of 10.3% dehydrogenase and 22.6% acid phosphatase soil enzyme in Bt cotton soil.

**Green Revolution:**

Lakshmi Devi (1971) and Jain (1997) mentioned that due to green revolution agriculture production was increased and solved the food problem of India.

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.” In Indian agriculture sector the use high yielding hybrid variety of seeds with proper and adequate management of fertilizer and water. The second green revolution started with introduction of genetically modified crops.