CHAPTER II

REVIEW OF LITERATURE
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This chapter focuses on reviews of literature on cotton cultivation at macro and micro levels.

A comprehensive review of literature is a significant part of any scientific investigation and hence this part is devoted to the review of literature and seeks to examine the results of available research studies pertaining to various aspects of cotton cultivation. An attempt has been made to review the research studies relating to (A) Cost of cultivation of cotton, (B) Growth of area and production of cotton, (C) Yield level performance of cotton and (D) Other relevant literature reviewed for cotton crop. A brief review of various research studies in respect of these aspects has been presented in the following paragraphs:

[A] Cost of Cultivation of Cotton

Adhvaryu J.H. and Parikh G.O. (1968) had prepared a research paper “The Economics of Farm Management in the I.A.D.P. Region of Surat and Bulsar (Gujarat State)”. They had covered 15 villages and 150 cultivators. The samples were selected with the help of a multi stage stratified random sampling method. The data were collected of the three agricultural years i.e., 1966-67 to 1968-69. The field work was carried out according to the cost accounting method. They had also attempted to find out the per hectare and per quintal cost of cultivation for different crops. They had found that the per hectare total cost of cultivating cotton was Rs. 670 on the average, while on an average per quintal total cost of cotton was Rs. 325. It was worth Rs. 472 in the size group of farmers operating between 5.01 to 7.50 hectares, but it was Rs. 251 in the biggest holding group (above 10 hectares). They had also summarized that on an average Cost A1 was Rs. 366 for cultivating a hectare of cotton land and was Rs. 177 per quintal. They had concluded that the per hectare Cost A1 was higher on the smaller farms and was lower on the bigger farms, while the per quintal Cost A1 was lower on the smaller and higher on the bigger farms. In this study, land and labour as factors of cotton production accounted for over 50 per cent of the total cost.
Patel A.S. and Patel H.F. (1989) in their working paper “Recent Trends in the Cost of Cultivation in Gujarat” have examined the trends of the cost of cultivation for the principal crops on the basis of Cost of Cultivation Scheme; Gujarat’s data. The reference period for the study was two-year ending 1976-77 and 1984-85. They examined the cost of cultivation of important non-foodgrain crops of the State. They found that the improvement in productivity was poor and the per quintal cost of production of such crops were also found to be higher. Among the non-foodgrain crops, on an average, the economy of irrigated and unirrigated cotton, S4 and S6 in Gujarat were found better over the study period. In case of seven major crops (wheat, rice, bajara, jowar, maize, groundnut and cotton) of Gujarat, the cost and income estimates of the different varieties, including their irrigated and unirrigated counterparts, of the respective crops were clubbed together. In their study, the net income-expenditure ratio revealed that except wheat, the real income of all other crops substantially declined over the period under study.

Pray Carl, Dameng Ma and et. al. (2001) have reported in their article “Impact of Bt Cotton in China” that the cost of production and pesticides was reduced after the adoption of Bt cotton. They have further observed that out of the 31 insect species found in Bt fields, 23 were found to be beneficial. Exchange of Bt seeds with fellow farmers were continued with meant that monetary benefits accrued to the farmers were higher than that of the seed companies, which was attributed to the weak intellectual property rights regime in China. However, it is not very clear whether refuge varieties were planted or not along with Bt crops in China.

Kashyap L.R. (2001) has revealed in his study “Economics of Production and Marketing of Cotton in Khargone District of Madhya Pradesh” that on an average, the per hectare cost of cultivation of hybrid cotton came to Rs. 14517.00 on Cost A1, Rs. 15248.07 on Cost B1, Rs. 16876.61 on Cost B2, Rs. 17819.05 on Cost C1, Rs. 19447.59 on Cost C2 and Rs. 21392.00 on Cost C3 basis. He has also worked out the average per quintal cost of production of hybrid cotton was Rs. 670.08 on Cost A1, Rs. 704.59 on Cost B1, Rs.779.84 on Cost B2, Rs. 823.13 on Cost C1, Rs. 898.64 on Cost C2 and Rs. 988.50 on Cost C3. It was highest on the large size group of farms. The return from one rupee of investment was obtained higher for small size group of farms.
Prasad Rajendra V., Raju V.T. and et. al. (2001) have worked out the cost of cultivation of cotton and its competing crops viz., Soyabean, Bengal gram, Jowar, and Red gram in their research work “Study of Costs and Returns in Cotton Production vis-à-vis Its Competing Crops in Guntur District, Andhra Pradesh”. They had selected Gottipadu village of Pratipadu mandal of Guntur district of Andhra Pradesh. They had collected the data on costs and returns relate to the year 1999-2000. They had selected 120 farmers from the four cropping systems viz., (i) Cotton, (ii) Soyabean-Bengal Gram, (iii) Soyabean-Red Gram and (vi) Soyabean-Jowar cropping system. They have observed that the contribution of the plant protection chemicals in the total operational costs of the cotton cultivation was highest (per hectare Rs. 11331.37 or 41.33 per cent of the total). This was very high when compared to soyabean, bengal gram (per hectare Rs. 4217.90 or 22.31 per cent), soyabean red gram (per hectare Rs. 4379.81 or 27.04 per cent) and soyabean-jowar (per hectare Rs. 1334 or 9.83 per cent). This study also found that the human labour was the highest contributing factor towards the total operational cost of all the cropping systems except for cotton (Rs. 7223.74 per hectare or 26.35 per cent) for which it was the second highest contributing factor towards the operational cost. They have also worked out that per hectare net returns and benefit-cost ratio was highest for soyabean-jowar cropping system among the four cropping systems. Finally, they have suggested that to avoid excessive use of plant protection chemicals (PPC) by replacing chemical control methods with integrated pest management strategies, which involved physical, cultural and biological methods for pest management. They have also suggested to divert the expenditure on plant protection from cotton to soyabean based cropping systems which will assure more returns in the village. To adopt soyabean-jowar cropping system where ever it is feasible, in place of cotton mono-crop to increase net returns and to improve the overall economic condition of the farmers in the village.

Kumar Sant (2002) has found in his study “IPM - An Opportunity to Crop Protection in Cotton” that the per hectare cost of cultivation in IPM and Non-IPM practices was estimated to be Rs. 7000 and Rs. 6600 respectively in Kinwat taluka of Nanded district of Maharashtra. He has also found that per quintal cost of cotton production were Rs. 1029 and Rs. 602 in Non-IPM and IPM practices respectively. Thus, per quintal cost of production of cotton decreased by 71 per cent in IPM practice over Non-IPM practice. He has also worked out that total labour days
employed was 131 days under IPM practices and it was 72 days under Non-IPM technology. In total farm operations, 93 per cent women had participated under IPM technology, while 88 per cent had participated under Non-IPM technology.

Shah V.D. and Patel H.F. (2003) have observed in their research project “Impact of Minimum Support Prices on Agricultural Economy in Gujarat” the difference between minimum support price (Rs. 1625/1825) and Cost $C_2$ (total cost) of cotton cultivation was positive but very small, suggesting near parity*. If one adds the cost of transportation, managerial cost and other incidental costs in Cost $C_2$, then the situation will turn non favourable to cotton growers of the Gujarat state. They concluded that in such a situation MSP fixed for cotton was discouraging for cotton farming community of the State.

Raveendaran N., Ajjan N. and et. al. (2004) have derived in their paper “Impact Study on Technology Intervention in Cotton-Based Cropping Systems in Tamil Nadu” that the technologies such as IPM, foliar application of DAP spray, intercrop/trap-crop in between cotton crop were adopted by more than 85 per cent of the farmers. Due to this type of adoption, the cost of cotton cultivation had declined. The cost on pesticides was reduced by 76 per cent and the overall cost reduced by 23 per cent. The benefit-cost ratio was found as 1.94 using improved technologies compared to 1.35 in farmer’s practices. The per hectare net benefit had increased from Rs. 6475 to Rs. 13315. The first priority of farmers was for IPM, followed by foliar application of DAP spray and inter crop/trap-crop. They have also noticed that the overall impact of these technologies had encouraged to the farmers. Moreover, there remained a lot of scope to increase the production and income of the farmers.

Singh Nirmal, Sohi A.S. and et. al. (2004) have brought out in their paper “Economic Viability of Integrated Pest Management (IPM) Technology in Cotton-Based Cropping System of Punjab” that the IPM farmers had higher education level, higher rate of adoption for hybrid cotton but had lower investments on farm power and machinery than the Non-IPM farmers. The per hectare human labour was about

*Note: $A_1$ - All actual expenses (cash and kind) incurred for cultivation,  
$B_2$ - Cost $A_1$ + Rent paid for L. I. + Rental value of owned land (net land revenue) + Interest on value of owned capital assets (excl. land) and  
$C_2$ - Cost $B_2$ + Imputed value of family labour.
25 per cent more on IPM farms than Non-IPM farms. The quantity of pesticides used in the cotton cultivation by IPM farmers was 4.74 kg/hect. which was less than half of the quantity used by Non-IPM farmers (10.76 kg/hect.). They have also depicted that the IPM technology had reduced the per quintal production cost by about Rs. 158. The net returns analysis also reveals that these costs were significantly higher, amounting to Rs. 7310, Rs. 5325 and Rs. 7248 per hectare for hybrid, non-hybrid and overall cotton crop for IPM farmers as compared to the Non-IPM farmers. However, the input-output ratios were found higher under IPM than Non-IPM technology.

Fadadu A.M. (2005) has indicated in his M.Sc. Thesis “Comparative Economics of Bt Cotton and Hybrid Cotton in Saurashtra Region of Gujarat State” that the average per quintal total cost (Cost C2) of cotton production has been found Rs. 2381 for Bt cotton and Rs. 2746 for hybrid cotton groups. He has further revealed that the Bt cotton had realized about 29 per cent higher yield as compared to that by the hybrid cotton. The return to scale was found to be constant in both the groups of cotton growers. He has noted that the Bt cotton varieties had better allocation of human labour, bullock labour, insecticides/pesticides of sucking, while for seed inorganic fertilizer, insecticides for bollworms, irrigation and other paid out cost, hybrid cotton had depicted an edge over the Bt cotton. However, the Bt seeds had brought a downward shift in the threshold level of gross income from the cotton production. He has analyzed that the Bt cotton technology was found bias in favour of chemical fertilizer, insecticides for bollworms, human labour, irrigation, cropped area and against the seed, insecticides for sucking pest, bullock labour and other paid out cost. Further, he has noticed that a wider technology gap in cotton yield in hybrid cotton than Bt cotton.

Singh Nirmal, Singh Sukhpal and et. al. (2006) have exhibited in their research paper “Impact Evaluation of Insecticide Resistance Management of Cotton Production Technology in Punjab” that the total variable expenditure was higher on Non-IRM farms (Rs. 19884/hect.) than the IRM farms (Rs. 17533/hect.). This was because of the high variable cost incurred on insecticides/pesticides of Non-IRM farms. The share of insecticides/pesticides in the total variable cost was to the tune of 61.2 per cent on Non-IRM farms, which was only 57.8 per cent on IRM farms. They have also presented that the share of hired human labour was higher on IRM farms.
(18.2 per cent) than that of Non-IRM farms (12.7 per cent). This was mainly due to the higher cost incurred for picking the cotton due to higher productivity on IRM farms.

Visawadia H.R., Fadadu A.M. and et. al. (2006) have worked out in their paper “A Comparative Analysis of Production and Marketing of Bt Cotton and Hybrid Cotton in Saurashtra Region of Gujarat State” that the average per hectare total cost amounted to Rs. 44553 for Bt cotton and Rs. 39816 for hybrid cotton. In the case of hybrid cotton, the plant protection cost was higher as compared to that in Bt cotton, while the seed cost was meager. The other cost components remained almost the same for both the groups of cotton. They have also estimated that the average per quintal total cost of production was Rs. 2381 in Bt cotton and Rs. 2746 in hybrid cotton. They implied that reduction in the unit cost of cotton production was an added advantage for Bt cotton farmers. They have showed that Bt cotton technology was superior to hybrid cotton in terms of higher yields and lower cost of production.

Rao Rama C.A., Rao Srinivasa M. and et. al. (2007) have revealed in their paper “Profitability of Cotton on a Pest Management Continuum in Guntur District of Andhra Pradesh” that cotton was an investment-intensive crop with cost of cultivation as Rs. 24010/hect. Plant protection was the most dominant cost item, accounting for about 37 per cent (Rs. 8822/hect) of total variable costs. Cotton was also labour-intensive crop with an expenditure of Rs. 6695/hect. (about 28 per cent) on labour. When the interest on working capital, depreciation of implements and land revenue were taken (Cost A), the gross return exceeded the costs by Rs. 12556/hect. They have also worked out that the net return from cotton was just Rs. 6481/hect. When all the costs, rental value of own land and imputed value of family labour were included (Cost C), the cost of production worked out to Rs. 1349/qtl. They have further showed that the total plant protection expenditure was the least (Rs. 6682/hect.) when IPM practices were adopted on the non-Bt varieties, while the plant protection expenditure with Bt and IPM were higher (Rs. 8337/hect.).

Naidu Balakrishnama V. and Shankar Siva A. (2007) have worked out in their article “An Econometric Analysis of Cotton Crop: A Study in Guntur District of Andhra Pradesh” that the cost of production of cotton crop by adopting the cost concepts used in Farm Management Studies undertaken by the GOI. Cost A₁, Cost A₂,
Cost B and Cost C (Actual Cost) have been adopted here. They have explained that the per acre Cost A1, Cost A2, Cost B and Cost C (for the sample farmers was Rs. 12956.40, Rs. 13860.76, Rs. 14832.12 and Rs. 15679.40 respectively. In the case of actual cost (Cost C), marginal farmers, small farmers, medium farmers and large farmers incurred Rs. 15266.90, Rs. 14944.30, Rs. 16099.39 and Rs. 16406.93 respectively, whereas the average cost incurred by the sample farmers was Rs. 15679.40 per acre. Cost A1, Cost A2 and Cost B also fluctuated. The same trend was observed in the case of Cost C. It was highest in the case of large farmers and lowest for small farmers.

Patel Sejal (2007) has observed in her study “Income, Employment and Benefit-Cost Analysis of Selected Major Crops - A Micro Analysis of Bharuch District” that the per hectare total cost of cotton cultivation was Rs. 13777 in the sample farmers (50 farmers) of the study area (i.e., Bheram village, Bharuch district, Gujarat). Out of the total cost, the cost of human labour was found to be highest (28.87 per cent of the total), followed by ploughing (16.54 per cent), pesticides (15.61 per cent), chemical fertilizers (13.26 per cent), seeds (12.64 per cent), irrigation (6.84 per cent), machinery (2.91 per cent), miscellaneous cost (2.49 per cent) and farm yard manure (0.84 per cent). The cost of cultivation of this crop was higher in the case of marginal farmers as compared to other farmers.

She has further noted that the per hectare yield of cotton obtained by the sample farmers was 1387 kg/hect. The average per hectare gross income in cotton cultivation was Rs. 26922. On an average per hectare net return was Rs. 13145 and the net benefit-cost ratio was Rs. 0.95 for cotton cultivation. The net benefit-cost ratio was lowest (Rs. 0.81) on small farm size group and highest (Rs. 1.09) on large farm size group due to realization of lower productivity by small farmers. She has also noted that the net surplus income was highest in the cultivation of cotton as compared to that in the cultivation of other three selected crops viz., jowar, wheat and tur.

Peshin Rajinder, Dhawan A.K. and et. al. (2007) in their research paper “Attributes and Socio-Economic Dynamics of Adopting Bt Cotton” observed that the overall per hectare cost of cultivation of Bt cotton, hybrid cotton and non-hybrid cotton was Rs. 22431, Rs. 24259 and Rs. 21713 respectively. The cost of cultivation of Bt cotton was lower by 7.54 per cent than that of other hybrid varieties, but was
higher by 3.31 per cent than that of non-hybrid varieties due to the significant reduction in the insecticide cost (including the cost of sprays), which even neutralized the higher cost of Bt seed. The higher cost of cultivation than non-hybrid varieties was due to the reason that the difference in the cost of seed was much higher, which could not be neutralized by reduced insecticide cost and the labour charges for the sprays. The per hectare average cost of seed was Rs. 4621 for Bt cotton, Rs. 1914 for other hybrids and Rs. 484 for non-hybrids, while the per hectare cost of insecticides was Rs. 3005 and Rs. 7546 and the labour cost of sprays was Rs. 476 and Rs. 1046 for Bt and non-Bt varieties respectively. Further, the cost of insecticides amounted to 17.37 and 41 per cent of the total cost of cultivation of Bt cotton, other hybrids and non-hybrids respectively. Thus, here it is clear that adoption of Bt cotton in the State had helped in reducing the cost of cultivation of the crop. The per hectare cost of picking varied accordingly and was Rs. 4109, Rs. 3976 and Rs. 3147 for Bt cotton, other hybrids and non-hybrids respectively.

Shah V.D. (2007) in his research project “Returns to Bt Cotton vis-à-vis Traditional Cotton Varieties in Gujarat State” found that the average per hectare gross cost of cultivation (including imputed values of family labour and own machineries) of Bt cotton was higher than that of non-Bt cotton in Rajkot and Vadodara districts. Overall average per hectare cost of cultivation of total Bt cotton was Rs. 29743/hect. which was about 10 per cent higher than Rs. 26993/hect. for non-Bt cotton. He further noted that the per hectare cost of cultivation for Bt as well as non-Bt cotton was found much higher in Rajkot district as compared to Vadodara district. Thus, the cultivation of Bt cotton was cost intensive. He has also reported that the per hectare cost of cultivation was lowest for small size farmers for both Bt as well as non-Bt cotton. On the whole, average per quintal cost of production for Bt cotton and non-Bt cotton were Rs. 923 and Rs. 1077 respectively. Thus, the average cost of production of total Bt cotton was lower by Rs. 154/qtl. This shows that Bt cotton is more cost effective. Across the size group, the per hectare cost of cultivation for both Bt and non-Bt cotton was highest for medium farmers, whereas it was lowest for small farmers.

Gandhi Vasant P. and Namboodiri N.V. (2009) have found in their report “Economics of Bt Cotton vis-à-vis Non-Bt cotton in India - A Study Across Four Major Cotton Growing States” that the average total cost of cultivation under irrigated
condition was, in general, higher than under unirrigated conditions both for Bt and non-Bt cotton in four selected states viz., Andhra Pradesh, Gujarat, Maharashtra and Tamil Nadu. The average per hectare cost of cultivation of Bt cotton exceeded that of non-Bt cotton in these selected States and the difference was the highest in Maharashtra exceeding Rs. 8250. The average per hectare cost of cultivation of Bt cotton was Rs. 32139, Rs. 29743, Rs. 31679 and Rs. 23040 in Andhra Pradesh, Gujarat, Maharashtra and Tamil Nadu respectively, while in case of non-Bt cotton it was Rs. 30444, Rs. 26993, Rs. 23207 and Rs. 20260 respectively in Andhra Pradesh, Gujarat, Maharashtra and Tamil Nadu.

They have noted that the lower cost of Bt cotton seeds in Gujarat and Andhra Pradesh as against to Maharashtra and Tamil Nadu could be due to use of non-genuine Bt seeds in Gujarat and Andhra Pradesh. The share of seed cost of Bt seeds in total cost of production was about 10 to 17 per cent in the above mentioned four states, whereas it varied from 4 to 6 per cent for non-Bt cotton seeds. They have concluded that the average per hectare cost of Bt seeds was more than double than the non-Bt seeds in the study States.

Further, they have reported that the average number pesticides sprays as well as its per hectare cost was higher on non-Bt cotton in these States. But the difference across states was very high. The share of pesticide cost in total cost of cultivation ranged from 8.29 per cent in Tamil Nadu to 24.29 per cent in Andhra Pradesh for Bt cotton, it varied from 11.96 per cent in Gujarat to 35.73 per cent in Andhra Pradesh for non-Bt cotton.

Loganathan R., Balasubramanian R. and et. al. (2009) in their working paper “Productivity and Profitability Impact of Genetically Modified Crops - An Economic Analysis of Bt Cotton Cultivation in Tamil Nadu” analyzed the economic impact of biotechnologically engineered cotton cultivation in Tamil Nadu and the factors affecting the adoption of Bt cotton varieties. This study was based on a sample size of 76 Bt cotton farmers and 44 non-Bt cotton farmers (120 farmers) from Salem and Perambalur districts of Tamil Nadu. This study pertained to the agricultural year 2004-05. The study indicates that the total cost of cultivation was Rs. 30895 and Rs. 33686 for Bt and non-Bt cotton respectively. In the total cost of cotton cultivation, human labour was the major component of cost (about 45 and 40 per cent cost for Bt
and non-Bt cotton respectively) of inputs applied for both types of cotton production. However, the cost of pesticides had shown a significant difference between Bt and non-Bt farmers in terms of absolute amount spent on pest control as well as its relative share in total cost of all inputs. The share of pesticides in total cost was less than 5 per cent in Bt cotton, while it was close to one-fifth of total cost of inputs used for non-Bt cotton. The share of seed cost to total inputs costs was about 14 per cent in Bt cotton and less than 7 per cent in non-Bt cotton. Hence, the study concluded that the savings in pesticide costs for Bt cotton have been found more to offset the higher seed cost for Bt cotton. The total cost of all inputs used was about 10 per cent higher in non-Bt than Bt cotton cultivation.

Rao Chandrasekhara N. and Dev Mahendra S. (2009) have reported in their study “Socio–Economic Impact of Transgenic Cotton” that the per acre cost of production was 17 per cent higher in Bt cotton (Rs. 16975) than for non-Bt cotton (Rs. 14507) during 2004-05 in Andhra Pradesh and this difference was statistically significant. It included paid-out costs and imputed costs of depreciation, interest on owned fixed capital, rental value of owned land, family labour etc. The expenditure on insecticides decreased by 18.2 per cent in Bt cotton over non-Bt cotton. This decrease in cost of insecticides by Rs. 594 was more than matched by the increased costs on seed, labour, fertilizers and irrigation. All these changes were statistically significant, except in fertilizers.

Rani Usha S. and Selvaraj G. (2009) have reported in their article “Empirical Analysis of Adoption and Impact of Bt Cotton Cultivation in Cotton Production Systems of Tamil Nadu, India” that 86.88 per cent of the respondents in both the conditions (rainfed and irrigated) felt that the seed and sowing cost of Bt cotton was more. At the same time, all of them felt that the cost spent for plant protection chemicals was drastically reduced due to the cultivation of Bt cotton which in turn reduced the total cost of cultivation. They have also noted that majority of farmers in both cases (irrigated and unirrigated) harvesting cost was less due to Bt cotton cultivation, while all other almost costs remained the same. About 61.67 per cent of the Bt cotton growers in both irrigated and rainfed conditions had opined that due to increase in market price of cotton, their gross returns and net returns had increased due to the Bt technology.
Satpute T.G., More S.S. and et. al. (2010) have estimated the per hectare cost of cultivation of organic and inorganic cotton farming in their article “Economic of Cotton Grown Under Organic and Inorganic Farming in Parbhani District of Maharashtra”. They had selected 60 organic and 60 inorganic cultivators. The data collected were for the reference year 2006-07. They have observed that the per hectare cost of organic cotton was Rs. 29085.38, while Cost A was estimated to Rs. 18366.7 (63.14 per cent) and Cost B was estimated to Rs. 27781.28 (95.51 per cent). Among the Cost A for organic cotton farming, highest item of the cost was irrigation (18.75 per cent), followed by vermi compost (9.67 per cent), bullock labour (8.34 per cent), human labour (5.30 per cent) whereas cost of plant protection and interest on working capital was 4.48 per cent 3.51 per cent respectively. Rental value of land was the major item of the cost of cultivation of organic cotton, which contributed to 31.10 per cent of the total cost. They have also noted that per hectare Cost C of inorganic cotton was Rs. 32117.32, Cost A was Rs. 21712.18 (67.70 per cent) and Cost B was to Rs. 30492.22 (94.94 per cent). Among the Cost A highest item of the cost was irrigation (16.01 per cent), followed by bullock labour (10.67 per cent), seed (8.81 per cent), plant protection (8.74 per cent), machine labour (8.81 per cent) and human labour (8.24 per cent) etc. They have reported that the rental value of own land was the major item of the cost of cultivation of inorganic cotton which contributed to 26.40 per cent of the total cost. The per hectare cost of organic cotton farming was Rs. 3031.94, which was 9.44 per cent less than inorganic cotton farming. They have further noted that the rental value of own land and irrigation cost were the major cost items of cost of cultivation (both in organic and inorganic cotton farming).

Hatti Jayanand V. (2011) has explained the cost of cultivation of cotton in his article “Cotton Growing Farmers and their Problems: A Case Study”. He had selected the Dharwad district of Karnataka state. He had selected 255 sample farmers from the selected villages of the district. He reveals that in the sample villages cost of fertilizers was a major item in material cost which indicated that the farmers were using fertilizers extensively. In the production of cotton the cotton picking activity consumed nearly 1/3rd of the total labour of cotton cultivation. He has noted that out of the total cost of cultivation, labour cost was a major cost which revealed that high demand for labour in the sample villages. He has further noted that the Cost A, Cost B, gross returns and net returns were high for medium and large farmers. This was
due to the reason that they had sold their cotton production in APMC’s. As a result, the benefit-cost ration was also higher for medium and large farmers. He also revealed that labour cost, pesticides cost and fertilizers cost were the major cost components for the cotton cultivation in the study villages. The cost of fertilizers and pesticides was high due to the use of high priced agricultural inputs like fertilizers, plant protection chemicals and the farmers generally used them more than the recommended doses.

Kiresur V.R. and Ichangi Manjunath (2011) have examined the per hectare input expenditure of Bt and non-Bt cotton in Karnataka in their article “Socio-Economic Impact of Bt Cotton - A Case Study of Karnataka”. The authors had selected 60 sample farmers comprising 30 Bt cotton and 30 non-Bt cotton. Haveri district of Karnataka was purposively selected. They found that the per hectare expenditure on seeds was higher (Rs. 3718) in Bt cotton than in non-Bt cotton (Rs. 2550) farms, largely due to higher cost of Bt cotton seeds. But, the per hectare cost incurred on chemical fertilizers and organic manure was higher in non-Bt cotton (Rs. 2605) than Bt (Rs. 2502) farms. The use of human labour was more on non-Bt cotton than Bt cotton. On non-Bt cotton, more number of sprays for pest management was required and it had added more cost of human labour. They have also described that there was a significant difference in per hectare expenditure on plant protection chemicals (PPC) between Bt (Rs. 6369) and non-Bt (Rs. 4394) farmers. However, Bt farmers, under the direct guidance of extension workers and scientists, used the pesticide judiciously and thereby reduced the per hectare expenditure on PPC to 11.6 per cent of the total cost as compared to 16.2 per cent by non-Bt farmers. They have further reported that the per hectare total cost of production (Cost D) including interest on working capital, land revenue, depreciation charges, imputed value of family labour and marketing cost was higher for non-Bt cotton (Rs. 39304) than Bt cotton (Rs. 36675), due to higher expenditure on more number of pesticide sprays in the case of non-Bt cotton. This cost increased with increase in the size of landholding in both Bt and non-Bt farms.

Rajendran S. and Satheswaran P. (2012) have reported the cost of cultivation of Bt and hybrid cotton in their research work “Productivity Differentials and Cotton Cultivation-Empirical Evidence from the Foot Hills of Western Ghats”. They had
selected the Alamarathupatty revenue village of Kolathur block of Salem district of Tamil Nadu. They had selected 90 sample cotton growers, 45 Bt cotton growers and the remaining 45 Traditional cotton (Tt cotton) growers. They had taken 2009-10 as a reference year and field work was done for this agricultural year. They have noted that the harvesting cost was almost higher (1/4 of the total cost), followed by the cost of initial operations for both Bt and Traditional cotton. With regard to cost on seed, as is expected it is quite more for Bt and less for Tt cotton. They have also reported that for both types of cotton, weeding also took a considerable proportion of cost. Though the authors have reported that depending upon the season, rainfall and availability of water the cost slightly varied between these two types of cotton (Bt and Traditional). Authors also noted that the input cost was more for Bt as compared to Tt cotton. In the case of operational cost, the Bt cotton farmers spend more than Tt cotton. The Bt cotton absorbed more fertilizer than Tt cotton and pest and diseases were common in the cotton cultivation.

Conclusion

It can be concluded from the above review of the studies that the chemical fertilizers, irrigation, pesticides, human labour, rental value of own land were the major cost components in the total cost of Bt and hybrid cotton cultivation. Among these components, the cost of human labour was found higher. The cost of fertilizers and pesticides was high due to the use of high priced agricultural inputs like fertilizers, plant protection chemicals and the farmers generally used them more than the recommended doses. The results of the studies indicate that the per hectare cost of cultivation of Bt cotton was lower than that of other hybrid varieties, but it was higher than that of non-hybrid varieties (desi varieties). The average per hectare cost of Bt seeds was more than double than the non-Bt seeds. Further, input cost was more for Bt as compared to Traditional cotton. In the case of operational cost, the Bt cotton farmers spend more than Traditional cotton. Thus, the cultivation of Bt cotton was cost intensive. In the case of hybrid cotton, the plant protection cost was higher as compared to that in Bt cotton, while the seed cost was higher in Bt cotton than non-Bt cotton. Hence, it can be concluded that the savings in pesticide costs for Bt cotton have been found more to offset the higher seed cost for Bt cotton. Besides, the average per quintal total cost of production was lower in Bt cotton than in hybrid
cotton/desi cotton. Thus, Bt cotton technology was superior to hybrid cotton in terms of higher yields and lower cost of production. The results of majority of the studies show that per hectare cost of cultivation decreased with the increase in size of farms, while per quintal cost of production increased with the decline in size of farms.

[B] Growth of Area and Production of Cotton

Pavate M.V. (1979) has reported the state-wise share of area and production of cotton in all-India’s area and production in his study “Progress of Cotton in Three Decades: A Study of Growth Rates”. This study was conducted during 1950-51 to 1977-78 and the entire study period was divided into three periods namely: (1) 1950-51 to 1959-60 (Decade-I), (2) 1960-61 to 1969-70 (Decade-II) and (3) 1970-71 to 1977-78 (Decade-III). He had examined the percentage share in total cotton production for all important cotton growing states of India. He has noted that in early fifties, the share of Maharashtra in total cotton production was as high as 25 per cent, followed by Gujarat (23 per cent). The Punjab, including Haryana stood third contributing 12 per cent. However, the share of Maharashtra in the total cotton production remained the same (25 per cent), while that of Gujarat increased to 28 per cent and that of Punjab (and Haryana) to 17 per cent in the early sixties, while in the remaining states viz., Rajasthan, Madhya Pradesh, Karnataka, Andhra Pradesh and Tamil Nadu, only marginal changes in percentages had occurred. He has further reported that the share of Gujarat had jumped to 31 per cent (17.78 lakh bales), while that of Maharashtra has slumped to 14 per cent (8.38 lakh bales) in the early seventies. Whereas, the share of Punjab has increased to 9.54 lakh bales (16 per cent). He has noticed the Gujarat figures of triennium ending 1977-78 remain the same viz., 17.50 lakh bales (28 per cent) and that of Punjab had increased substantially to 11.99 lakh bales (19 per cent). While the figure for Maharashtra had slightly improved to 9.58 lakh bales (15 per cent). He has also noticed that the three southern states like Karnataka, Andhra Pradesh and Tamil Nadu had substantially increased their per hectare yield and hence their production reached 6.09 lakh bales (10 per cent), 2.43 lakh bales (4 per cent) and 3.35 lakh bales (5 per cent) respectively. Moreover, the share of Rajasthan in the total cotton production had increased to 4.02 lakh bales. Only Madhya Pradesh had not done well, during the three periods under consideration.
Mellow L.D. (1979) in his study “Agro-Based Industries Feedback and Prospects - Cotton, Jute and Sugarcane” discussed the problems of agro-based industries in India. He has noted that the wide year to year variations in the production of cotton had resulted into uncertain supplies of raw cotton and consequence swing in the prices. He has further noted that the vagaries of monsoon played an important role for the fluctuations of the indigenous raw cotton.

Yoginder K, Alagh and Sharma P.S. (1980) have estimated growth rates for cotton output in their study “Growth of Crop Production: 1960-61 to 1978-79 - Is It Decelerating?” They have reported that at the all-India level, the growth rate per annum in cotton output during 1960-61 to 1978-79 was 1.62 per cent. It was nominal, being 0.31 per cent during 1960-61 to 1969-70 but increased substantially to 3.38 per cent during 1969-70 to 1978-79. They have indicated that Rajasthan, Haryana and Andhra Pradesh had shown the highest growth rates, viz., 6.62, 6.55 and 6.00 per cent respectively during 1960-61 to 1978-79. They have further noted that the performance of Andhra Pradesh, Rajasthan, Karnataka, Punjab and Maharashtra in the seventies had been better as compared to the sixties. In Haryana, however, a sharp deceleration in output growth rate of cotton was observed during the seventies as compared to the sixties.

Narappanavar S.R. (1987) has examined in their research paper “Determinants of Acreage and Production Behaviour of Cotton in India” that the co-efficient of acreage under cotton was found to be positive and significant. The elasticity of production with respect to acreage was of the order 0.589 which was significant at 20 per cent level of probability. He has also observed that the co-efficient of rainfall was positive and elasticity of production with respect to growing season rainfall was of the order 0.023, which was significant. He has noted that the consumption of chemical fertilizer had favourable impact on production of cotton. This study also found that the effect of irrigated area under cotton on production behaviour was found to be positive which indicated that larger the area of cotton under irrigation greater the output obtained. This variable was highly significant at 1 per cent level and the elasticity of production of with respect in irrigation was of the order 0.754. The author has suggested that the percentage of irrigated area of cotton was very small in India (nearly 23 per cent) and hence, attention should be given to increase cotton area under irrigation, particularly in command areas.
Basu A.K., Narayanan S.S. and et. al. (1992) have reported in their research article “Cotton Production and Improvement in India” that area under cotton increased dramatically to 8.1 million hectares in 1955-56 and subsequently went down to 7.6 million hectares in 1960-61 in India. Production also came down from 7.6 million bales (170 kgs. each) to 5.6 million bales during this period. However, the cotton production crossed 10 million bales in 1984-85, marking a new turning point in Indian cotton history with 243 kg.lint/hect. yield. During the 1980’s showed good progressive trends with 1989-90 making a record production 13.36 million bales with productivity of 303 kg.lint/hect. However, due to adverse factors, the production was only 11.6 million bales in 1990-91. They have also noted that research and extension efforts paid rich dividends to improve total production without increase in area during 1960’s to 1990’s.

Dutta R.A. (1993) has worked out in her research project “Some Aspects of Land Use Planning in Gujarat” that the area under cotton continuously declined (about 13 per cent of the total area) from 1970-73 onwards as cultivation of cotton had been replaced by tur, while the production of cotton increased slowly during the period of 1960-63 and 1988-90 in the State. Around 29 per cent of the total cultivated area of cotton was under irrigation in 1980-83 in the State. She has also reported that cotton was cultivated in varying degree in all the districts of Gujarat, except the Dangs. However, the hectarage and production of cotton crop vary considerably between different districts. The districts which had large proportion of TCA under cotton cultivation were Surendranagar, (57 per cent), Vadodara (29 per cent), Ahmedabad (28 per cent), Sabarkantha (23 per cent), Bharuch (21 per cent) and Rajkot (16 per cent) in 1980-83. She has noted that the share of these districts was around 70 per cent in total area under cotton and contributed about 65 per cent to total cotton production in the State. The area under cotton increased before green revolution, but growth rate of area was negligible for this crop during post-green revolution period in the State.

Patel A.S., Patel H.F. and et. al. (1996) have examined in their study “Performance of Agriculture in Gujarat-I” that the growth rate of area, production and yield of cotton in the State during 1949-91 was -0.11 per cent, 1.74 per cent and 1.82 per cent respectively. The figure of co-efficient of variations was found to be 19.58
per cent, 31.24 per cent and 23.11 per cent respectively for area, production and yield of cotton. For the districts having good irrigation facilities, the production growth rate varied from -2.06 per cent in Surat to 11.59 per cent in Banaskantha, the figure of co-efficient of variations on the other hand, varied from 31.78 per cent in Surat to 63.34 per cent in Kheda. In the case of districts having low irrigation facilities, the production growth rate varied from -2.47 per cent in Bharuch to 7.75 per cent in Amreli. The figure of co-efficient of variations on the other hand, varied in between 42.75 per cent in Bharuch and 76.35 per cent in Kutch.

Kohls Rechard L. and UHL Joseph N. (1998) have indicated in their study “Cotton and Textile Marketing” that cotton was produced in seventeen states with major concentrations of production in the Mississippi delta states (Mississippi, Arkansas, Louisiana), the Texas high plains, Central Arizona and the san Joaquin Valley of California. From the end of the Civil War until the mid-1920’s, US cotton acreage increased from 8 million acres to 44 million acres. Cotton production reached a peak of 18 million bales in 1926. US cotton acreage declined from 40 million acres in 1930 to 10 million acres in 1966 and remained at about that level through 1988. Acreage expansion had occurred in the 1990’s. Between 1965 and 1985, the Western States’ share of US cotton production rose from 17 to 31 per cent. They have derived that the number of US farms producing cotton declined from 1.1 million in 1949 to 35000 in 1992 while the average size of these farms grew from 24 to 315 acres. Western cotton farms average twice the acreage of cotton farms elsewhere. They have also noted that cotton yields had increased dramatically in the past 20 years as a result of improved production and harvesting technologies and irrigation.

Gaddi G.M. and Mundinamani S.M. (2002) have indicated in their article “Resource Use Efficiency and Constraints in Cotton Production in Karnataka - An Economic Analysis” that most of the sample farmers in the region were familiar with the production techniques and had employed them to the best possible advantage. On an average, large sample farmers obtained 60.60 per cent, while small sample farmers obtained 58.97 per cent of the frontier output level (19.52 qtl./hect.) of cotton in the study area. Majority (41.25 per cent) of the sample farmers achieved 76.85 per cent output efficiency. Further, farm size group-wise analysis revealed that 41.86 per cent of small farmers achieved 76.85 per cent of the frontier output and only 23.50 per cent
they achieved more than 86 per cent of output efficiency. In case of large farms more number of farmers (43.24 per cent) operated in low efficiency category of less than 75 per cent and only six farmers achieved more than 86 per cent output.

Chahal S.S., Singh Ravinder Harika and et. al. (2003) have worked out in their research paper “A Study into Growth Analysis of Production and Acreage Response of Cotton in Punjab” that the area under cotton increased significantly at an annual compound growth rate (CGRs) of 0.25 per cent in India during 1950-51 to 2000-01. The production and yield also grew at 2.43 per cent and 2.18 per cent per annum respectively during the same period. Thus, the yield contributed maximum to increased production during this period. They have also indicated that the area under American cotton increased at the rate of 5.04 per cent per annum in Punjab during 1950-51 to 1965-66. This was resulted into increased production of cotton during this period in the State. The CGRs for the period 1950-51 to 2000-01 (2.73 per cent) also turned out to be negative for area and productivity of cotton. In case of Desi cotton there was widespread fluctuations in the area under Desi cotton in Punjab due to which CGRs turned out to be non-significant statistically. This was caused corresponding fluctuations in the production of Desi cotton and CGRs of cotton production turned out to be statistically non-significant.

Navadkar D.S., Birari K.S. and et. al. (2003) have reported in their research paper “Government Support for Increasing Production and Marketing of Cotton” that the area and production of cotton in the country during 1950-51 to 2001-02 increased from 5.88 million hectares and 3.04 million bales to 8.75 million hectares and 11.3 million bales respectively. They have also derived that the production increased rapidly than area due to increased productivity by 2.5 times over 1950-51. The share of Maharashtra, Gujarat and Andhra Pradesh in total production of cotton in India was larger than other States. The productivity of cotton was noticed highest (430 kg./hect.) in Punjab (2000-01).

Jahagirdar S.W., Ratnalikar D.V. and et. al. (2004) had conducted a study on “Growth Rate of Cotton in Maharashtra”. This study was based on 35 years data from 1960-61 to 1995-96 and the entire period was divided into three periods namely: (a) pre-green revolution period (1960-61 to 1969-70), (b) Green revolution period (1970-71 to 1979-80), (c) Post-green revolution period (1980-81 to 1995-96). They revealed
in their study that out of the nine selected districts of Maharashtra, three districts, viz., Akola, Yavatmal and Nanded districts exhibited positive growth rate of area under cotton ranging from 0.42 to 1.29 per cent over the total period of 35 years whereas Aurangabad and Jalgaon districts indicated declining trend in area at the rate of -1.57 per cent and -5.48 per cent respectively. They had further described that the phase of introduction of new technology (1970’s), out of nine selected districts of Maharashtra, five districts, viz., Akola, Amravati, Yavatmal, Wardha and Parbhani exhibited positive growth rate of area under cotton ranging from 0.72 to 1.97 per cent. However, it could not be maintained further from the phase of introduction of new technology by these districts excepting Yavatmal. During 1980’s onwards, there had been positive growth rate only in Yavatmal and it was 1.26 per cent, whereas, three of the nine districts, i.e., Wardha, Jalgaon and Parbhani indicated negative growth rates ranging from -1.74 per cent to -2.74 per cent.

Singh P.K. (2004) has worked out in his research project “Building Up of An Efficient Marketing System to Obviate the Need for Large–Scale State Intervention in Gujarat” that the cotton area ranged between 74.40 lakh hectares (1993-94) to 92.87 lakh hectares (1998-99) in India. Among the cotton growing states in the country, Maharashtra and Gujarat occupied a prominent place. The production of the crop in the country had varied from 119 lakh bales in 1991-92 to about 178 lakh bales in 1996-97. Among the major States, the most notable increase in production was in Gujarat (15 lakh bales in 1991-92 to 47.50 lakh bales in 1998-99), followed by Andhra Pradesh (18.25 lakh bales in 1991-92 to 25 lakh in 1998-99 bales). However, in Gujarat there had been a substantial decline in production of cotton after 1998-99 due to climatic factors.

Pathak Mahesh and Singh P.K. (2008) have brought out in their study “Frontiers of Agricultural Development in Gujarat” that the striking feature of Gujarat agricultural had been the growing importance of non-foodgrains which claimed nearly 70 per cent of the area. Among the non-foodgrain crops, there had been a significant increase in area under cotton (about 16 per cent of TCA during 2000-03) and it had retained its dominant position in the crop pattern of Gujarat. For the purposes of detailed analysis of agricultural growth, they had divided the entire study period into two periods namely: (1) The green Revolution Period (1970 to 1991) and (2) The
Reform Period (1991 to 2005). During the former period the productivity of cotton realized positive and significant growth rate. State’s farmers had been scaling marginally higher peaks of productivity of cotton during 1995 to 2000. During the reform period, significant and higher growth rate of production of maize, groundnut, sesameum and cotton were recorded compared to earlier period. The performance of cotton as an important crop of the State, had improved from -2.50 per cent growth rate of production during 1970-91 to 4.45 per cent in 1991 to 2005 period.

Kajale Jayanti (2010) has presented the data on divergence between the OEs (OE = Statistical Information Relating to Maharashtra, GOM, Various Years) and the TEs (TE = The OJTC, Mumbai) in Maharashtra in his research paper “Estimating Cotton Production in Maharashtra”. He has reported that the TEs were higher than OEs for majority of the years though the direction of the movement was seen to be the similar. There were a few years when the DES estimates were higher than the CAB ones. As far as the years 1983-84 and 1988-89 to 1990-91 were concerned, the OEs were marginally higher than the TEs. However, for the years 1993-94 and 1994-95, the OEs were substantially higher than the TEs. He has also described that the zone-wise procurement data from MSCCGMF showed that the figures for TE had dropped down suddenly due to lower procurement in almost all zones of Maharashtra and specifically in the Dhule zone in those years whereas the TEs were substantially higher than OEs in years 1985-86, 1999-00 and 2001-02. The possible reason for this difference might be the cross border trade in cotton by private traders. For the remaining years when TE were higher than the OE, the gap is seen to be marginal i.e., TE were marginally higher than the OE.

Hemambara and Kumar Arun K.S. (2010) have examined in their study “Production and Marketing Performance of Cotton” that the production of cotton in India increased from 32.80 lakh bales (170 kgs. of each) in 1950-51 to 310 lakh bales in 2007-08. It was due to increase in the area under cotton. Per hectare yield also increased from 95 kg. to 553 kg. in the year 1950-51 to 2007-08.

Ashok K.R., Uma K. and et. al. (2012) have reported in their article “Economic and Environmental Impact of Bt Cotton in India” that Gujarat was the largest producer of cotton in India and stood second in terms of area under cotton. Surendranagar district alone covered 21 per cent of the total cotton area in the State,
while Bhavnagar (11.17 per cent), Rajkot (10.99 per cent), Vadodara (8.86 per cent), Ahmedabad (8.47 per cent), Amreli (7.37 per cent) and Bharuch (7.36 per cent) were the other major cotton growing districts whereas Maharashtra was the second largest producer of cotton though it ranked first in terms of area with 3.15 million hectare under cotton. In this State, nearly 38 per cent of cotton was cultivated in Amravati division, followed by Nashik and Latur divisions. From the Amravati region Amravati and Yavatmal districts were the major cotton growing districts, while Andhra Pradesh was the third largest cotton growing State in India with 1.40 million hectares under cotton. In Andhra Pradesh, the districts, viz., Adilabad, Guntur and Warangal were the major cotton growing districts and each district covered an area of 15 per cent of the total cotton area in the State. They have also observed that in Tamil Nadu, nearly 15 per cent of the area under cotton was in Virudhunagar district, while Salem (9.04 per cent), Madurai (8.38 per cent), Perambalur (7.59 per cent), Dharmapuri (6.84 per cent), Coimbatore (6.53 per cent) and Thoothukudi (6.39 per cent) were the other major cotton growing districts.

Shah Deepak (2012) has noted in his paper “Bt Cotton in India: A Review of Adoption, Government Interventions and Investment Initiatives” that initially the area under Bt cotton hybrids was 38038 hectares, which gradually increased to 0.56 million hectares in 2004-05, 1.3 million hectares in 2005-06 and 3.72 million hectares in 2006-07. Whereas, the area under Bt cotton in India was estimated at 3.7 million hectares in 2006-07 which was higher than the area under Bt cotton in China (3.5 million hectares) during the same year. India had 6.3 million hectares of hybrid cotton area during 2006-07, which encompassed about 60 per cent area under Bt cotton. Further, the states of Haryana, Rajasthan and Gujarat showed more than 85 per cent of their cotton area under Bt cotton. Maharashtra showed the highest area under Bt cotton in 2006-07. However, the proportion of area under Bt to total cotton area in this State was nearly 36 per cent during this year. They have reported that the studies conducted by Central Institute of Cotton Research had observed that there had been enormous farmer support for Bt cotton as is evident from the fact that more than 90 per cent of the area in all the cotton growing states in India was under Bt cotton.

Murty Ramana R.V. and Sailaja A. (2012) have reported in their article “An Empirical Analysis of Production, Prices and Profitability of Cotton in India” that cotton production in India had witnessed an impressive growth in the last two study
decades. It had increased from 30.62 lakh bales in 1950-51 to 78.96 lakh bales in 1980-81. Further, it increased to 117 lakh bales in 1990-91 and 158 lakh bales in 2000-01 and 315 lakh bales in 2007-08. This growth in production was enabled by both area and yield. They have further noted that the area under cotton had increased from 78.24 million hectares in 1980-81 to 94.39 million hectares in 2007-08. The yield had gone up from 170 kg/hect. to 567 kg/hect. during the same period. Hence, the authors have observed that the adoption of Bt hybrid cotton was largely responsible for this surge in yield in new millennium. The growth in yield was particularly visible since 2001-02 onwards.

**Conclusion**

It can be concluded from the above review of the studies that the production of cotton had increased due to improvement of the productivity of cotton. The major cause for increase in the yield of cotton was higher adoption of Bt cotton technology by the farmers. Due to the research and extension efforts the production was increased without more increase in area. Thus, the production was increased rapidly due to increased productivity. The area under cotton was increased before green revolution, but growth rate of area was negligible for this crop during post-green revolution period.

**[C] Yield Level Performance of cotton**

Patel A.S. (1979) has found out in his study “Yield Differentials in Irrigated and Unirrigated Areas - A Case Study of Desi Cotton in Gujarat” that in both the regions, viz., Gujarat and Saurashtra, the gap between yields of cotton in irrigated as also unirrigated areas were found to be wide. Similar differences were obtained in inter-farm size-group and intra-farm size-group analysis for these regions. In Gujarat, the yield of irrigated cotton was higher by 0 to 1400 per cent (4 areas) while in Saurashtra the yield was higher by 0 to 216 per cent (7 areas). Thus, between the two regions the variations were found to be higher in Gujarat. He has also noted that the gap between the highest yield and other yields of cotton in above said two regions was found to be very high. He further noted that within the irrigated areas, the gap between the highest yields and other lower yields was higher (79 per cent) in Gujarat region than in Saurashtra region (51 per cent). Similarly, within the unirrigated areas,
the gap was higher (82 per cent) in Gujarat region as compared to Saurashtra region (78 per cent).

Patel K.A. (1982) has examined the extent and impact of risk variables on per hectare yield of cotton in Kheda district of Gujarat in his article “Impact of Risk Variables on the Yield of Cotton in Kheda District (1970-71 to 1979-80)”. He had worked out the simple correlation co-efficients between selected risk variable and per hectare yield of cotton. He has observed that the co-efficient of correlation between per hectare yield of cotton and non-seasonal rainfall was -0.84, which was statistically significant. This indicates that non-seasonal rainfall had made adverse impact on cotton yield. Whereas, the co-efficient of correlation between per hectare yield and irrigated area was 0.31 and it is significantly positive. He has reported that there was a favourable impact of irrigation facilities on cotton yield. Further, the co-efficient of correlation of per hectare yield of cotton with seasonal rainfall and maximum temperature was -0.16 and -0.26 respectively, which were insignificant. The simple correlation co-efficient between cotton yield and cloudy days was significantly negative (-0.71). This indicates that increase in the number of cloudy days adversely affected the yield of the cotton crop.

Rao G.V.K. (1987) has examined in his study “The High Powered Committee on Fertilizer Consumer Prices” the impact of application of fertilizer in excess of the quantity recommended by scientists in Andhra Pradesh for the years between 1983-84 and 1985-86. He has concluded that in spite of higher fertilizer use, productivity of cotton declined by 58 per cent and 76 per cent in Guntur and Prakasam districts respectively during the period under study. He has suggested that fertilizer use efficiency can prevent such declining trends in productivity. The study revealed that Indian agriculture had also negative impact of the use of fertilizers on productivity.

Patel P.G. and Mehta N.P. (1989) have examined the profitability of application of NPK to cotton varieties in their research paper “Response of Cotton Varieties/Hybrids to NPK Fertilizers in Different Cotton Zones of Gujarat”. They conducted the large number of fertilizer trials on various varieties of cotton. They have studied the effect of three major nutrients NPK separately and observed that in most of the trials the differences in seed cotton yield due to application of nitrogen (N) was significant, whereas, those due to application of P and K individually or in
combination with N were non-significant. However, with a view to generate some numerical information, all these trials with yield difference significant or otherwise were subjected to this economic analysis. They have further observed that the average response of effect of N application was more than 2 in most of the trials. While in most cases the differences in yield due to the application of P was statistically non-significant and numerically un-economical. Out of 119 trials, only in 19 trials the response was more than 2. Generally such response was at low level of P application. In the case of K application, in all the 29 trials the response was negligible and negative. In most cases the differences in yield due to application of K was statistically non-significant and numerically uneconomic. They have concluded that of the three chief fertilizer elements; nitrogen, phosphates and potash, application of nitrogen alone was found essential for increasing yield. The other remaining two phosphates and potash had not affected the yield favourably. Hence, potash and phosphate had not beneficial effect on cotton yield and it clearly shows that there was no primary importance of these two fertilizers elements.

Kute S.B. and Hariya N.H. (1989) have prepared a research paper “Response of Cotton to Phosphorus in Gujarat Farmers’ Fields”. They have described that in their study that GSFC conducted special two plot trials on farmers’ fields in important cotton growing zones of Gujarat. In one plot, phosphorus was applied on the basis of soil test, while in other plot; phosphorus was not applied, while nitrogen and potash were applied in both the plots as per soil analysis. They have indicated that there was an increase in yield, due to application of phosphorus, from 13 per cent to 51 per cent and the increase in per hectare net realization was to the tune of Rs. 2000 to Rs. 7200 during the year 1986-87. Whereas, in the year 1987-88, the yield increased, due to application of phosphorus, from 20 to 50 per cent, and the increase in per hectare net realization was to the tune of Rs. 2500 to Rs. 6500. They have further noted that the yield increased from 16 to 100 per cent, due to application of phosphorus, while the increase in per hectare net realization was to the tune of Rs. 1800 to 7000. They have further reported that in the phosphorus applied plot, the number of flowers, squares and bolls were more. The size of the boll was bigger. The crop resisted against wilt and maturity and ripening started earlier. The crop was lustrus as compared to non-treated plot. They concluded that cotton responses well to phosphatic fertilization. Such results were also received from the trials conducted by number of agencies like
Indian Council of Agriculture Research, State and Central Governments, Fertilizer Manufactures, etc.

Shah V.D. (1989) has analyzed in his research project “Fertilizer Consumption in Gujarat” and concluded that in the cultivation of irrigated cotton HB, irrigated cotton Digvijay and unirrigated cotton Desi, the actual consumption of fertilizers was below 50 per cent of highest level of recommended doses. However, rainfed cotton Desi, the impact of fertilizers on yield was negative or negligible; there was a need to evolve suitable varieties of crop which were fertilizer effective and high yielding. The percentage of actual use to the lowest recommended level was 365.7 per cent for irrigated cotton. The yield of unirrigated Desi cotton increased about 53 per cent due to the application of fertilizer, while the extent of decrease in the yield was 2 per cent for unirrigated cotton Digvijay despite the use of fertilizers. The yield of irrigated cotton HB and cotton Digvijay was increased about 25 per cent and 74 per cent respectively due to the application of fertilizer, while the extent of decrease in the yield was 7 per cent for irrigated cotton Desi despite the use of fertilizers.

Chishti Salim and Husain Ahsan (1990) have studied “Extension Services and Cotton Productivity: A Case Study of Cotton Maximization Project in Tharparkar District (Sindh) of Pakistan”. This study was based on the pooled data set collected for several years during the project. The primary purpose of the study was to ‘isolate’ the disembodied productivity improvement due to extension services. Cobb-Douglas type production function with constant returns to scale had been estimated with disembodied productivity differential proxied by a dummy variable. In 1976, Pakistan Central Cotton Committee, with the financial assistance from the Asian Development Bank, launched a special cotton maximization project in the Provinces of Sindh and Punjab to increase cotton productivity. They had selected two samples of farmers to evaluate the impact of the project: one from pre-assigned project area and the other drawn from the non-project area. They conducted three times field interview in the crop season: immediately after the first irrigation, after ball-forming and finally after the picking operation. They had collected the data for three years, viz., 1983-84, 1984-85 and 1985-86. This data collected was from 195 observations from the project area and 106 observations from the non-project area. They have observed the relation between cropped area and productivity and have reported that the medium size farmers were more efficient while there was not much difference between the small
and large farms. However, most of the earlier studies showed either the large farms or the small farms to be more efficient. They have also noted that the co-efficient of the dummy variable, which represents the disembodied productivity differential between the project and non-project areas, turned out positive and significant. It is noted that if the farmers in the project and non-project areas used the same quantities of physical inputs and face the same production environment with regard to share-cropping, farm size, pest attack, irrigation, spray intensity as proxied by the variables in the regression equation, then the farmers in the project area have productivity which was higher by 15.8 per cent than the non-project farmers. They have also found that extension services had improved the productivity of cotton by about 16 per cent. They have noted that the medium size farmers were relatively more efficient than the small or large farmers.

Dutta Rajeshree A. (1994) has worked out the per hectare district-wise maximum, minimum and average productivity coefficient of variations for each crop in Gujarat in her research work “Some Aspects of Regional Variations in Agricultural Development in Gujarat.” The whole time series data were divided into three decades, i.e., 1960-70, 1970-80 and 1980-90. The average per hectare yield of cotton was lowest in Surendranagar (109 kg.) and highest in Vadodara district (208 kg.) during 60’s. The average per hectare yield of cotton was between 117 kg. in Bharuch and 231 kg. in Mehsana districts during 70’s. While it varied from 126 kg./hect. in Ahmedabad to 302 kg./hect. in Surat districts during 80’s. Inter-district variations in yield got widened during 80’s. The CV continuously increased during different decades and was 27.33 per cent during 80’s. She has further noted that the gap between maximum and minimum yield of cotton was quite significant in all the districts of the State, except Surat and Mehsana, during different decades under study. The highest maximum yield was 549 kg. (1989-90) in Bhavnagar during 80’s and lowest 150 kg. (1966-67) in Surendranagar during 60’s. She has concluded that the gap between maximum and minimum yield of the crop was significant during 80’s in all the districts as compared to other two decades but it was highly significant in Bhavnagar, Rajkot, Surendranagar and Kutch of Saurashtra.

Patel A.S., Patel H.F. and et. al. (1998) have worked out in their paper “Agricultural Productivity Performance in Gujarat-II” that the yield growth rate of

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cotton was 2.68 per cent, 0.67 per cent and 1.82 per cent respectively in Gujarat in the first (1949-67), second (1967-91) and entire (1949-91) period. The figure of CV was 18.53 per cent, 22.30 per cent and 23.11 per cent respectively in the first, second and entire period. At the State level, over two periods, the growth rate of cotton had sharply declined, while the figure of CV slightly increased. The yield growth rate of this crop for the good irrigation districts varied from 2.09 per cent in Mehsana to 4.00 per cent in Ahmedabad in the first period and -1.02 per cent in Ahmedabad to 5.43 per cent in Surat in the second period. In the case of low irrigation districts, the yield growth rate varied from 1.11 per cent in Kutch to 5.68 per cent in Amreli in the first period and -1.67 per cent in Panchmahals to 3.05 per cent in Junagadh in the second period. At the district level, the growth rate of cotton yield declined in all the districts of the State, except in Surat.

Shiyani R.L., Kuchhadiya D.B. and et. al. (1999) have remarked in their research paper “Economic Impact of Drip Irrigation Technology on Cotton Growers of Saurashtra Region” that the per hectare yield of cotton was 22.60 quintals in case of drip adopters and 18.56 quintals in respect of farmers using conventional method of irrigation. They have indicated that about 22 per cent higher yield of cotton could be harvested with the adoption of drip irrigation as compared to surface irrigation method. Pre-monsoon sowing of cotton through drip irrigation resulted in higher yield, which was rather difficult and highly expensive through surface irrigation method. They have noted that about 23 per cent higher gross income was realized in drip irrigation system, whereas, farm business income, family labour income and net income earned were more than 40 per cent than the conventional method of irrigation. They have also reported that the per hectare net income of cotton cultivation was Rs. 16481 in case of drip adopters and Rs. 11605 in respect of non-adopters. An input-output ratio over different costs in cotton cultivation was comparatively higher in case of drip irrigation system when compared to surface irrigation method.

Patel A.S. (2000) has worked out in his research article “Growth Pattern of Agriculture in Gujarat – An Aspect of Non-foodgrain Economy” that during the entire 1949-96 period of development, the rate of growth of productivity of cotton was relatively better (2.06 per cent) than that of groundnut but it was poor compared to that for rice, wheat, jowar, bajara, all cereals’ group and also all foodgrain crops’
group. Thus, the productivity performance of the two major crops covering more than half of the GCA under non-foodgrain crops (1993-96 estimates) had remained poor during 1949-96. For each of two sub-periods, i.e., pre and post green revolution periods, productivity performance of groundnut and cotton was found to be poor. For cotton, the productivity performance was poor in the 1970’s but it was relatively better compared to foodgrain crops in the 1980’s and 1981-96.

Prasad Rajendra V. (2002) has prepared a research article “Sustainable Cultivation of Cotton - An Economic Analysis”. He has analyzed the relative economics and economic sustainability of soyabean crop as against the cotton mono-crop in Gottipadu village of Prattipadu mandal in Guntur district of Andhra Pradesh. He has noted that the soyabean-jowar cropping system had the highest net returns and benefit-cost ratio, while the reverse was noticed for cotton mono-crop. He has also revealed that the estimation of yield gaps in cotton production, Gap I (Research Station Yield – Demonstration Yield) and Gap III (Research Station Yield – Farmer’s Average Yield) were high and the Gap II (Demonstration Yield – Farmer’s Average Yield) was negative. This was due to the fact that farmers got high yield while they follow the high input traditional agricultural system (high cost plant protection chemicals) when compared to the low input more sustainable agricultural system (with IPM practices).

Gaddi G.M., Mundinamani S.M. and et. al. (2002) had prepared a research paper “Yield Gaps, Constraints and Potential in Cotton Production in North Karnataka - An Econometric Analysis”. They had selected 80 sample farmers spread over in eight villages of four talukas from two leading districts, viz., Dharwad and Bellary with respect to cotton area in Karnataka. They had observed that the adequacy of the soil moisture was a crucial factor in tapping the farm potential (7.78 per cent) as its co-efficient was statistically significant by small farms, while growing of cotton on problematic soils was responsible for 6.18 per cent of the yield gap. Non-application of chemical fertilizers at the recommended level and incidence of pest and diseases were responsible for 11.58 per cent and 11.72 per cent of the yield gap. Therefore, they have suggested that 23.30 per cent of the observed yield gap could be bridged by using the recommended quantity of fertilizers and adopting efficient plant protection measures against pest and diseases. On the other hand, non-availability of
recommended variety and genuine seeds restricted the large category farmers to exploit about 5 per cent less of the farm potential. Non-availability of labour during the peak crop seasons was responsible for 6.59 per cent of the observed yield gap and co-efficient of this variable was significant at 1 per cent probability level. They have further noted that the incidence of pest and diseases suppressed the exploitation of farm potential by 5.58 per cent, while non-availability of labour and growing of cotton on unsuitable soils resulted in 7.42 per cent and 5.66 per cent of the observed yield gap respectively. The co-efficient of these three dummy variables were highly significant at 1 per cent probability level. They have also noted that application of chemical fertilizers at the recommended level would reduce yield gap by 5.15 per cent and the regression co-efficient of this variable was significant at 5 per cent probability level.

Gaddi G.M. (2003) has worked out in his paper “Path Co-efficient Analysis of Yield Gaps in Cotton Production in Karnataka” that the potential yield of cotton was estimated to be 2669 kg./hect. As against this, the yield realized on the demonstration plots was 1805.50 kg./hect. and the overall category of farmers’ fields was 1172.70 kg./hect. He also worked out that the total yield gap was 1526.30 kg./hect., which comprised of relatively higher magnitude of Yield Gap-I than Yield Gap-II. The sample farmers exploited hardly 43.45 per cent of potential yield and 64.95 per cent of potential farm yield. The analysis of path co-efficient also revealed that lower uses of human labour and bullock labour were important factors conditioning yield gap.

Maharjan A., Hiremath G.K. and et. al. (2003) have indicated in their study “Profitability of Growing Crops in Northern Dry Zone of Karnataka” that under both irrigated and rainfed conditions, cotton was found profitable. The actual yield was much more than the breakeven yield during 1990-91 to 1998-99. The actual yield was much more than the breakeven yield during 1990-91 to 1998-99. The only exception was found during the year 1992-93. This was because during this year (1992-93) the breakeven yield was excessively high at 144.53 kg./hect. However, the price reduced from Rs. 2001.36/qtl. to 1004.30/qtl., while the variable cost increased from Rs.

*Note:* Yield Gap-I: It is the difference between the potential yield and the potential farm yield or the demonstration plot yield, Yield Gap-II: It is the difference between the potential farm yield and the actual yield and Total Yield Gap: Yield Gap-I + Yield Gap-II.
Navadkar D.S., Birari K.S. and et. al. (2004) have observed in their research work “Factor Influencing the Yield Gap for Sugarcane and Cotton in Maharashtra” that there existed a gap for all the inputs and output as well. The highest magnitude was noticed for the use of manures (86.01 per cent), followed by phosphoric fertilizers (56.67 per cent). There was a yield gap of 44.84 per cent of cotton output. Sixty nine per cent variations in the yield gap of cotton were jointly explained by the independent variables included in the functional analysis. The human labour, phosphatic fertilizer, expenditure on seed and plant protection and number of irrigations were the important variables minimizing the yield gap in cotton cultivation. The increase in area under cotton and use of bullock labour would result in increasing the yield gap. The co-efficients of N and K were negative but non-significant.

Thakare A.B. and Nugpure S.C. (2004) have reported in their article “The Impact Assessment of Agricultural Technology (i.e. Water Harvesting and Recycling Technique) on Cotton Production in the Yavatmal District of Central Vidarbha Zone of Maharashtra” that the beneficiary farmers had utilized the land more efficiently under double crop in addition to the irrigated area, whereas, the non-beneficiary farmers had brought their land under rabi crop only (with the available irrigation). Cropping intensity was more in respect of beneficiary than non-beneficiary farmers. They have also worked out that the total yield of 13.5 quintals with gross return of Rs. 25990 was recorded by the beneficiary farmers while the corresponding figures for non-beneficiary farmers were 8.9 quintals and Rs. 17130. The net returns had been found to be Rs. 15540 for the former and Rs. 5850 for the latter farmers. They have further worked out the cost-benefit ratio was 2.49 for beneficiaries and 1.52 for non-beneficiaries. It showed a clear impact of the agricultural technology on production of cotton.

Dhandhalya M.G. and Shiyani R.L. (2006) have estimated the yield gaps in their research paper “Yield Gaps, Constraints Prioritization and Potentials of Cotton Production in Saurashtra Region”. They have adopted the methodology developed by International Rice Research Institute (IRRI) to estimate the magnitudes of yield gaps. They have described that the yield gap was the difference between potential yield and
actual yield. The difference was explained by a number of constraints-biological, physical and socio-economic. All these constraints together accounted for the total yield gaps. They decomposed the total yield gap into two parts viz., yield gap I and yield gap II. They have explained that the yield gap I was the difference between experiment stations average attainable maximum potential yield and on farm experiments average maximum yield. Whereas, yield gap II was the difference between yield attained in on-farm experiments and the average actual farm yield. They have examined that the yield gap I was 49 kg./hect. and yield gap II was 936 kg./hect. Thus, the total yield gap (yield gap I + yield gap II) was 985 kg./hect., which was about half of the actual yield (2015 kg./hect.) obtained by the sample farmers. Further, the technology gap (yield gap I) was negligible but the extension gap (yield gap II) was substantially higher. The total yield gap constituted about 49 per cent of actual farm yield, which had largely attributed to the yield gap II (46 per cent of actual farm yield). The magnitude of yield gap II was as high as 936 kg./hect. due to high susceptibility of hirsutum hybrid cotton varieties to wide range of pests and they demanded more nutrients and frequent irrigation, which were quite inadequate in Saurashtra region.

Kumar Shiv, Devender and et. al. (2007) have examined in their paper “Impact of Contract Cotton Farming vis-à-vis Non-Contract Cotton Farming in Haryana State” that among the different size group of contract farmers and non-contract farmers the higher yield uncertainty was noticed in large farmers (42.71 per cent in contract farming and 45.91 per cent in Non-contract farming), followed by small farmers. It was due to more acceptance and rejection of cotton by the certification officers of the HSSCA to maintain the stringent quality parameters as per norms of seed certification standards. They have concluded that the contract farmers had less yield uncertainty than that of non-contract farmers of cotton in Haryana due to better quality seed supplied and a steady technical and financial guidance rendered by the trained personnel of private cotton producing firms.

Shah V.D. (2007) has conducted a research project on “Returns to Bt Cotton vis-à-vis Traditional Cotton Varieties in Gujarat State” and found that the average yield of Bt cotton was 32.20 qtls./hect. for both the districts (Rajkot and Vadodara) taken together, which was 28.44 per cent higher than that of 25.07 qtls./hect. for non-
Bt cotton. He revealed that Bt cotton and non-Bt cotton farmers of Rajkot district obtained about 12 per cent and 18 per cent higher yield respectively than that for Vadodara district. He also observed that the yield level of Bt cotton was found highest (34.34 qtls./hect.) for medium landholding farmers, wherein it was observed lowest (29.24 qtls./hect.) for small landholding farmers, while the yield performance of non-Bt cotton was found highest (26.95 qtls./hect.) for large farm size group and it was lowest (21.07 qtls./hect.) for small farm size group.

He has further noted that in his research project that the average Bt yields were higher but the difference in the yield levels under irrigated and unirrigated was not consistent in Andhra Pradesh, while the yield of Bt cotton irrigated was significantly higher in Maharashtra and Tamil Nadu. There was not consistent yield difference between farm sizes. He has also observed that the average yield of Bt cotton over non-Bt cotton was higher in all four study States and it was higher by 18.2 per cent in Andhra Pradesh, 28.4 per cent in Gujarat, 46.4 per cent in Maharashtra and 28.5 per cent in Tamil Nadu.

Narala Anuradha, Patel G.N. and et. al. (2009) have derived in their study “An Economic Analysis of Integrated Pest Management (IPM) Technology in Cotton Production in Vadodara District of Gujarat” that there was no significant difference in yield of cotton between IPM (23.38 qtls./hect.) and Non-IPM farmers (21.85 qtls./hect.) during 2003-04. The net incremental gain to the farmers, due to adoption of IPM, was Rs. 4163.22 per hectare (58.20 per cent). The benefit-cost ratio for IPM farms was higher (1.37) compared to Non-IPM farms (1.23). Thus, IPM package was providing the cotton farmers a profit of Rs. 37 for every Rs. 100 invested per hectare. This gain was mainly attributed to the reduction in pesticides cost, better prices and marginal increase in the yield of cotton.

**Conclusion**

The studies reviewed indicate that for cotton, the productivity performance was poor in the 1970’s but it was relatively better in 1980’s and 1981-96. The yield level was increased considerably during 2000’s due to the adoption of Bt technology had played a key role in increasing the production and productivity of cotton. The majority of the studies show that productivity performance had improved but
significant variation in the growth of productivity of cotton was observed. All studies reviewed show that the average yield of Bt cotton over non-Bt cotton (both hybrid and desi) was higher. Further, human labour, fertilizers, expenditure on seed and plant protection and number of irrigations were important variables for minimizing the yield gap in cotton cultivation.

[D] Other Cotton Related Review of Literature

Ramaswamy P. and Sastry Peri M.V.V. (1970) have analyzed the co-efficients of correlation between area and production of cotton as well as production and productivity of cotton in their research paper “Recent Trends in and Relationship between Area, Production and Productivity of Cotton in India”. The production, area and productivity of cotton were worked out with the year 1956-57 as the base for the Indian Union and the eight important cotton growing states of Andhra Pradesh, Gujarat, Madhya Pradesh, Maharashtra, Mysore, Punjab, Rajasthan and Tamil Nadu were taken into consideration. The period of the study was from 1956-57 to 1968-69. They have worked out that the correlation co-efficient between production and area and also between production and productivity were both statistically significant at 5 per cent level for the Indian Union. The relationship between production and productivity was stronger than that between production and area. They have further worked out that the state level correlation co-efficients between production and productivity and found that they were highly significant in almost all the states, whereas, the correlation co-efficient between production and area was seen to be significant in the case of Andhra Pradesh, Tamil Nadu and Punjab only. They have indicated that the growth in the output of cotton had a greater bearing on the technological developments in the field of Indian farming than on the area planted with cotton. Finally, they have suggested that any additional production of cotton henceforth will have to be achieved almost entirely by improving productivity. Raising the yield level, therefore, should be the central objective around which the future strategy for cotton development required to be planned.

Patel M.K. (1984) has presented the comparative cost of ginning of kapas of ginning factories of the three agencies for 1978-79 in his article “Economics of Seeds Processing - A Case of Cotton in Gujarat”. He selected eight ginning centres where the sample seed growers got their seed cotton (kapas) ginned for detailed study, viz., 5
centres were co-operative ginning, 2 were seed kapas co-operative ginning centres and one was the private one. This study was based on the information gathered from the three alternative cotton ginning agencies. He has worked out that the total cost of the ginning was Rs. 26149, Rs. 25259 and Rs. 12339 in the case of Co-operative ginning factories, seed crop (kapas) co-operative ginning factories and private ginning factory agencies respectively. He has further estimated the item-wise cost of ginning. The salaries of staff and labour wages alone were 41.16 per cent, 67.50 per cent and 53.01 per cent of the respective total cost of the co-operative, seed crop co-operative and private agencies. Whereas, the remaining cost was on account of insurance, oil, electricity bill, depreciation, interest on fixed investment etc. The agency of co-operative ginning factories was found to be relatively more efficient as its operating cost was lower as compared to that of the other two categories of ginning factories. He has further estimated that the overall average cost of ginning one kilogram of kapas was only Rs. 0.26. However, in actual practice the seed growers paid Rs. 1.22 per kg. of kapas to the agencies. He has concluded that the ginning charges were four times higher than actual ginning cost. Similar conditions prevailed with regard to the other ginning factories (32) in Gujarat.

Umapathi T.S., Karamathullah N. and et. al. (1994) had carried out in their study on “Estimation of Implicit Market Prices of Quality Characteristics of Cotton in Davangere, Karnataka”. They had focused on the important characteristics of cotton and its relationship with price. This study was based on the primary data collected from the buyers of cotton kapas (unginned cotton) in Davangere cotton market in Chitradurga district of Karnataka. They had selected five cotton lots for three genotypes, viz., DCH-32, LRA and Jayadhar on each day. Thus, in all 150 lots were evaluated over 10 days with the help of personal interviews with the buyers of cotton kapas in the market. They had used three Hedonic price models for the evaluation of the objectives of the study, viz., linear model, semi logarithmic model and logarithmic model. These models were used with quality characteristics, viz., staple length (mm), staple strength (gm/texture), staple length uniformity (per cent), micronaire value (numerical value), trash content (per cent) and colour (scores 1 to 5). They had reported that the selected quality characteristics were strongly associated with each other. They had revealed that price and quality characteristics were closely related. They had further reported that staple length, staple strength, staple length uniformity
and fineness had affected the price at 1 per cent level of significance, while colour affected the price at 5 per cent level of significance. Positive co-efficients indicated that as the value of the variable increased, the price also increased. Staple length, staple strength, colour and fineness had significant positive effects on the price of cotton kapas. Moreover, the staple length and staple strength of cotton kapas were the strongest determinants of the price with a co-efficient of 0.43 and 0.17 respectively. Colour was found to be another significant factor in determining the price of cotton kapas. Length uniformity and fineness were looked for their levels since these were important in the manufacture of both carded and combed yarn. Whereas, other two characteristics, viz., maturity level and trash content had no significant effects on the price of cotton kapas. The results under all the three models revealed that staple length was the only characteristic that affected the price of cotton lint. The other characteristics were found to have non-significant effects on price. The standardized regression co-efficients revealed that staple length alone had explained 79 per cent of price variation. Thus, there was a large demand for staple length from the fabric manufacturers.

Edge Julie, Benedict John and et. al. (2001) have observed in their research article “Bollgard Cotton: An Assessment of Global Economic, Environmental and Social Benefits” that the negative effects of insecticides on non-target animals found in streams, rivers and ponds would reduce due to the reduction in the use of insecticides. They have further pointed out that assuming an average reduction of per hectare 2.2 sprays on the 972000 hectares cotton produced in 1998 in the US actually implied that 962280 kg. insecticide active ingredients did not enter the environment and local watersheds and thus the potential exposure to non-target animals and farm workers was reduced.

Shanmugam K.R. (2003) has analyzed in his study “Technical Efficiency of Rice, Groundnut and Cotton Farms in Tamil Nadu” that both land and fertilizer variables turned out to be significant determinants of cotton crop. However, landholding size positively and significantly (at 10 per cent) influenced the Technical Efficiency Levels of farmers, which indicated that the Technical Efficiency raising cotton crop increases as the land holding size increases. Fertilizer variable also influences positively the yield levels of cotton crop. The average TE value of raising
cotton in Tamil Nadu was 68 per cent. Therefore, there was considerable room for improvement in the productivity of sample farms. They have also analyzed that in almost 30 per cent of the sample farms that raise cotton, the TE was below 60 per cent, which indicated that they could cut their input resources up to 40 per cent without any production loss. Their analysis has also showed that the farmers having larger area were more efficient in cultivating cotton crop, which indicated that the small farmers should follow the practices followed by the big farmers to reap more yield or they would have to from cotton cultivation to some other crops for which they were efficient.

Singh Alka, Kumar Ranjit and et. al. (2007) have calculated in their article “An Economic Evaluation of Environmental Risk of Pesticide Use: A Case Study of Paddy, Vegetables and Cotton in Irrigated Eco-system” the average per hectare quantity (kg. active ingredient), number of applications and expenditure incurred on each category of pesticides (insecticides, fungicides and herbicides) for Non-IPM and IPM farms separately for paddy, vegetables and cotton in the sample area. They had concluded that per hectare consumption of pesticides was found to be 2.71 kg. and 2.01 kg. on Non-IPM and IPM farms respectively in the cotton cultivation, out of which the use of fungicides was found to be extremely low and none of the farmers used herbicides. In the study area, the cotton farmers were used mostly Ethion, Acephate, Trizophos and Monocrotophose in cotton cultivation. Hence, they had concluded that not only the intensity of pesticide use but also the high-risk pesticides were being used in crop production in the study area. In the case of cotton, 80 per cent of farmers had practiced deep ploughing, timely planting and destruction of crop residues in the study area. Further, they have noted that only 10 per cent of farmers had reported that they had used pesticides on the basis of economic threshold levels of pest infestation in cotton growing areas. They have also concluded that eco-ratings had reduced 31 to 40 per cent cotton cultivation in different environment categories due to IPM practices. They had noted that a market exists for environment friendly pesticides in the study area and farmers were willing to pay a premium price for reduction of pesticide hazards. Hence, they had suggested that pesticide risk to environment could be successfully reduced by developing farmers’ own capacity by imparting information and awareness, development of simple and safer methods of
pest control and assuring their adequate supply would go a long way in reducing pesticide risks to the environment.

Singh Alka, Vasisht A.K. and et. al. (2008) have examined in their research study “Adoption of Integrated Pest Management Practices in Paddy and Cotton: A Case Study in Haryana and Punjab” the adoption of IPM practices on cotton in Punjab and on Paddy in Haryana and have assessed the impact of key socio-economic and institutional factors on IPM adoption. They have used the poisson count regression models for the analysis technology adoption. The primary data was collected for the year 2003-04 from a sample of 95 cotton farmers from the Bhatinda and Ferozpur districts of Punjab. They have pointed out that the highest number (88 per cent) of sample farmers were mainly influenced by the private pesticide dealers, followed by fellow farmers and media sources (64 per cent) and State Department of Agriculture and State Agricultural University (60 per cent). Whereas, about 50 per cent sample farmers had consulted extension personnel before going for insecticide application. They have also reported that the awareness generation about technology through formal crop-specific IPM training provided by the farmers’ field schools was found extremely effective in wider adoption of IPM in the study areas and hence, investment in IPM education through these programmes would have long-term beneficial impact.

Regarding effectiveness of extension services, this study has not shown any statistically significant impact on IPM adoption rates. Mixed evidence was observed about the relationship between farm size and adoption of IPM practices. They have concluded that a higher gross value of crops had no positive impact on IPM technology adoption in cotton. They have further found that in case of cotton, formal IPM training, knowledge level of farmers regarding adverse impact of pesticides on environment, farm-size and gross value of crop turned out to be significant in explaining high IPM adoption score. The co-efficient of gross value of the crop turned out to be negative, indicating risk adverse nature of farmers. They did not have much faith in alternative pest control technology in combating the pest menace.

Dodamani M.T., Rajur B.C. and et. al. (2009) have reported in their article “Study on Quantification of the Cotton Growers Alienation from Land in Karnataka State” that the alienation refers to State of mind where farmers develop estrangement or negative attitude towards land. In this study this variable was quantified by considering various dimensions of alienation such as powerlessness, meaninglessness,
isolation and self-estrangement of cotton growers. The study was based on the data collected from a sample of 200 farmers in villages in Haveri and Shiggoan talukas from Haveri district and Bellary and Siraguppa talukas from Bellary district in the Karnataka State. In this investigation, the selection of districts, talukas and villages were based on the criteria of highest area under cotton cultivation and more number of farmers’ suicides in the selected area. The results of the study shows that the cotton production had become meaningless to farmers due to certain factors such as uncertain rain and drought, too low credit cap and non co-operative attitudes from family members. About 40 per cent of small farmers and 48 per cent of big farmers were belonged to high meaninglessness category, followed by low meaninglessness category. This statement indicates that there was no guarantee of remunerative market prices for cotton and received prices were not based on the cost of cultivation. This study also found that cotton farming was meaningless and credit cap is too low than that of requirements. Moreover, the cotton farming was at loss and the price was not obtained on the basis of inputs expenditure and therefore, the area under cotton was reduced. These statements were high rated by the sample respondents and it also supported more number of the cotton growers which belonged to the high self-estrangement category.

Gandhi Vasant P. (2011) has, in his research study “ICT Based knowledge and Information System for Brand-Variety Selection by Farmers: Study and Design Using the Crop-cutting Survey System in Cotton” noted that various advantages and disadvantages existed between the Bt varieties versus non-Bt varieties. This study covered a stratified random sample of 694 cotton farmers spread over four major cotton states, namely, Andhra Pradesh, Gujarat, Maharashtra and Tamil Nadu. The sample had covered almost equal numbers of Bt cotton and non-Bt cotton farmers, across small, medium and large landholdings (with and without irrigation for cotton). The field survey was conducted in 2004-05. He has noted that Bt cotton had a statistically significant impact on the yields (significant at 99 per cent level). He has also observed that Bt cotton yields was 30.71 per cent higher than that of non-Bt cotton. The impact on the value of output was also highly significant of Bt cotton. However, the total cost also increased and this was estimated to be 6.69 per cent higher than non-Bt cotton. While the pesticide cost was reduced by 23.98 per cent, but the seed cost increased by 168.77 per cent of Bt cotton. He had further noted that the
difference in the output price between Bt and non-Bt cotton was positive but not statistically significant. The increase (87.58 per cent) in profit was found to be highly significant. The results of his study clearly indicated a strong economic advantage of Bt varieties over non-Bt varieties. However, the farmers find very little difference in the availability of seeds, fertilizer need, machine need irrigation need and market preference. He has also noted that a large number of farmers had reported disadvantage in the seed cost of Bt cotton whereas in respect of pest incidence, pesticide need, cotton quality, staple length, yield and profitability from Bt cotton cultivation, majority of farmers were seen advantage/strong advantage.

Singh Amrik, Bhalla J.S. and et. al. (2014) had prepared a research paper “Adoption Dynamics of Recommended Production Techniques of Bt Cotton (Gossypium Hirsutum L.) in Muktsar District of Punjab”. This study was based on primary data collected from Muktsar district of Punjab during the year 2013. All the four blocks of Muktsar district were selected for the study. The list of villages in which Bt cotton was cultivated was obtained from the Department of Agriculture and two villages from each block were randomly selected from the list. Further, from the list of Bt cotton growers in each village, 20 small, 20 medium and 20 large farmers from each village were selected. The researchers selected 160 Bt cotton growers for their study. They have found in their study that majority of the respondents had adopted recommended Bt cotton hybrids on their fields and had sown the seeds at proper time by using the recommended seed rate. Growing refuge was a vital practice in Bt cotton cultivation which was adopted by only 10 per cent of the sample farmers whereas foliar spray of potassium nitrate was practiced by 23.75 per cent of the sample farmers. They have further found that 39.38 per cent of the total selected farmers had used recommended chemicals, 58.75 per cent had used non recommended chemicals whereas 1.87 per cent had not used any chemical. Very few of the respondents had used non-conventional methods of pest control. They had also observed that Bt cotton growers were found to be using more number of sprays for sucking pests management as compared to bollworm management. Observation of Economic Threshold Level (ETL) was not found very popular among the sample cotton growers for adopting chemical control measures. They had concluded that all the recommended production techniques for Bt cotton were not adopted by the farmers. The important production techniques of Bt cotton viz., growing refuge, soil
testing, fertilizer application, spray of potassium nitrate, observing ETL level for sucking pest and bollworms were not adopted by the majority of the Bt cotton growers. They had suggested that farmers training should be intensified in the light of changing Bt cotton scenario. Farmers should be intimated about the proper selection of Bt cotton hybrid, the importance of refuge, judicious and need based use of pesticides and foliar spray of potassium nitrate.

Conclusion

The other studies reviewed reveal that the price of cotton and quality characteristics was closely related with each other. The staple length, staple strength, staple length uniformity, colour and fineness had significantly affected the price. The studies further reveal that a higher gross value of crop had no positive impact on IPM technology adoption in cotton. The formal IPM training, knowledge level of farmers regarding adverse impact of pesticides on environment, farm-size and gross value of crop turned out to be significant in explaining high IPM adoption score. Some studies showed that the recommended production techniques for Bt cotton were not adopted by the farmers. Moreover, a large number of farmers had described disadvantage in the seed cost of Bt cotton whereas in respect of pest incidence, pesticide need, cotton quality, staple length, yield and profitability from Bt cotton cultivation, majority of farmers were seen advantages.
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