CHAPTER-IX

SUMMARY, CONCLUSIONS AND SUGGESTIONS
Over the last-one and a half centuries, agricultural research has undergone various technological changes and have given room to innumerable innovations, which have commendably converted and tremendously transformed institutional structures of agriculture sector, its products and practices. The prime components of this agricultural research and development are mechanical, chemical and biological innovations. During the period of green revolution traditional technologies had been used together with naturally enriched resources in the agricultural production. No doubt the agricultural production has got increased many times due to technological break through in agriculture. In addition, many new problems related to chemical technologies and irrigation practices and management, have also cropped up barriers which bereft enhanced agricultural production. The emergence of biotechnology, which is prominently placed among the scientific and technological advances, has generated unprecedented exuberance and skepticism in the twenty first century.

Agricultural biotechnology is now emerging as a wellspring of innovations that will reshape agriculture as profoundly as any previous innovation paradigm. Agricultural bio-technology is a contribution of biology and technology which works on the genetics of the plant and transforms the potentiality of the plant into sustainable protective potentiality.

The application of biotechnology tools in agriculture is expected to open up a wide space for potential benefits. It has widened the expectations on breaking the barriers of yield, it is expected to benefit dry lands as well as ecologically futile area, predominantly perpetuating the life standards of the farmers.

Bt cotton, which has been bestowed with resistance to insects and pests, was first introduced in India as hybrids in 2002. In cotton, bollworms cause
significant yield losses. Three types of Bollworms, viz., American bollworms (Helicoverpa armigera), Pink bollworm (Pectinophora gossypiella) and spotted bollworm (Earias vitella) attack the cotton crop. We do not have source of resistance to the bollworms in the germplasm of cotton the world over. Moreover, about 10 per cent of insecticides on global basis and 45 per cent in India is used for control of insects in cotton crop alone.

Use of insecticides leads to environmental pollution (soil and water), increase in cost of cultivation and sometimes development of resistance in insects against insecticides. Hence, there is demand to develop bollworm resistant cotton to control yield losses due to bollworms. The Bt Cotton assumed to be the only ray of hope to control bollworms. The new technology has attracted more farmers towards cotton cultivation in many countries, and in some other countries, policy reforms have strengthened the willing of the farmers to plant cotton.

India with its 13 per cent share of world’s cotton production ranks third largest producer of cotton in the world. Although India has the world’s largest acreage of cotton, its productivity is among the lowest in the world. Since India is a country with diversified geographical and agro-climatic conditions the adoption of Bt cotton has not been drastic. And extension of area under transgenic cotton cultivation has increased year by year from 2002-03 to 2008-09, which has reached to the area of 17.2 million hectares, constituting 80.0 per cent of the total area under cotton cultivation.

As the need and demand for Bt cotton has been increasing, it has invoked novel interest and exciting emotion among a large section of eminent Indian personalities like biotechnologists, plant breeders, social scientists, environmentalists and farmers. Some genuine concerns have been reported from time to time in media and scientific journals. Agricultural research center like center for sustainable Agriculture, Research foundation for science Technology
and Ecology and NGOs like Gene campaign have been expressing different opinions about the performance and desirability of GM crops in general and Bt cotton in particular for Indian agriculture and social environment. In this background there is a need to address some of the concerns about the performance of Bt cotton under different agro-climatic conditions, keeping in view of the growing importance of cotton production in India. So it is proposed to study on the impact of Bt cotton technology on cotton cultivation and cultivators.

Andhra Pradesh is one of the major cotton growing state in India and it occupied third position among Indian cotton growing states both in terms of area as well as outturn. The state accounted for 10.63 per cent of area under cotton and 12.86 per cent of total production in the country. Thus cotton farmers in the state provide livelihood and wage employment to about one tenth of rural population. The living standards of rural people will be affected by the performance of cotton cultivation, which is mater for serious concerns.

Keeping in this view, the present study is proposed to examine the impact of Bt cotton cultivation on farm economy in Andhra Pradesh, with the following objectives.

1. To examine the socio-economic dimensions of Bt cotton cultivators.
2. To study the impact of technology on farm economy.
3. To study the impact of technology on cost and returns.
4. To estimate the impact of Bt cotton technology on productivity.

**Methodology:**

The study is based on a sample survey of selected farmer households in six villages in Warangal and Guntur districts of the State. It was decided to select a sample of 408 farm households. A detailed structured questionnaire was used to conduct face-to-face interviews with the farmer households.
The study used multi-stage stratified random sampling method to select the respondents from among the farmer households.

Review of literature:

Various studies reviewed, clearly reveals that they have investigated extensively on the impact of Bt cotton on farm income, resource use efficiency and income distribution at different farm levels. The use of pesticides and insecticides levels have also been studied. Besides, some of the studies have been done on the impact of Bt on cotton yield levels. Further, researchers have also studied on the cost of cotton cultivation after the adoption of Bt, comparing with that of non-Bt. The micro surveys of different studies show that the impact of Bt varies between regions and agro climatic conditions. A close scrutiny of all the studies reveal that there is still a dearth of comprehensive studies on the impact of Bt cotton.

Profile of the study area:

An assessment of the agro-physical features of the study area reveals that the Andhra Pradesh state is agrarian in character and agriculture is the prime occupation of the people, which provides employment around 65 per cent of the population. The literacy rate is found to be 60.47 per cent, and female literacy rate is lesser (50.43 per cent) than that of male (70.32 per cent).

Three major rivers, namely, Godavari, Krishna and Pennar drain 70 per cent of state’s land area. The rainfall of Andhra Pradesh is influenced by both the South-West and North-East as well as North-West monsoons, while the rainfall in these monsoons accounts for 73 per cent and 19.5 per cent respectively to the total actual rainfall in the state. About 37.33 per cent of area (102.39 lakh) in the total geographical area of the state is net sown area and 26.64 lakh hectares of area will be sown more than once. Nearly 22.63 per cent of the total geographical area is under forest which is near to the nation’s average.
In the state, food crops occupy 56.37 per cent of the total cropped area and among them Rice is an important crop and among non-food crops, Groundnut, Cotton, Chillies are the important crops and agriculture production is almost carried in private individual holdings. Cotton crop is cultivated in 7.5 per cent of gross cropped area in 2006-07. The major Cereal crops, such as Rice, Jower, Bajra, Maize and Ragi are cultivated during both the Kharif and Rabi seasons but commercial crops like Cotton, Tobacco and Sugarcane crops are cultivated during Kharif season only. About 47.37 per cent of the gross cropped area is being facilitated with irrigation. The net irrigated area is reported to be as 44.52 lakh hectares. Major sources of irrigation in the state are canal irrigation (22.98 lakh hectares) and irrigation through tube wells (20.20 lakh hectares).

Andhra Pradesh being an agrarian state sympathetically there has been observed a gradual and constant decline in the growth rate of share of agriculture to GDP. During 1960-61 the share of agriculture to GDP is 63.49 per cent, which is 26.66 per cent in 2005-06.

The per capita land available per person and per capita land available per cultivator has been decreasing resulting in socio-economic problems. The farm lands have been fragmented over the years making many of the farmers as marginal and small farmers who are economically poor to have agricultural implements of their own.

Trends in cotton cultivation:

India holds largest area under cotton with 29.5 per cent of the world cotton area. In terms of cotton production China ranks first among cotton producers in the world, followed by USA and India. Australia, ranks first in its productivity marking 1655 kgs of lint per hectare. India stands at 70th rank in its productivity with 263 kgs of lint per hectare, which is just half of the international average.
The area under cotton cultivation in India had increased from 56.48 lakh hectares in 1950 to 91.58 lakh hectares in 2006-07. The production and productivity of cotton also increased, from 30.62 lakh bales production to 280 lakh bales and 92 kgs per hectare to 520 kgs per hectare of productivity in the same period. In India major cotton producing states are Punjab, Haryana, Rajastan, Madhya Pradesh, Mahararashtra, Andhra Pradesh, Karnataka and Tamilnadu. Among major cotton producing states Maharashtra stands at first place, Gujrath followed in second place and Andhra Pradesh continues in the third place. There has been a consistent increase in productivity over the years.

The area under cotton in the sample districts of Guntur and Warangal accounting for more than 33 per cent to the total cotton area in the state of Andhra Pradesh. The sample areas Guntur and Warangal districts contribute more than 37 per cent to the total cotton production in the state of Andhra Pradesh. Regarding yield of lint cotton per hectare, Warangal district had 43 kgs of lint per hectare in 1950-51 and 397 kgs of lint per hectare in the year 2006-07. Where as in Guntur district it was 80 kgs of lint per hectare in 1950-51 and 601 kgs of lint per hectare in 2006-07. It could be found that the yield levels have increased after 2003-04.

In 2002-03 the area under Bt cotton is about 0.47 per cent to the total area under cotton cultivation in Andhra Pradesh. There has been a tremendous increase in the area Bt cotton by 2006-07, which, occupies 85 per cent of the total area under cotton cultivation. And the same trend is observed in sample districts of Andhra Pradesh. The analysis leads to the conclusion that the adoption of Bt cotton in India has not taken place suddenly with a rapid rate and has not been drastic. All together, it is concluded that there is positive shift in favor of Bt cotton crop in India as well as in Andhra Pradesh.
Socio-Economic dimensions of Bt cotton cultivators:

The analysis of the socio-economic dimensions of Bt cotton cultivators reveals that the receptiveness of new technology by the farm holdings is high. The socio-economic structure does not have any direct influence on the adoption of Bt cotton technology. From the analysis it is clearly evident that 43 per cent of the selected farm households belongs to higher socio-economic strata in the study. And 40 per cent of farm holdings belong to Backward caste communities. Nearly 17 per cent of the farm holdings belong to schedule caste and scheduled tribe communities.

From the analysis of land holding distribution it is evident that 64 per cent of the selected households are small and marginal farm households. The farm size of 25 per cent of the farm households ranges from 5 to 10 acres and 8 per cent of the households have farm size ranging from 10 to 25 acres and only 2 per cent of the farm households have owned more than 25 acres. The average size of the selected farm households is 5.42 acres. The average family size among the selected farm households is four. The data on literacy status reveals that 40 per cent of the respondents are illiterates. Illiteracy is high among Scheduled castes and Scheduled Tribe respondents. The data on family system clearly reveals that 73 per cent of the families are nuclear families.

The occupation structure of the farm households reveals that 93 per cent of the households practice cultivation as main occupation. Nearly 36 per cent of the respondents are working as agricultural laborers which is a subsidiary occupation. The data on cropping pattern reveals that 55 per cent of the land operated by farm holdings are allotted to Cotton crop, 20 per cent of land is allotted to Chillis and 19 per cent of land is allotted to Paddy.
The particulars of the agricultural implements owned by the sample respondents reveal that one tractor for every 110 acres, one power sprayer for every 11 acres, and one diesel engine for every 17 acres are owned by sample respondents. The data on an average annual income of the respondents from different sources reveals that 62 per cent of the income is from cultivation and the rest is from subsidiary occupation. The data on annual average expenditure of the respondents reveals that 42 per cent of the consumption expenditure is spent on food items, 23 per cent is on non-food items and 22 per cent is on education and only less than one per cent is spent on health.

With regard to the civic facilities 95 per cent of the respondents have electricity, 68 per cent of the respondents have the drinking water facility and 50 per cent have the drainage facility. Further, it is evident that 38 per cent of the farm households are living in pucca houses, 48 per cent are living in semi-pucca houses and 14 per cent are living in kucha houses. Nearly 81 per cent of the farm households are covered under Public Distribution System (PDS).

**Impact of technology on farm economy:**

The study reveals that the sample respondents are cultivating cotton over major portion of their lands. And also it is observed that marginal and small farmers cultivating Bt cotton in large proportion of the total operated area. About 60 per cent of the respondents are cultivating cotton under unirrigated conditions. It is observed that around 50 per cent of the sample farm households cultivating cotton in their own lands. It is observed that there is no any written agreement for tenancy. Further, the mode of tenancy payment is varied depending on the financial status and convenience of the farmers. A positive relationship is found between total labour use and farm size. The contribution of family labour is quite significant in all categories of farms. But it is in inversely related with farm size.
Farmers are using multiple channels to sell the cotton. The choice of the channel depends upon the immediate payment and the price that is offered to the farmers. The analysis, explains that among the respondents who have attacked by diseases, majority have suffered from skin diseases and allergies and most of them belong to small and marginal categories of farm households.

Further, it is observed that almost all the sample farm households have borrowed loans. Though they incur major portion of the borrowed amount on productive purpose, they also invested on unproductive purposes. Further, it is observed that as the farm size increases the dependency on non-institutional sources, is decreasing and dependency on institutional sources is increasing with slight fluctuation. Thus, the debt burden due to non-institutional sources is very high among marginal and small farmers.

Further, it is observed that the farm perceptions extracted from the respondents that the amount of credit afforded by the banks and cooperative societies, but this is not sufficient to fulfill the agricultural requirements and general needs, that leads to the respondents for borrow money from non-institutional sources on exorbitant rate of interest, consequently by which farmers are being exploited and some times they will be harassed unscrupulously by the money lenders.

It is clearly observed from the perception, of 36.8 per cent of the respondents that their economic status has remained the same, while, 12 per cent of the respondent households are got deteriorated their economic status. It is also observed, despite many problems, most of the respondents are not willing to turn up their traditional occupation i.e. agriculture. However, as contradictory to this phenomenon, farmers are not willing their children to continue the same occupation and wish their children get good education, obtain some better jobs and settle in urban areas. Only a negligible number of them willing their children to continue in the same occupation.
It is observed that about 4.7 per cent of the sample respondents have purchased agricultural land and the same proportion of them have invested the amount of profit on other income generating activities. It is further observed, that there are also certain number of respondents who have disposed of their lands.

Impact of technology on Cost and returns:

To study the impact of Bt technology on cotton cultivation; changes in the input use pattern, cost of cultivation, net returns and input-output ratios of the sample households are analyzed. For this, cost of cultivation of Bt cotton crop is compared with that of Non-Bt cotton crop.

Per acre expenditure on Bt cotton is found to be 5 per cent higher than compared to Non-Bt cotton cultivation. A similar difference in total expenditure among size groups of farms is found with some variations. The results of the estimated regression equations indicate that there is a significant positive relationship between farm size and total cost in Bt cotton cultivation while it is not significant in Non-Bt cotton cultivation. This clearly indicates that the intensive use of inputs is found to be more in Bt cotton cultivation when compared to Non-Bt cotton cultivation as farm size increases.

The analysis leads to the conclusion that the expenditure on fertilizer and pesticides is higher in Non-Bt cotton cultivation. And per acre expenditure on fertilizer is 10 per cent higher in Non-Bt cotton cultivation than in Non-Bt cotton cultivation. The per acre expenditure on pesticides is 53 per cent higher in Bt cotton cultivation than in Bt cotton cultivation. The same difference in expenditure on pesticides is found among all size groups. The expenditure on seeds, irrigation, land preparation, hired labour is found to be higher in Bt cotton cultivation. The expenditure on seeds per acre is found to be 40 per cent higher in Bt cotton cultivation than in Non-Bt cotton cultivation and a similar difference is found among all size group of farm holdings.
The results of estimated regression equations reveal that there is an insignificant negative relationship between farm size and the value of fertilizers in Bt cotton cultivation and an insignificant positive relation is found in Non-Bt cotton cultivation. There is a negative relationship between farm size and value of pesticides in Bt cotton cultivation and an insignificant positive relationship is found in Non-Bt cotton cultivation. A positive relationship between farm size and fertilizers is found in both Bt cotton and in Non- Bt cotton cultivation. A negative relationship between pesticides and farm size is found in Bt cotton cultivation. And an insignificant positive relationship between farm size and value of pesticides per acre is found in Non-Bt cotton farms. The use of hired human labour input is found to have positive relationship with farm size in both crop situations and this relationship is significant.

Per acre cost of production by different cost concepts is found to be higher in Bt cotton cultivation when compared to Non-Bt cotton cultivation except Cost A1. This is due to higher cost incurred on use of pesticides in Non-Bt cotton cultivation. Cost A2 and Cost B is found to be higher in Bt cotton than in Non- Bt cotton cultivation. This leads to the conclusion that higher rental value of leased in land and owned land in Bt cotton cultivation has altered the cost pattern.

The proportion of operational cost to total cost is high in Non-Bt cotton cultivation, when compared to Bt cotton cultivation. The proportion of overhead cost to total cost is found to be higher in Bt cotton cultivation when compared to Non-Bt cotton cultivation. The main reasons for this due to the fact that the expenditure on pesticide is significantly higher in Non-Bt cotton cultivation, higher amount of depreciation, interest on fixed capital investment and rental value of the landing in Bt cotton.
The data further reveals that the proportion of paid out cost is marginally higher in Non-Bt cotton cultivation than in Bt cotton cultivation. Conversely the imputed costs are higher in Bt cotton cultivation than in Non-Bt cotton cultivation. The intra size group comparison also reveals the same pattern. The adoption of Bt cotton technology in cotton cultivation has altered the total cost structure, between operational and overhead costs and also between paid out costs and imputed costs.

Per acre returns from cultivation in both categories of farms are analyzed by calculating the following concepts of returns viz., gross returns, farm business income, family labour income, farm investment income and net returns. The data reveals that large and medium farmers have got higher returns than that of small and marginal farmers by efficient management of farms. This clearly leads to the conclusion that the impact of technology is not size neutral.

The gross returns from Bt cotton cultivation is found to be higher than that of Non-Bt cotton cultivation. The intra size group comparison also reveals that gross returns per acre from Bt cotton cultivation is high in all size groups.

The results of the estimated regression equations reveals that a significant positive relationship between farm size and gross returns is found in both Bt and Non-Bt cotton crop situations. A significant positive relationship is found between value of gross returns per acre and value of fertilizer used per acre in both the crop situations. The results further reveals that there is a significant and negative relationship between value of expenditure on pesticides and per acre gross returns in Non-Bt cotton cultivation and there is a positive relationship in Bt cotton cultivation. The elasticity of output with respect to human labour is higher in Bt cotton cultivation than that of in Non-Bt cotton cultivation.

Farm business income is 136 per cent higher in Bt cultivation than that of in Non-Bt cotton cultivation. Intra size group comparison also reveals that per
acre farm business income is higher in Bt cotton cultivation when compared to Non-Bt cotton cultivation. This phenomenon may be attributed to higher productivity associated with use of Bt cotton seeds.

The family labour income is higher in all size groups of Bt cotton crop situations, but in Non-Bt cotton cultivation resulted a loss for their family labour contribution. An inverse relationship between family labour income and farm size is found in both the Bt and Non-Bt crop situations.

The data clearly reveals that Bt cotton cultivation has yielded significantly higher profits from farm enterprise than from Non-Bt cotton cultivation. The intra size group comparison also reveals that net income is consistently higher in Bt cotton cultivation in all size groups, than that of in Non-Bt cotton cultivation. There is an inverse relationship between loss per acre and farm size in Non-Bt cotton cultivation and a positive relationship is found in Bt cotton cultivation.

It is found that the net returns from the farm investment in Bt cotton cultivation is higher than that of Non-Bt cotton cultivation. This implies that Bt cotton technology has enhanced the returns to investment. And per acre farm returns to investment is increasing with the farm size on both crop situations.

The output-input ratio clearly reveals that the return per a rupee is 22 per cent higher in Bt cotton cultivation when compared with Non-Bt cotton cultivation.

**Impact of technology on Productivity:**

The results of the estimated production functions reveal that seeds and fertilizer is the most important input to which output is highly responsive in both Bt and Non-Bt cotton crop situations. On the other hand, it is observed that elasticity co-efficient of output with respective to pesticides is higher in Non- Bt
cotton cultivation as compared to Bt cotton cultivation. The output elasticity of pesticide is higher in Non-Bt cotton cultivation than that of in Bt cotton cultivation. An increase in expenditure on pesticides resulted in increased output in Non-Bt cotton cultivation when compared to Bt cotton cultivation.

The elasticity coefficient with respect to human labour is positive and significant in both Bt cotton and Non-Bt cotton crop situations. The output elasticity of human labour is higher in Bt cotton cultivation when compared to Non-Bt cotton crop situation.

In order to evaluate the net impact of Bt technology and other inputs on cotton productivity, the results of the decomposition revealed that Bt technology alone is estimated to have increased the output by 10.88 per cent. That is with some level of use of seeds, fertilizers, pesticides and human labour, the farmers have obtained 10.88 per cent more output per acre by using Bt cotton seeds when compared to those who have used Non-Bt cotton seeds.

The differences in the use of seed, fertilizer, pesticide and human labour have increased the output per acre by 8.15, 0.61, 1.68 and 5.21 per cent respectively. Changes in the use of all these inputs put together have been increased by about 15.65 per cent.

The optimum utilization of resources is higher in Bt cotton than that of in Non-Bt cotton. The value (in Rupees) of inputs saved per acre with the adoption of Bt technology is Rs.2,021/- per acre when compared with Non Bt cotton. The adoption of Bt technology enabled the farmers to save inputs significantly. The value of extra output produced per acre with adoption of Bt technology is Rs.4,455/- per acre which is higher when compared to Non-Bt cotton cultivation.
CONCLUSIONS:

• The study area gifted with diversified geographical, climatical, physical and infrastructural facilities.

• Area production and productivity of cotton crop is found to be increasing over the years with some fluctuations.

• The area under Bt cotton to the total cotton area in the study area is consistently increasing.

• There is no direct relationship between adoption of technology and socio-economic status of farmers.

• Economic status of the cotton farmers is found to be stagnant.

• Bt technology reduced expenditure on pesticides in cotton cultivation

• Bt technology altered the pest tolerance capacity of cotton crop.

• The expenditure on seeds, irrigation, land preparation hired labour is higher in Bt cotton cultivation.

• The intensive use of inputs is found to be more in Bt cotton cultivation.

• Gross returns from Bt cotton cultivation is found to be higher than that of in Non-Bt cotton cultivation.

• A direct relationship between farm size and gross returns is found in both Bt cotton and Non-Bt cotton crop situations.

• The family labour income is high in Bt cotton cultivation in all size groups, where as in Non-Bt cotton cultivation resulted in a loss for their family labour contribution.

• The net income from farm management is high in Bt cotton cultivation where as in Non-Bt cotton cultivation farmers faced losses.
• The farm investment income and farm business income is high in Bt cotton cultivation in all size groups. And both are increasing with the farm size in both crop situations.
• The returns per a rupee of investment is high in Bt cotton cultivation. And returns per a rupee of investment is increasing with farm size in both crop situations.
• The elasticity of output with respect to inputs is higher in Bt cotton cultivation.
• Bt technology alone is found to have increased output by 10 percentage points.
• The output elasticity of human labour is higher in Bt cotton cultivation.
• Optimum utilization of resources is higher in Bt cotton than that of in Non-Bt cotton cultivation. The adoption of Bt technology enabled the farmers to save inputs significantly.
• The value of extra output produced per acre with the adoption of Bt technology is high when compared to Non-Bt cotton cultivation.
• Going by various parameters of the study it is clear that adoption of Biotechnology in cotton cultivation resulted in increased income and yield per acre. But going by perceptions of the cotton crop cultivators these changes has not translated into livelihood improvement of the farmers, which needs a deeper analysis.
Suggestions:

- The major policy implications from this study are that availability of Bt seeds should be made available to the farmers at affordable rates to increase the use by small farmers and to increase their profitability. Government should be subsidized the cost of Bt technology to encourage the farmers to adopt Bt cotton seeds.

- There is a great need to train the cotton farmers about the recommended practices of Bt cotton cultivation. This minimizes the chance of development of resistance in bollworm pests against the Bt gene and also reduces the chances of genetic contamination. Since Bt cotton is a new crop in India, it is necessary for the seed companies and Government to educate the farmers on Bt cotton cultivation specially with reference to refuge management, insecticide spray and other practices. There is an urgent need to develop appropriate package of practices for each Bt cotton hybrid keeping in view agro climatic conditions (rainfed/irrigated) of the States/regions by the state agricultural universities with funding from Govt of India.

- The appropriate role of government and public sector research system in GM Technology will be highly helpful in solving the current controversial issues regarding Bt cotton which is expected to be utilized for the benefit of farmers. As a long term measure a role for the public sector in transgenic cotton seed production could be envisaged by activating research and development activities.