DIVERSITY IN CULTIVATION OF Bt-COTTON HYBRIDS IN HAVERI DISTRICT - AN ECONOMIC ANALYSIS

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INTRODUCTION

Cotton (*Gossypium* spp.) “the Queen of fibers” is multipurpose crop grown under various agro-climatic conditions. Cotton is an important fibre crop of global significance, and cultivated in tropical and sub-tropical regions of more than seventy countries, the world over. The major producers of cotton are China, India, USA, Pakistan, Uzbekistan, Argentina, Australia, Greece, Brazil, Mexico and Turkey. These countries contribute about 85 per cent to the global cotton production. India has the largest area (11.98 m. ha) under cotton at global level and has the productivity of 518 kg lint/ha and ranks second in production with 365 lakh bales after China during 2012-13.

World cotton production was 118.95 million bales (480 lb) in 2012-13 (USDA, February 2013). India continued to maintain the largest area under cotton and second largest producer of cotton next to China with 34 per cent of world area and 21per cent of world production. China is going to be the largest importer around 14 million bales of cotton in this year (2012-13) and share of 34 per cent of the world total cotton imports. China also likely to emerge as a leader to stock large cotton reserve, and it is estimated to be around 52 per cent followed by India with 10 per cent of the world cotton reserve. United States continues to be the largest exporter of raw cotton and expected to export around 12.5 million bales which are 31per cent of the world total exports, followed by Brazil, India and Australia. China, India and Pakistan continue to be the largest consumer of raw cotton this year also (2012-13). (65 per cent of the total world raw cotton consumption by these countries). Among the major cotton growing countries, Australia tops the productivity level with 2055 kg/ha followed by Brazil and Turkey (1415 kg/ha).

Cotton Production in India – Current Scenario

Indian cotton production during 2012-13 will be 334 lakh bales as per the projection of cotton Advisory Board (CAB). There is a decline in cotton production to a tune of 19 lakh bales when compared with the previous season. This was mainly due to the decrease in cotton area. There was a decline of 5.64 lakh ha in cotton area during this year in the country. Highest contribution to this decline was from the state of Gujarat where there was a decline of 5.99 lakh ha. Except Andhra Pradesh, Orissa and Maharashtra all other states experienced a decline in cotton area. In Andhra Pradesh cotton area increased by 2.61 lakh ha. In Maharashtra and Orissa the increase was marginal. Cotton yields also recorded a decline but it was offset by the increased productivity in other states. In North zone about 69 per cent, in central zone about 50 per cent, in south zone 56 per cent cotton arrived in the market during the current season. Per day arrivals ranged between 2.30 to 2.35 lakh bales.

India’s cotton area represents 25 per cent of the global area of cotton, in the past it produced only 12 per cent of world production because Indian cotton yields were among of the lowest in the world. The advent of Bt. cotton over the last 8 years has coincided with almost a doubling of productivity from 308 kg/ha in 2001 to 518 kg/ha in 2012-13, mainly attributed directly from Bt-cotton.

Cotton occupies a predominant place among cash crops touching the country’s economy at several points by generating direct and indirect employment in the agricultural and industrial sectors. Cotton occupies a place of pride being the prime supplier of raw material (85 per cent) for textile industry, which is one of the leading industries in the country. Cotton industries provide means of livelihood for about 250 million people through its cultivation, trade and industries in India. Commercially cotton is one of the best export earning commodities in the country. Textiles and related exports of which cotton constitutes nearly 65 per cent, accounts for nearly 33 per cent of the total foreign exchange earnings of the country (Bhagirath and Kadambini, 2010).

Over 150 different insect pests species are reported to attack cotton at various stages of its growth causing sever reduction in yields and resulting in massive pesticide use by farmers and high cost of cultivation. It is estimated that over 55 per cent of the pesticides sold in the country are used on cotton. As a result of this situation, farmers have been highly dissatisfied and have been looking for cotton varieties that have pest resistance. It was at this juncture that the transgenic Bt-cottons arrived in the world and then in the country.

It was after much hesitation and delay that the Government of India allowed the cultivation of three genetically modified Bt cotton hybrids in April 2002 for a period of three years. This followed the controversial unauthorized cultivation of Bt cotton hybrids in some areas of the country. Analysis from several years of Indian trial data had demonstrated the superiority of Bt technology in terms of reduced pesticides application and increase in effective yield. The impact assessment commissioned by Mahyco and Monsanto Biotech claimed sizable benefits for Bt technology adapters. However anti biotechnology activist declared the technology as a complete failure. Even though the performance of Bt cotton has been projected to be satisfactory in government circles, there is great discontent in different quarters with Bt cotton. Strong views both for and against Bt technology have surfaced. The major advantage claimed for Bt cotton include reduction in the use of insecticides (almost 50 %), reduction in the harmful effect on the environment, good quality of cotton fibre at par with that of non-Bt cotton, better yield per unit of input use, and lesser residue of pesticide in the fibre resulting in reduced harmful effects such as allergic reactions (Graham and Peter, 2013).

Despite these concerns Bt cotton cultivation has spread quite rapidly in India than elsewhere and farmers in developing countries are willing to adopt this technology. In view of the above mentioned diverse views on Bt-cotton and considering the importance of cotton in Indian agriculture, a good number of private seed companies have come out with Bt-cotton cultivars. Each one of them are having different features and yielding abilities so it seemed important to undertake a comprehensive and systematic study on economic returns and other related aspects of important Bt-cotton cultivars.

Biodiversity

The concept of biodiversity has passed from the domain of academic specialists to the widespread attention of the popular press in the past decade. The general public and policy makers are increasingly aware of the scope and seriousness of the disappearance of the earth's genetic heritage. Although much of the debate focuses on animals and wild plant species, there is growing recognition that the diversity of cultivated crop species has vastly diminished, affecting the livelihoods of resource-poor farmers and threatening the future of agricultural development. Modern agricultural technology has helped tremendously in increasing the food production in India and in other parts of the world. The spread of modern high yielding varieties was the most important part of this technology. The expansion of area under high yielding varieties gradually replaced the traditional varieties resulting in narrowing the field diversity of cultivated crops. The new agricultural technology threatens to narrow the genetic-base of the cultivated crops called as genetic erosion. There is an active debate surrounding the relationship between dissemination of high yielding modern varieties (MVs) and erosion of plant genetic diversity, as the former is often argued to have the potential to induce genetic uniformity rather than crop diversity(Krishna, *et al.*,2008) The 'genetic erosion hypothesis' – that is, adoption of modern high yielding varieties eliminate the diversity of indigenous crop varieties, as proposed by Harlan (1975) – got significant support in literature (e.g. Fowler and Mooney, 1990; Berg *et al.,* 1991; Pretty, 1995). Wood and Lenne (1997), however, raised a completely different perspective that the diffusion of new varieties could only be one of the multiple intervening factors behind loss of landraces. According to them, modern varieties are also capable of maintaining and facilitating the genetic diversity, rather than inevitably replacing the landraces.

Agro biodiversity or crop varietal diversity is the part of biodiversity that is directly relevant for agricultural production. It includes the genetic diversity within and between crops and animals used for agricultural production. Biodiversity that closely interacts with crops is usually considered part of agro biodiversity. It includes pests, diseases, soil organisms, pollinating insects, etc. (Almekinders, 2001).The function of agro biodiversity in agricultural systems is still poorly understood. The objective to increase agro biodiversity for more sustainable agriculture is still largely based on assumptions and anecdotal information, rather than on solid ecological and socio-economic evidence. Varietal diversity, broadly defined as the extent of dissimilarity among a set of varieties, is increasingly recognized as important to crop production and has commanded growing attention from research in recent years.

Farmers and agricultural policy makers may have an interest in varietal diversity because no single variety can completely resist or tolerate all potential stresses, and yield reduction from a particular stress may be lower, on average, when there are more sources of stress tolerance. By providing a broader base of stress tolerance, varietal diversity may also reduce yield variability when pest infestations strike or bad weather occurs.

An important gap in the diversity literature is the lack of research addressing the impact of varietal diversity on yield and income of farmers. In industrialized countries, most studies on crop diversity are limited to genetic analysis of varieties and breeding stock and they rarely addressed the impact of diversity in developing countries, little is even known about crop diversity, and virtually nothing is known about the varietal diversity and how it affects production and income at the household and regional or national level. Therefore this study is planned to assess the impact of hybrid diversity in cotton on yield, income and employment levels in Haveri district with the following specific objectives.

Objectives

1. To analyze the growth in area, production and productivity of cotton in Haveri district.
2. To study the extent and magnitude of diversity in cultivars of Bt-cotton.
3. To estimate the cost and returns of major Bt- cotton hybrids.
4. To examine the technical and allocative efficiency in Bt- cotton hybrids cultivation.
5. To study the factors influencing the preference of Bt-cotton hybrid.

Hypotheses

1) There is a positive growth in area production and productivity of cotton in Haveri district.
2) There is diversity in cultivars of Bt-cotton.
3) Cost and returns are different for different Bt-cotton hybrids.
4) There is technical and allocative efficiency in cultivation of Bt-cotton hybrids.
5) Many factors influence the preference of Bt-cotton hybrids.

Limitations of the study

Since, the data were collected by survey method and responses were mostly from recall memory of the respondents; the inherent lacunae associated with this type of enquiry might have crept in to the study. However, the degree of discrepancy if any would be negligible as estimates presented are averages.

Presentation of the study

The study has been presented under six chapters as indicated below

Chapter – I deals with the nature, importance, specific objectives of the study.

Chapter – II describes comprehensive review of the relevant research work done in the past related to the present study.

Chapter – III outlines the features of the study area, sampling design followed, types of data, method of data collection, analytical tools employed.

Chapter – IV contains the findings of the study presented under appropriately titled tables and graphs.

Chapter – V discusses the results presented in the previous chapter.

Chapter – VI provides summary of the whole study and brings out the policy implications based on the findings of the study.

At the end important references relating to the present study have been listed alphabetically. In the appendix, the schedule used for the study is presented.

REVIEW OF LITERATURE

With a view to evaluate the objectives of the study, it was considered desirable to have an idea of the findings of some earlier research and the methods adopted for arriving at the same. Such a review of literature connected with the main objective of the study, it is hoped, would provide a basis either for confirming the earlier findings or for contradicting the same and thereby to suggest points of departure for further studies. Consistent with the objectives of the study, the review of literature is presented in this chapter under the following heads:

2.1 Growth in area, production and productivity of crops.

2.2 Extent and magnitude of diversity in cultivars and cultivation.

2.3 Cost and returns of major crops.

2.4 Technical and allocative efficiency issues.

2.5 Factors influencing the preference of hybrid crops.

2.1 Growth in area, production and productivity of crops.

Tripathy (1993) examined the temporal and spatial variations in the growth rates of area, yield and production of major crops in Orissa state, India during two periods i.e., 1970- 71 to 1979-80 and 1980-81 to 1989-90. Semi-logarithmic trend equations were fitted to the annual time series data to obtain growth rates. It was found that food grain production in the State increased at the rate of 2.21 per cent per year during the period and the major contribution was from maize (6.8%) followed by pulses (6.81%), jowar and bajra (5.06%) and ragi (3.63%).

Shankaran (1994) worked out the compound growth rate of area, yield and production of sorghum at All-India level by classifying the study period into pre-green revolution (1950-51 to 1964-65) and post-green revolution (1967-68 to 1992-93) periods. In the first sub-period both area and yield of sorghum have increased at the rate of 0.91 per cent and 2.2 per cent per annum, respectively which led to a 2.9 per cent per annum increase in the production. The result further revealed that the area of sorghum declined by 0.94 per cent per annum during the post-green revolution period, whereas productivity grew at 1.84 per cent, which offset the decline in area and ultimately the growth in production of sorghum was 1.2 per cent per annum. For the entire period (1950-51 to 1992-93), the author reported that although the area under sorghum declined by 0.47 per cent per annum the yield and production increased at the rates of 1.51 per cent and 1.27 per cent per annum, respectively.

Vani and Vyasulu (1996) studied the growth rates for three important cereal crops in Karnataka, namely rice, jowar and ragi in the three sub- periods 1955-56 to 1964-65, 1965-66 to 1979-80 and 1980-81 to 1989-90. The results indicated that, in the case of rice there was a positive growth rate in the production and yield over the entire period and a negative growth rate in area. In the case of ragi, the growth rate of production was higher than that of rice. A positive growth rate in area and production over the entire period with the highest growth in the second sub period was reported. In the case of jowar, there was a high growth rate in area and production in most of the districts. Productivity in most of the districts was high in the second period compared to the first and third sub periods.

Sawant (1997) studied the growth performance of India's agriculture sector during different periods. Compound annual growth rates were estimated by fitting a log-liner trend function for two periods viz., Period-I (1968-69 to 1980-81) and Period-II (1981-82 to 1994- 95). The growth scenario for pulses indicated that from acute stagnation in output in the early part of the green revolution period, the situation improved to a positive significant but low growth in output (1.00% during period – II). The former was the outcome of low pace of expansion in area accompanied by decline in the yield per hectare of pulses, while, in the post 1981 period expansion in pulses output was totally induced by growth in their yield per hectare (growth rate of 1.00%). The dismal performance of the two major pulses, namely, gram and tur, was largely responsible for low level of productivity growth for all pulses after 1981. By and large, pulses represented a group of growing crops throughout green revolution period.

Uttar *et al.* (1999) studied impact of modern cultivars on growth and relative variability in sorghum yields in India. The analysis was on the secondary data, collected from 146 most important sorghum-growing districts in India. (Madhy Pradesh, Andra Pradesh, Karnataka, Tamil Nadu, Maharastra, Gujarath and Rajastan). The Secondary data were assembled by the international crops

Research for the semi-Arid Tropics (ICR ISAT) and the World Bank largely from the season crop reports and statical abstracts of the concerned states. Regression analysis was used to examine the impact of modern cultivars and other important factors on sorghum yields. The study revealed that there was a wide difference in yields level of sorghum in different district. The per hectare yield level has increased during 1981-82 to1993-94 compared to 1966-67 to1980-81 in majority of the districts in India. Modern sorghum cultivars contributed to higher level of yield. The study also revealed that the expansion of modern sorghum cultivars helped to increase sorghum yield and reduced the relative variability in yield of sorghum in India.

Girma (2002) studied growth and instability of cotton production in Karnataka. The researcher has used secondary data for the study. Secondary data were collected from the Directorate of Economics and Statistics, Bangalore for a period from 1970-71to 1989-99 Compound growth rate, or thogonal polynomial regression analysis, coefficient of variance factor analysis and Nerlovian price Expectation –cum-Area Adjustment model were among the analytical techniques employed for analysis. The study revealed that growth performance of cotton production in Karnataka was more pronounced (2.9%in period I, 4.55% in period II) during period II due to significant growth in both area and productivity, while in period I yield was sole contributor. Production instability increased in the second period because of area variance (48.03%), yield variance (22.44%) and interaction between changes in mean yield (11.8%). Acreage response analysis indicated that cotton area was elastic with respect to lagged relative price, expected yield, lagged acreage and the time variables.

Singh *et al.* (2004) reveled that rice and wheat have come to contribute around three-fourths of India's food grains production in 2000, up from just one- half in 1950's. The food grains production itself having increased by four times from 50 million tonnes in 1950 to 200 million tones 2000' Punjab has been known for wheat for too long in history. Its productivity increased by more than five times in five decades (1950-2000), area by three times and production by more than fifteen times. Its productivity continues to increase at the growth rate of more than two per cent. Its yield variability across districts has declined over time

Hasan *et al.* (2008) studied the changes and instability in area and production of wheat and maize in Bangladesh. Time series data on area, production, and yields of different cereal crops for 24 years from 1980-81 to 2003-04 were collected from different issues of the Statistical Yearbook of Bangladesh. The whole period was divided into two periods viz., period-I from 1980-81 to 1991-92 and period-II from 1992-93 to 2003-04 to compare area, production, and yield between the two periods. Statistical measures, such as mean, correlation co-efficient and co-efficient of variation were worked out. Study revealed that in the last two decades, the maize area has increased by more than three times, while its production has increased by fifteen times. Area and yield of maize showed remarkable degree of instability during two periods. The overall trend of maize production in Bangladesh was quite satisfactory. The average yield of maize was double in period-II compared to period-I. Growth rate in production and yield of maize was greater than the growth rate in area.

Borkar *et al.* (2010) examined the growth rates and extent of variability in area, production and productivity of cotton in Vidarbha region of Maharashtra state. The Vidarbha region of Maharashtra state constituting of two divisions i.e., Amravathi and Nagpur region, were purposefully selected. The study was based on secondary data collected from various government publications and pertained to a period of 26 years i.e., from 1980-81 to 2005 -06. To estimate the growth rate of area, production and productivity of cotton, the period was grouped into, i.e., period-I (1980-81 to 1992-93) and period-II (1993-94 to 2005- 06). From this study it is concluded that, the Vidarbha agriculture has observed definite change in the cropping pattern. Soyabean attained important position in the cropping in both divisions. The magnitude of variability in area and production was observed to be small in Nagpur division whereas, productivity has been comparatively small in Amravathi division.The proportion of area under cotton in kharif in total cropped area has reduced in both divisions. The growth rate of area and yield has decreased in period II in both divisions.

Barakade and Lokhande (2011) studied the trends in area, production and productivity of onion in Maharashtra. The researcher has used secondary data for the study. Secondary data were collected from the various published and unpublished sources. The other requisite data were also collected from the various publications and websites of Directorate of Economics and Statistics Government of India and Department of Agriculture, Maharashtra state. The data have been collected for the period from 1974-75 to 2007-08. The study has used basic statistics viz.Arithmetic mean, standard deviation and co-efficient of variation to know the average position and variability in the acreage, production and productivity of onion in Maharashtra in comparison with India. To know the growth rates of area and productivity during the overall period, the compound growth rates were also estimated. The study revealed that acreage under onion in Maharashtra and India has shown large amount of variation over the last three decades. There were also wide fluctuations in the onion production and productivity. The fluctuation in area and production of onion, however, were roughly in linear fashion. The state and country has experienced the continues increasing trend in both area and production of onion since 1974-75 to 2007-08.

Saraswathi *et al.* (2012) studied the growth in area production and productivity of major crops in Karnataka. The secondary data on area production and productivity of different crops were collected for a period of 26 years from 1982-83 to 2007-08. Data used for the study was collected from various published sources from the Directorate of Economics and Statistics (DES), Bangalore, Karnataka. Time series data pertaining to area, production, productivity of vegetable and fruit crops was collected for the same period from Centre for Monitoring Indian Economy (CMIE) reports. The growth in the area, production, productivity of different crops in Karnataka was estimated using the compound growth function. Growth rates showed a significant positive growth in area under pulses, vegetable and species and fruits and nuts while cereals showed significant negative growth. The area under jower, bajra, ragi and minor millets experienced a substantial annual decrement. The area under rice has recorded a mild annual increment. The growth in area under oilseeds and commercial crops were negative and insignificant. Similarly the production of cereals, pulses, vegetable and fruits showed a significant positive growth. The production of oilseeds and commercial crops registered insignificant positive growth. The productivity of different crops recorded significant growth in the case of cereals, pulses and fruits. Productivity of oilseeds recorded moderately positive growth. The productivity of commercial crops registered insignificant positive growth and for vegetables the growth in productivity was insignificant and negative.

Anuradha and Reddy, (2012) studied the growth and instability of cotton production in India. The researcher has used secondary data for study. Secondary data was collected from Cotton Advisory Board, Ministry of Agriculture, and Government of India. The period of analysis was 1951-52 to 2010-11. The entire period was divided into six sub periods of ten years each. Further to study the growth before and after Bt cotton introduction, the period from 1993-94 to 2001-02 was taken as pre-introduction of Bt cotton period and from 2002-03 to 2010-11 as post- introduction of Bt cotton period. Compound growth rates of area, production and productivity of cotton were worked for different periods as well as for entire period by fitting exponential function. The study revealed that during the last period and in the post- Bt period there was a significant increase in area, production and productivity and registered high growth rate. This was due to introduction of Bt cotton in India. Although the cotton production and productivity was increasing, it was associated with many problems. Cost of production was escalating due to the rise in the prices of inputs. The prices of cotton were fluctuating from place to place and year to year making the production risky. Most of the cotton area was sown with Bt hybrids where seed cost was very high. The nutrient requirement was also high. Similarly the labour cost for cotton picking was also increasing exorbitantly. Since the Bt cotton matures early and because of synchronized bole bursting at one time the labour demand for cotton-picking increased abruptly.

2.2 Extent and magnitude of diversity in cultivars and cultivation of Bt-cotton hybrids

Duvick (1984) concluded in his study that genetic vulnerability did not at that time present a major threat to production of United States filed crops, according to a 1981 survey of US crop Breeding Directors. But plant breeders did regard genetic vulnerability as an important and potentially dangerous problem. The 1981 survey indicated that although the genetic base of the US filed crops production was not as in 1970 was still concentrated on a relatively small number of favored cultivars. Survey responses indicated that the genetic base of elite germplasm pool was wider and provided useful diversity than was usually supported.

Singh *et al.* (1985) studied the diversification of Punjab agriculture using time series data. They suggested that Punjab agriculture was getting more and more diversified. Fertilizer consumption, number of regulated markets, inequality in distribution of holding, percentage of irrigated area etc. were important determinants of diversification.

Gupta and Tewari (1985) used Herfindahl Index to find out the crop diversification in Punjab agriculture. The results suggested that farm income, experience, distance from nearest market and net worth were significant factors.

Hanley *et al.* (1995) discussed the problems in valuing the benefits of biodiversity protection. They considered two problems in valuing the benefits of biodiversity protection, firstly that preferences for biodiversity protection might be lexicographic rather utilitarian. Secondly, people might be poorly informed about the meaning of biodiversity, complicating the case if contingent valuation as a means of information provided. The authors proved that willingness to pay for biodiversity protection increased with the level of information provided.

Louette *et al.* (1997) studied the maize varieties and seed sources in a traditional community in Jalisco, Mexico, in which questions regarding relationship between genetic erosion and introduction of varieties released were discussed. The morphological diversity of local materials was shown to be enhanced by introduction of both improved cultivars and landraces from farmers in other communities. The geographical point of reference for defining local landraces was shown to be larger than the community itself. Farmers would satisfy seed obtained from other farmers in and outside the community as that of local landrace if it resembles their own according to the phenotypic characteristics they used to distinguish varieties. Maize diversity in that community turned out to be the result of a certain level of introduction of genetic material and not of geographical isolation.

Suresh (2003) studied rice varietal diversity and its conservation in Kerala. The study was based on both primary and secondary data. The primary data was collected from 300 farmers. Percentage analysis and Herfindahl index was employed to know the diversity at farm level. The result revealed that seventy four varieties were grown by the respondent farmers, which includes fourty nine modern varieties (66.22 %) and twenty five traditional varieties (33.78 %). Out of 300 respondents, 109 (36.33 %) respondents cultivated only modern varieties whereas117 (39 %) farmers cultivated only traditional varieties and 27 per cent of farmers cultivated both modern and traditional varieties.

Muttaleb *et al.* (2008) studied the diversity of rice varieties in Sunamganj district. Data were collected through multistage sampling procedure from six villages of Sunamganj district. A total of 102 farmers constituted the sample for the study. Data were collected through pre-tested structured interview schedule by face-to-face interview procedure. Rice varietal diversity was measured through rice varietal diversity index (VDI). The study revealed that majority (65.69%) of the farmers cultivated two to three rice varieties, 26.47 per cent farmers cultivated single variety and only 7.84 per cent farmers cultivated four to five varieties. Among the varieties, BRRI and dhan29 ranked first in respect of per cent of cultivated farmers (92.20%) and area (58.30%) followed by BR19. Overwhelming majority (69.30%) of the farmers had low to moderate rice varietal diversity while 26.47 per cent had no rice varietal diversity and only 3.92 per cent farmers had high rice varietal diversity.

Singh (2010) studied the genetic diversity for sustainability of rice crop in Punjab and its implication. The researcher has used both primary and secondary data for the study. For making production estimates, a survey on 'Prospects of rice crop in Punjab' was carried out by Punjab Agricultural University every year by taking a sample of about 1000 farmers. Data regarding shift in area, sowing time, seed rate, area under different varieties etc was collected. The data on varietal scenario have been used for this analysis. The Theil's Entropy Index (E) was used for measuring the diversification. The secondary data were also used to construct series of probable explanatory variables, explaining the yield of rice crop in the regression analysis. Study revealed that there was in general, increase in the number of rice varieties adopted by the farmers over time. In 1982 -83, only seven varieties with dominance of PR 106 were in cultivation. The number gradually swelled to fifteen in 1999 -2000. The varietal diversification index measured by Theil's Entropy index was 0.3591 in 1982 -83 which increased to 0.6246 in 1992 - 93, 0.8008 in 2002 - 03 and 0.8974 in 2007 -08.

Reshmi (2011) studied black pepper varietal diversity and its conservation in Kerala. The primary data was collected from 300 farmers representing different farm size groups. Percentage analysis and Herfindahl index was employed to know the diversity at farm level. Study revealed that fourty one varieties were grown by the respondent farmers, which includes twelve modern varieties (29.69 %) and twenty nine traditional varieties (70.73 %). It was observed that out of 300 respondents, seventy four (24.67%) respondents cultivated only modern varieties whereas forty four respondent (14.67 %) farmers cultivated only traditional varieties and 182 respondents (60.67 %) cultivated both modern and traditional varieties.

2.3 Cost and returns of major crops

Reddy *et al.* (1997) carried out a research on the comparative economics of cotton cultivation in Guntur district of Andra Pradesh. Results indicated that the total cost of cultivation for cotton is positively associated with farm size. Pesticides, labour and fertilizer were major cost components accounting for 60-65 per cent of total costs. Similarly, productivity of cotton was directly related to farm size .Gross returns, net returns and input –output ratios were directly associated with farm size.

Julie et al (2001) assessed the global economic, environmental, and social benefits. The study revealed that compared with conventional broad-spectrum insecticide use of bollgard cotton , there were many economic, environmental, and societal benefits associated with adoption of Bt cotton for insect pest management. These benefits have resulted in quicker and more widespread adoption by growers than any recently introduced conventional cotton insecticide, especially for a biopesticide specifically, the benefits of using bollgard Bt cotton in integrated pest management systems worldwide.

Rajendraprasad *et al.* (2001) studied the costs and returns of cotton production vis-à-vis its competing crops in Guntur district of Andhra Pradesh and reported that the per hectare expenditure on PPC in cotton was Rs.11,331.37. It is very high compared to Rs.4,217.92 in soybean-bengal gram cropping system, Rs.4,379.81 in soybean-red gram and Rs.1,334.00 in soybean-jowar cropping systems. The proportion of expenditure on PPC in total operational cost was the highest in cotton (41.33%) when compared to soybean-bengal gram (22.3%), soybean-red gram (27.04%) and soybean-jowar (9.83%). The gross return was also the highest in cotton i.e., Rs.29, 884.77 compared to soybean-bengal gram (Rs.27,802.84), soybean-red gram (Rs.29,171.42) and soybean-jowar (Rs.2,954.78) whereas net returns were very low in cotton compared to other cropping systems on account of high operational cost.

Damte *et al.* (2003) conducted study on costs and returns of wheat, paddy and cotton in Punjab state. The analysis indicated that the total cost of cultivation and returns from these crops have been increasing over the years. The total cost of cultivation of cotton per hectare at current price has increased by 94.13 per cent from Rs 1700.34 in 1972-73 to Rs 3300.95 in 1982-83. The total cost at current price increased farther by 333.71 per cent in 1993-94 over 1982-83 and fixed and variable costs by 439.02 per cent and 267.69 per cent respectively. Gross returns per hectare at current price from cotton crop increased by 68.40 per cent in 1981-82 over 1971-72 and returns over by variable by 28.28 per cent. But net returns from cotton have declined by 34.98 per cent over the 1972-73,which was due to drastic decline in the yield of cotton crop in the early eighties.

Ramasundaram *et al.* (2005) carried out a research on cost of cultivation of hybrid cotton under rain fed and irrigated conditions of central India, hybrid under rain fed conditions of south India and varieties under irrigated condition of North India. Study revealed that the per hectare total cost of cultivation of cotton varieties (Rs 25358) was relatively highest in irrigated north India followed by rain fed hybrid cotton of south India (Rs 22637), irrigated (Rs18958)and rain fed (Rs 15640) hybrids of central India. The variable cost accounted for 83 per cent of total cost of cultivation of the hybrids cultivated in rain fed central zone followed by 81 per cent in south irrespective of the ecosystem while it was only 65 per cent for irrigated cotton variety under northern conditions. The fixed costs for central and south zones varied between 17 and 22 per-cent, while for north it was 35 per cent. The main reason for high fixed cost was the exorbitant land values in fertile Indo-gangetic plans. Plant protection accounted for the major share (19% and 26%) followed by intercultural operation (15.45%) in southern rain fed farm samples and fertilizers and manures (14%) in case of others. The cost of cultivation per quintal ranged from Rs 1541 in irrigated cotton of north to Rs 2148 in rain fed central. Though the cost of cultivation increased with irrigation availability, the associated high yields reduced the cost of production .Returns over total cost were the highest in irrigated hybrid (Rs 10810) of central India followed by varieties (Rs 9025) in irrigated north, rain fed hybrids (Rs 8873) in south India and rain fed hybrid (Rs 4448) in central India.

Chahal and Kataria (2005) estimated the cost and returns of maize in Punjab. The total operation cost of hybrid maize was Rs 8956 per hectare as compared to Rs 6427 per hectare for local variety and Rs 8009 per hectare for composite varieties. Human and animal labour cost contributed more than one third of the operation cost, fertilizer accounted for 20 per cent of the operational cost in case of hybrid varieties. The estimated average yield of hybrid varieties was 36.26 quintal per hectare. Both gross and net returns in case of hybrid maize amounted to be Rs 19637.48 and Rs 10681.65 per hectare respectively.

Bennett et al (2005) studied contradictory evidence of impacts of genetically modified crops in developing countries. The study compared the performance of growing official and unofficial hybrid varieties of Bt cotton and conventional (non-Bt) hybrids in Gujarat by 622 farmers. Results suggested that the official Bt varieties (MECH 12 and MECH 162) significantly outperformed the unofficial varieties. However, unofficial, locally produced Bt hybrids also performed significantly better than non-Bt hybrids, although second generation (F2) Bt seed appears to have no yield advantage compared to non- Bt hybrids but saved on insecticide use. Although hybrid vigor was reduced, or even lost, with F2 seed the Bt gene still conferred some advantage.

Morse et al (2005) studied genetically modified insect resistance in cotton. Study revealed that impact of insect-resistant Bacillus thuringiensis (Bt) cotton on costs and returns over the first two seasons of its commercial release in three sub-regions of Maharashtra State, India. Data were collected for a total of 7793 cotton plots in 2002 and 1577 plots in 2003. Results suggested that while the cost of cotton seed was much higher for farmers growing Bt cotton relative to those growing non-Bt cotton, the costs of bollworm spray were much lower. While Bt plots had greater costs (seed plus insecticide) than non-Bt plots, the yields and revenue from Bt plots were much higher than those of non-Bt plots (some 39% and 63% higher in 2002 and 2003, respectively). Overall, the gross margins of Bt plots were some 43% (2002) and 73% (2003) higher than those of non-Bt plots, although there was some variation between the three sub-regions of the state. The results suggested that Bt cotton has provided substantial benefits for farmers in India over the years, but there were questions as to whether these benefits are sustainable.

Bennett et al (2006) studied performance of genetically modified cotton in Maharashtra, India. The study compared the performance of over 9,000 Bt and non-Bt cotton farm plots in Maharashtra over the 2002 and 2003 seasons. Results showed that since their commercial release in 2002, Bt cotton varieties have had a significant positive impact on average yields and on the economic performance of cotton growers. Regional variation showed that, in a very few areas, not all farmers had benefited from increased performance of Bt varieties.

Qaim et al (2006) studied adoption of Bt cotton and impact variability in India. Study revealed that there was a growing body of literature about the impacts of Bacillus thuringiensis (Bt) cotton in developing countries. While many studies showed remarkable benefits for farmers, there were also reports that questioned these results. Most previous studies considered impacts in deterministic terms, neglecting existing variability. This study explained the main factors influencing the agronomic and economic outcomes. Apart from differences in pest pressure and patterns of pesticide use, germplasm effects could play an important role. Theoretical arguments were supported by empirical evidence from India. Better understanding of impact variability could help explain some of the paradoxes in the recent controversy over genetically modified crops.

Visawadia *et al.* (2006) studied production and marketing of Bt cotton and hybrid cotton in Saurushtra region of Gujarath state. Researcher has used primary data for study. Primary data were collected from 128 cotton farms by the survey method through pre tested questionnaires. Simple tabular analysis was used for estimating the cost and returns structures of Bt cotton and hybrid cotton. Various farm management cost concepts were followed. The study has revealed that the total cost per hectare was higher in Bt-cotton than in hybrid cotton. The cost of seeds has been found higher in Bt-cotton where as hybrid cotton growers incur more cost of insecticides/pesticide. This showed the effectiveness of the new technology (Bt-cotton) for insect resistance. The average total cost of production as well as the bulk line cost despited a reduction in the unit cost of Bt-cotton which was the distinct advantage of the new technology. Higher yield of 29 per cent was obtained by the Bt-cotton farmers over the hybrid cotton growers. Bt-cotton was found to be superior technology over hybrid cotton as it gave higher yield with low cost of production.

Mahendra and Chandrasekhara (2007) studied the impact of Bt. cotton. The cost of production was 17 per cent higher in Bt. cotton at Rs.16975 per acre compared to Rs.14507 for non-Bt. cotton in the state. The cost A2 was Rs.11445 and was higher by 11.8 per cent over non-Bt. cotton. The expenditure on insecticides decreased by 18.2 per cent in Bt-cotton over non-Bt. cotton. This decrease in cost on insecticides (Rs.594) was more than of set by the increased costs on seed (Rs.804), labour (Rs.801), fertilizers (Rs.86) and irrigation charges (Rs.45). The cost of seed increased by 134.4 per cent from Rs.598 in non-Bt. cotton to Rs.1402 in Bt. cotton, whereas labour costs increased by 20.58 per cent in Bt- cotton.

Monlruzzaman *et al.* (2009) conducted a farm level study on agro-economic analysis of maize production in Bangladesh. The study was conducted in four major maize growing districts. A total of 200 maize growers were selected. Data were collected from the sampled maize growers by survey method with the help of pre-tested interview schedule during 2006-2007. The collected data were summarized and analyzed by tabular methods using average, percentage, ratios, etc. Human labour cost was the major (25%) among the total cost. The total cost, variable cost, and cash cost in maize production were Tk. 44197, Tk. 33195 and Tk. 24441 per hectare respectively. The average gross return from grain and stover was Tk. 69773 per hectare.

Puran *et al.* (2010) studied economic profitability and adoption of Bt. cotton and non- Bt. cotton in North India. The study was based on primary data collected from farmers through personal interviews in Haryana and Punjab states of North India. For collection of data, multistage sampling technique was used. From each state 100 farmers were interviewed. Thus, 200 farmers were selected. For profitability analysis, partial budgeting tool was used. With Bt. cotton, additional cost was mainly from increased use of seed, fertilizer, irrigation and picking to the extent of Rs.3076.69 per acre. On the other hand, there was reduced insecticide cost by nearly about 26 per cent of total cost in Bt-cotton. Bt. farmers obtained higher yield, and they realised about 50 per cent more returns than from non-Bt. cotton which compensated all increased cost. Thus the Bt-cotton farmers received higher net return (Rs.5275.20 per acre).

Manjunatha *et al.* (2010) studied yield and yield components, uptake of nutrients, quality parameters and economics of Bt. cotton (*Gossypium hirsutum* L.) genotypes as influenced by different plant densities. A field experiment was conducted during *kharif,* 2008 at Agricultural College Farm, Raichur to study the performance of Bt. Cotton genotypes to different plant densities under rainfed condition. The results revealed that among genotypes, Bunny Bt. BG-II recorded significantly higher uptake of nutrients (105.5, 22.08 and 114.25 kg ha-1; N, P and K, respectively) and also exhibited superior quality parameters with higher net returns (Rs.39,152 ha^{-1}), lower cost of cultivation (Rs.20431).

Hina *et al.* (2010) studied economics of cotton production in Pakistan using secondary data. Secondary data were collected from different organizations of Pakistan which have documented cost of production of cotton. The Cobb Douglas production function was used to study the impact of individual input on total return. The study revealed that the input cost has increased over time. The cost of seed, irrigation and interculture had shown significant relation with total return. The negative return indicated that the cost of inputs have increased at increasing rate. The highest (8.89%) input cost growth rate was observed in case of plant protection. Whereas the lowest cost growth rate was found in case of seed. The major share (28.53 %) in the total cost of production was that of land rent and minimum was that of seed (2.13 %).

Akit and Hugar (2011) studied economics of soybean cultivation vis-à-vis its competing crops in Madhya Pradesh. The study was based on primary data. A multistage sampling procedure was adopted for the selection of districts, blocks, villages and farmers in the study area. The total sample size of soybean farmers was 90. Correspondingly, 30 farmers were chosen randomly who were growing competing crops of soybean such as jowar and maize from the selected districts. The tabular technique was followed to study the economic characteristics of different size groups of sample farmers such as costs and returns expressed by the farmers in case of soybean, maize and jowar. The study revealed that the cost of cultivation of soybean worked out to be Rs 15946/ha, of which variable cost and fixed cost formed about 76.79 and 23.21 per cent, respectively. The expenditure on human labour (Rs 3890/ha) formed major component (24.39%) in variable cost followed by cost on machine works (20.59%). Similarly, rental value of the land (Rs 3225/ha) formed major component among fixed costs. The total cost of cultivation of jowar worked out to be Rs 8923/ha which was about three fourths of total cost of cultivation of maize (Rs 12516/ha). Human labour requirement was similar in both the crops with 34.33 man days in maize and 36.13 man days in jowar per hectare.The profitability of soybean vis-à-vis its competing crops showed that cultivation of soybean was highly profitable over jowar and maize. Even though the cost of cultivation of soybean was higher than that of jowar and maize, its gross returns as well as net returns were also correspondingly higher than jowar and maize. The net returns in soybean over jowar (868.72%) was significantly higher than maize (121.67 %). Similarly, benefit cost ratio was higher in case of soybean (1.29) than that of maize (1.16) and jowar (1.05). The percentage change in benefit cost ratio of soybean over maize and jowar was 11.21 and 22.86 percents, respectively.

Gamanagatti (2011) studied economics of Bt. Cotton cultivation–A comparative analysis across different farm sizes in northern transitional zone, Karnataka reported that among the three categories of farmers the total cost incurred by the large farmers was the highest (Rs.32723.9/ha) as compared to small and medium farmer (Rs.29217.63/ha and Rs.30820.15/ha). Net returns per hectare obtained by large farmers were again the highest (Rs.84677.90 /ha) as compared to small and medium farmers (Rs. 69212.04/ha and Rs.84479.15/ha respectively). The gross returns obtained per hectare by overall category of farmers were Rs.110376.92 with a yield of 24.98 q/ ha. The total variable cost incurred per hectare by large farmers was high (Rs.23256.85/ha) as compared to small and medium farmers (Rs.21040.05/ha and Rs.22279.54/ha respectively). The per quintal cost of production and returns worked out to be Rs.1237.81 and Rs.3180.80, respectively and B; C Ratios was 3.57 for the overall study area.

Menasinahal (2011), studied performance of cotton in traditional paddy fields of Uttara Kannada district, Karnataka – an economic analysis reported that, the average yield of cotton was 16.98 q/ hectare. The gross returns and cost of cultivation was Rs. 85680 per hectare and Rs. 34452.67 per hectare respectively. The net returns were Rs. 51227.33 per hectare. The B:C ratio obtained was 2.48. Thus the B:C ratio obtained was higher in case of cotton compared to paddy.

Paitasigh and Goyari (2013) studied growth and instability in of agriculture of Odisha. The study used secondary data on area ,yield ,production for a period of fifty one years from 1970-2010 collected from various issues of Odisha Agricultural Stastics, Center for Monitoring Indian Economy (CMIE) and agricultural data book. The growth rate of yield, area and production of crops was calculated by using the method of kinked growth rate formula. The study revealed that some crops like wheat, ragi and millet experienced decline in pre- liberalization period, which exaceralated in the post- liberalization period. Other crops like bajra, jower, gram, arhar, experienced a deceleration in post reform period compared to pre-form period.

2.4 Technical and allocative efficiency issues

Coelli *et al.* (2002) conducted study on technical, allocative, cost and scale efficiency in Bangladesh rice cultivation. Primary data were collected from 406 farm households from twenty one villages. These villages were selected following multistage stratified random sampling procedure. Data Envelopment Analysis (DEA) model was used to simultaneously construct the production frontier and to obtain the technical efficiency measures. Study revealed that for the Boro (dry) season, mean technical efficiency was 69.4 per cent, allocative efficiency was 81.3 per cent, cost efficiency was 56.2 per cent and scale efficiency was 94.9 per cent. The Aman (wet) season results were similar, but a few points lower. Allocative in efficiency was due to over use of labour and fertilizer. Second-stage regression showed that large families were more inefficient. Whereas farmers with better access to input markets, and those who did less off-farm work tend to be more efficient. The factors like age, education, experience, soil fertility, extension and training did not have a large influence on efficiency levels.

Bambawale *et al.* (2004) reported performance of MECH-162 Bt. along with non-Bt. MECH-162 and a conventional variety/hybrid under integrated pest management (IPM) in farmers' participatory field trials were conducted in Maharashtra. Under IPM, 11.5 per cent of the fruiting bodies were damaged in MECH-162 Bt. compared to 29.4 per cent in conventional cotton and 32.88 per cent in non-Bt. MECH-162. Population of sucking pests was also lower in MECH-162 Bt. Seed cotton yield in MECH-162 Bt (12.4 q/ha) was much higher than that of non-Bt. MECH-162 (9.8 q/ha) and conventional cotton (7.1 q/ha). Net returns after taking into account cost of production and protection were Rs.16,231 (US$368.9)/ha in MECH-162 Rs.12,433 (US$282.6)/ha in non-Bt. MECH-162 and Rs.10,507 (US$238.8)/ha in conventional cotton.

Bennett *et al.* (2004) assessed the performance of Bt. cotton grown under typical farmer-managed conditions during 2002 and 2003. The study analysed commercial field data rather than trial plot data collected from 9,000 farmers' plots in Maharashtra. It met the recommendations of FAO (2004) for market-based studies that would accurately reflect the agronomic and economic environments faced by growers. Over both the seasons, the number of sprays required to control sucking pests (aphids and jassids) was similar for Bt. and non-Bt. plots. However, the number of sprays required for bollworm was much lower for Bt. plots (1.44 for Bt. versus 3.84 for non-Bt. during 2002 and 0.71 for Bt. versus 3.11 for non- Bt. during 2003). There was a corresponding reduction in expenditure amounting to 72 per cent and 83 per cent in 2002 and 2003, respectively. However, when balanced with higher cost of Bt. cotton seed, the results showed higher average costs for Bt cultivation compared to non-Bt. cultivation (15% and 2% in 2002 and 2003, respectively). The real benefit came from the higher yield of cotton in Bt. plots in 2002. The average increase in yield for Bt. over non-Bt. was about 45 per cent while in 2003 this was 63 per cent. Taking into account the seed cost and variable cotton prices, the results showed a much higher gross margin for Bt. growers [Rs.50,904 (US$1156.9)/ha] than for non-Bt. growers [Rs.29,279 (US$665.4)/ha] during 2003.

Verma (2005) employed functional analysis technique for evaluating the resource productivities and resource-use efficiency of eight different inputs in garlic production in Indore district of Madhya Pradesh. In the study, returns per farm as dependent variables while land, seed, manures and fertilisers, human labour, bullock labour, machine power, plant protection and irrigation expenditure were considered as independent variables. The marginal value product of land, seed, manures and fertilizers, bullock labour and plant protection (Rs.42.95, Rs.0.35, Rs.1.22 Rs.0.08 and Rs.0.71, respectively) were found to be positive while MVP values were negative for human labour, machine power and irrigation (Rs.-1.11, Rs.-1.07, and Rs.-0.69, respectively). This indicated that on the small farms, seed, manures and fertilisers, bullock labour and plant protection chemicals were underutilised and human labour, machine power and irrigation were excessively used on the small farms. In case of medium farms, marginal value product of land, seed, manures and fertilisers, machine power, plant protection and irrigation were Rs.69.80, Rs.0.21, Rs.0.29, Rs.0.23, Rs.0.06 and Rs.0.17 positive, respectively. While the MVP ratios were negative for human (Rs.-0.43) and bullock (Rs.-0.30) labours. This implied that the land, seed, manures and fertilisers, machine power, plant protection and irrigation were underutilised and human and bullock labour were excessively utilised in the case of medium farms.

Bhende and Kaliraja (2007) studied technical efficiency of major food and cash crops in Karnataka. The study used the farm level cross section data collected by the University of Agricultural Sciences Bangalore. They estimated farm specific technical efficiency for rice, sorghum, groundnut and cotton using stochastic frontier production function approach. The analysis of technical efficiency indicate that there was a considerable scope to improve the productivity levels of both food as well as cash crops with the existing level of input use and the available technology.

Mangalika *et al.* (2009) studied the technical efficiency of coconut production (TECP) in the Coconut Triangle (i.e. Western and North-Western provinces) of Sri Lanka. A series of face-to-face interviews were carried out with the help of a pre-tested structured questionnaire with 166 coconut growers selected randomly from the database managed by the Agricultural Economics and Agribusiness Division of the Coconut Research Institute of Sri Lanka during the period April to May 2009. A Stochastic Production Frontier model specified in Cobb-Douglas form was used to measure the TECP. The model included the extent of land, labor and contract work, amount of rainfall, use of fertilizer and dolomite as the explanatory variables. A number of managerial and farm characteristics were used to explain the variations in efficiency across production units. The inefficiency model was estimated by one-step Maximum Likelihood method using the FRONTIER 4.1 software package. The outcome of the analysis showed that the mean TECP was 73.8 per cent. While the effect of labour and contract work on coconut production was significant and positive, it was significant and negative for land and rainfall. Results from the inefficiency model suggested that grower's experience; land suitability class and intercropping had a positive and significant impact on the TECP, whereas the level of management and major source of income had a negative impact.

Kaur *et al.* (2010) studied technical efficiency of wheat production in Punjab. They used the farm level cross section data. The sample farms were selected using the multistage random sampling technique. The study revealed that wheat area, plant protection chemicals and fertilizers were the significant determinants of output in the semi hilly region. Only the area under wheat is significant in the central region and irrigation and fertilizers influenced positively. The yield of wheat in the south western region. The mean technical efficiency of wheat production was found to be around 87 per cent for the state as whole. Among different regions it was estimated to be highest for the central region (94 %) followed by semi hilly region (87 %) and south-western region (85 %).

Narala and Zala (2010) studied technical efficiency of rice farms under irrigated conditions in central Gujarat. Researchers have used primary data for the study. Primary data were collected from multistage sampling procedure by personal interview method with the help of pre-tested comprehensive interview schedule. In the study the stochastic frontier production function approach was used to measure technical efficiency of rice cultivating farms. The study revealed that variation in the output across agricultural farms in the region was due to difference in technical efficiency levels. Fertilizer and irrigation were found major determinants of rice productivity in the region. The mean technical efficiency was found 73 per cent among the sample farms, which indicated that on an average the realized output could be raised by 27 per cent without any additional resources in the region.

Kuchroo *et al.* (2010) studied technical efficiency of dry land and irrigated wheat using stochastic model. They have used primary data on resource use and input - output level as well as other information collected by interviewing the farmers personally with the help of a specially structured and pre tested schedule. For the estimation of technical efficiency, the stochastic frontier production function, proposed by Aigner *et al.* (1977) and Meeusen and Van den Broeck (1977) was used. The study revealed that the farmers under irrigated conditions were found to be 0.84 per cent technical efficient in dry land conditions and 0.88 per cent in irrigated condition.

Muhammad *et al.* (2011) studied resource use efficiency of small bt cotton farmers in Punjab, Pakistan. Using primary data. Primary data were collected from 150 randomly selected Bt cotton farmers from Punjab province using a multistage sampling procedure. The study revealed that fertilizer, spray number, irrigation acre inch and labour cost were significantly affecting Bt cotton production while farm size was found non significant. The resource use efficiency analysis showed that efficiency ratios (MVP/MFC) for inputs fertilizer, spray, irrigation and labour were found to be 1.5, 3.94, 3.01 and 1.27, respectively. All the efficiency ratios were more than unity indicating the under utilization of inputs. Bt- cotton production for small farmers showed increasing return to scale with elasticity of production of 1.27.

Karthick *et al.* (2013) studied the resource use efficiency and technical efficiency of turmeric production using primary data collected from 90 growers spread over three blocks in Dharmapuri district of Tamil Nadu. Primary data were collected using pre-tested interview schedule through personal interview. The Cob-Douglas production function was used to analyze the data. The study revealed that planting material, nitrogen, potash, harvesting and curing cost machine hours and irrigation exerted a positive and significant influence on turmeric yield. The economic efficiency of these variables except harvesting and curing cost are more than one indicating that these resources were used at sub-optimal levels. The technical efficiency of about 69 per cent of sample farmers has been found more than 80 per cent which indicated the possibility of increasing the yield.

2.6 Factors influencing the preference of hybrids.

Shiyani *et al.* (2000) examined the adoption of improved chickpea varieties in tribal regions of Gujarat. In the Tobit model, which the dependent variable, which was defined as proportion of land holding under improved chick pea, depended on the education level of the farmers, farmer's experience of growing chickpea, length of chickpea growing period, market distance, yield risk and village features representing agro ecological characters. The result showed that all the variables except market distance and level of education were significant and had expected signs. Size of land holding had negative influence on the level of technology adoption and it was due to faster adoption of intensive technologies by land constrained farmers. They concluded that there was substantial increase in yield levels, income and labour productivity in improved varieties in comparison with local varieties.

Aloyce *et al.* (2000) studied factors affecting adoption of improved maize seeds and use of inorganic fertilizer for maize production in the intermediate and lowland zones of Tanzania. About1000 farmers were interviewed nationwide. The study revealed that availability of extension services, on-farm field trials, variety characteristics and rainfall were the most important factors that influenced the extent of adopting improved maize seeds and the use of inorganic fertilizer for maize production. Farmers preferred those varieties which minimized field loss rather than maximizing yields.

Rao *et al.* (2000) studied farmers buying behavior of hybrid cotton seeds in Pallachi taluk of Coimbatore district. The study was based on the data collected from a random sample of 30 farmers who cultivated cotton hybrids. Garret ranking technique was employed to delineate the major factors influencing the buying behavior of farmers. Markov chain analysis was used to study the brand switching behavior of farmers. The study revealed that about 53 per cent of farmers cultivated TCHB213 cotton and rest 47 per cent cultivated RCH variety. Further results revealed that all the 14 farmers who cultivated RCH variety continued to cultivate the same variety. Besides, five farmers who cultivated TCHB213 earlier switched over to RCH variety. Higher resistance to boll worm attack and higher yield of RCH were the reasons attributed for their switching behavior. Among the various factors influencing buying decision of hybrid cotton seeds friends/neighbor farmers ranked first fallowed by pest and disease resistance, higher yield, private dealers and seed availability.

Salasya (2007) studied the factors influencing adoption of stress-tolerant maize hybrid (WH 502) in western Kenya. Data were collected from a random sample of 504 households and 68 stockists from three districts of western Kenya. Results showed that the main attributes of WH 502 that influenced its adoption were high yield, early maturity and non-lodging, whereas the important socio-economic factors were farm size, cattle ownership, and education level of the farmer and locality specific characteristics. The attributes of WH 502 that farmers disliked were poor storability and poor husk cover. Neighbors were found to play a major role than the public extension service in making WH 502 variety known to farmers.

Gandhi and Namboodiri (2009) studied adoption and economics of Bt cotton in India. Data from the survey, covering important cotton states of Gujarat, Maharashtra, Andhra Pradesh and Tamil Nadu indicated that Bt cotton offers good resistance to bollworms as well as several other pests. The incidence of these pests was reported to be considerably lower in Bt cotton versus Non-Bt cotton. The yields of Bt cotton were found to be higher and the yield increase was statistically significant in all the states under both irrigated and rain-fed conditions. The value of output per hectare was higher in all the states and conditions. The higher cost of cultivation existed because of high seed cost and not commensurate reduction in pesticide cost. However, the profit was found to be higher in all the states to the estimated extent of about 80-90 per cent. The returns were highest in Maharashtra followed by Gujarat and then Andhra Pradesh in value terms. Almost all farmers indicated that they plan to plant Bt cotton in the future. To increase the benefits from the technology, the farmers strongly urged reduction in the seed cost.

Padaria *et al*. (2009) studied Bt-cotton adoption behavior. Researcher used primary data for the study collected from randomly selected 120 adopters and 60 non-adopters of Bt-cotton from Punjab and Karnataka. He used logit regression model to identify the factors which influenced the adoption of Bt cotton. The study revealed a significant influence of size of holding, capital base, extension contact; innovativeness, achievement motivation, and perception about Bt cotton on adoption decision of the farmers for Bt cotton, whereas in contrary to apriori expectation, information source pluralism, mass media exposure, social participation and education were not found to have a significant influence. Plant protection measures, identification of quality seed, and use of refuge line were identified as the most important training needs of the farmers. Comparative analysis of training needs of farmers of Punjab and Karnataka with Mann-Whitney U test revealed significant difference in areas of identification of quality seed ($P<.01$), planting density ($P<.01$), use of fertilizers ($P<.01$), sowing ($P<.01$), use of micronutrients ($P<.05$), use of plant growth regulators ($P<.05$) and disease management ($P<.01$).

Kafle (2010) studied determinants of adoption of improved maize varieties in developing countries. Study revealed that socio-economic characteristic, agro-ecological variables and farmers' perception were important determinants of improved maize varieties in different countries. Among these variables, extension contact, education, farm size, credit availability, use of fertilizer, low land area, yield and profitability were found to be major determinants which had strong positive influences. The adoption studies were found more focused to socio-economic variables in comparison to agro-ecological variables and farmers' perception.

Lopes (2010) conducted study on adoption of improved maize and common bean varieties in Mozambique. A total of 6,075 small and medium scale farm households were interviewed in 658 primary sampling units. The probit model was used to estimate the likelihood of household adoption of improved varieties of maize and common beans at both the national and regional levels. Result revealed that at the regional level, the highest percentage of maize-producing households who planted improved maize in the 2006-2007 agricultural year were in the central region (17%), followed by the southern region (10%), and the northern region (4.6%).The adoption rate was highest in Manica Province (24%), followed by Tete (23.7%) and Maputo Provinces (15%). In contrast, the adoption rate was lowest in Cabo Delgado province (3%). At the national level, the results indicate that household head's education, access to extension services and credit were associated with the household's adoption decision. However, association membership was negatively associated with the adoption decision. Education and extension were statistically significant for the improved maize analysis.

Kiresur and Manjunath (2011) studied socio economic impact of Bt-cotton in Karnataka. They used primary data for the study collected from 60 farmers using multistage random sampling method. The data were processed using tubular analysis, production function, decomposition analysis and logit model. The study revealed that non availability of quality Bt-seeds was most important constraint hindering adoption of Bt-cotton production technology, as opined by nearly 80per cent of farmers. The other reasons constraining Bt-cotton production technology adoption were low adoption by neighborhood farmers, no belief in Bt-technology ,difficulty in adoption of Bt- technology, awareness about the technology and non-confirmation of its profitability and non-awareness about the Bt-technology in that order

Samal *et al.* (2011) studied the rice ecosystem and factors affecting varietal adoption in rainfed coastal Orissa. A multistage sampling procedure was followed to select districts blocks, villages and farmers. The primary data were collected from 193 sample farmers, comprising ninety-eight marginal, fifty three small, twenty-eight medium and fourteen large farmers. A multivariate probit model was used to study the factors affecting adoption of modern varieties. The study revealed that the probability of modern varieties adoption was found to be 0.54 for an average farmer who cultivated his owned land with irrigation facilities. However the probability of MVs adoption dropped to 0.23 for the same farmers under low land condition. Similar was the situation in the rain fed medium land plots. When an average farmer who cultivated his own rain fed land was considered, the probability of adoption of modern varieties was 0.47 and it dropped to 0.18, when the type of land was lowland. The probability of adoption further reduced to 0.11, when the low land plot was leased-in from a land lord. This indicated the lack of suitable varieties for lowland condition preventing the adoption of modern varieties in this type of lanond.

Ghimire *et al.* (2012) studied influence of sources of seed on varietal adoption behavior of wheat farmers in Indo–Gangetic plains of India. They used primary data for the study collected from 1200 farming households by using multistage sampling technique. A multinomial logit model was used for the analysis. The study revealed that quality and timely availability of seed was a necessary condition for proper uptake of new varieties.

METHODOLOGY

This chapter presents the agro climatic and economic features of the study area, the nature and source of data used for the study, the analytical tools and techniques employed for analyzing the data. These are presented under the following heads.

3.1 Description of the study area

3.2 Sampling procedure

3.3 Nature and sources of data

3.4 Analytical tools and techniques employed

3.5 Definition of terms and concepts

3.1 Description of the study area

3.1.1 Location of district

The study on diversity in cultivation of Bt-cotton - An economic analysis was taken up in Haveri district in Karnataka. This district was purposively selected as it is one of the most important cotton growing districts in terms of area in the jurisdiction of UAS Dharwad. An attempt is made to comprehend information about the district here under.

Haveri, popularly known for Byadgi chilli variety and its market in South East Asia, is almost in the center of Karnataka. Geographically the district is situated between north latitude 14^0 28' to14^0 39' and east longitude 75^0 07' to 75^0 38'. Haveri is one of the newly formed districts of Karnataka, one and a half decade ago (15^{th} August 1997). The district is located in northern semi rain fed and semi malnadu zone bound on the North by Dharwad and Gadag districts, on the East by Bellary district, on the West by Uttar Kannada district and on the South by Davangere and Shimoga districts. The total geographical area of the district is 4, 85,156 hectare (Table 3.1). The district has seven taluks with 208 gram panchayats, 691 inhibited and seven uninhibited villages. The initial provisional data suggest a density of population was 331 persons/sq km in 2011 compared to 298 persons/sq km of 2001 (Haveri district at a glance 2011-12).

3.1.2 Geomorphology and Soil Types

The district is generally a gently undulating plain except for the hilly area on the western most part of the district bordering Uttar Kannada district and ridges on Southern most parts of the district, which forms part of Hirekerur taluk. The landmass of the district is situated between the elevations of 515 to 732 m above Mean Sea Level (MSL). The general slope in the district is in North-East direction.

The Tungabhadra River flowing on the eastern boarder of the district is the only perennial river in the district. The Varada and Kumadwati rivers are major tributaries of Tungabhadra and the river Dharma is a major tributary of Varada, drains the district. All the rivers in the district together with their tributaries exhibit dendretic drainage pattern and they form part of Krishna main basin.

In the major part of the district, around 65 per cent red sandy soil is occurring, followed by the medium black and deep black soils. The red loamy soil and lateritic soil are seen in very small parts on southern border of the district. Apart from sand and building stones, no other mineral ores are found in the district.

3.1.3 Land utilization

The land utilization pattern in the district during the year 20011-12 is presented in Table 3.2. The total geographical area of the district is 4, 85,156 hectares, out of which the net cultivable area is 3, 63,207 hectares (74.86%) and area sown more than once is 47,922 hectares (9.88%). The area not available for cultivation is around 38,889 hectares (8.01%) which comprise of non-agricultural area (33,096 ha or 6.82%) and barren land (5,793 ha or 1.19%). About 17,445 hectares (3.59%) of land is fallow and 47,454 hectares (9.78%) is under forests. The cultivable waste is 2,989 hectares (0.62%) and other uncultivated land is 14,499 hectares (2.99%).

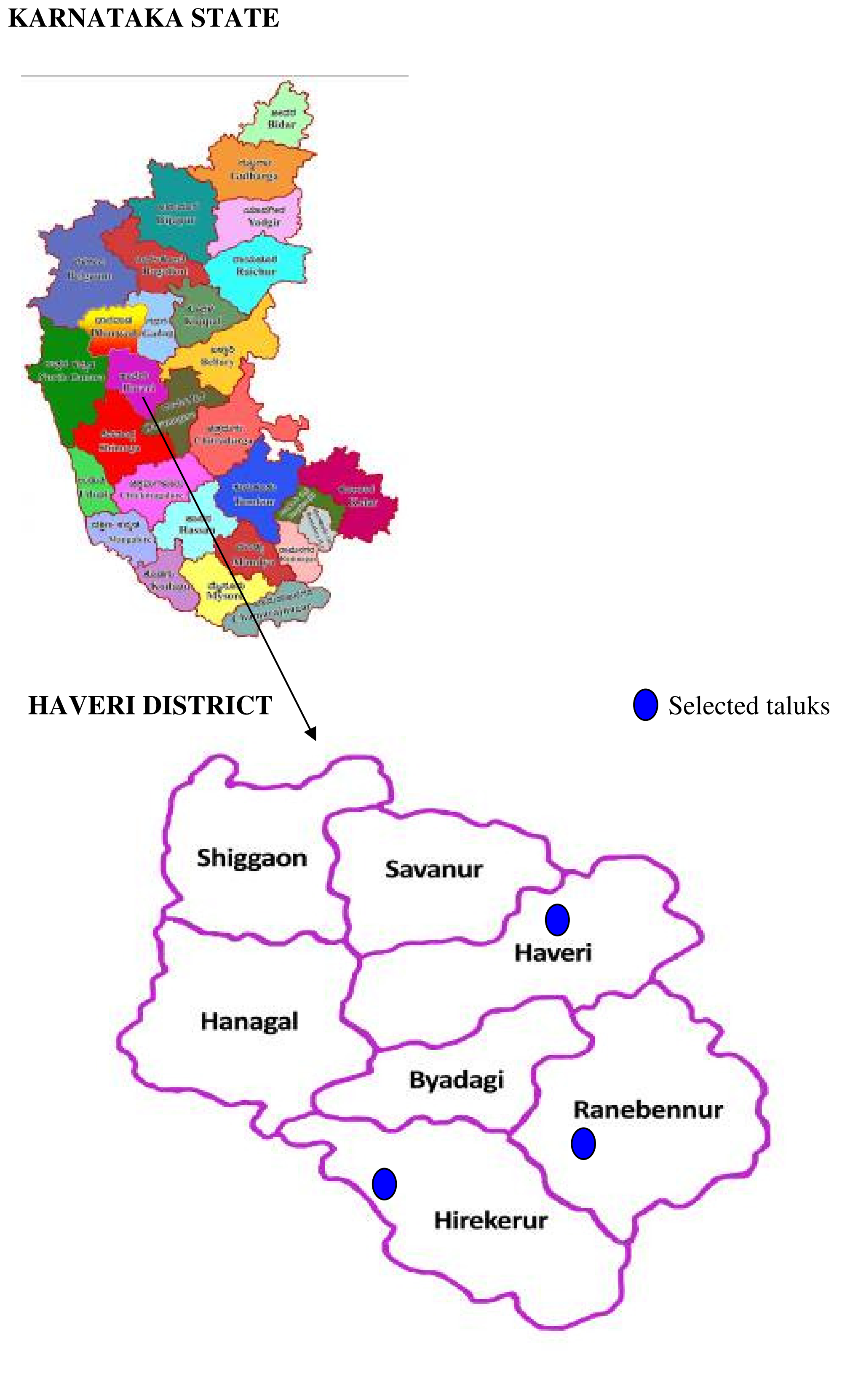


Fig.1. Map showing study area

Table 3.1 Demographic profile of Haveri district

Sl.No	Particulars	Value
1.	Geographical area (ha)	485156
2.	Population (numbers)	1598506
	Rural	1242442 (77.72)
	Male	638485
	Female	603957
	Urban	356064 (22.27)
	Male	180810
	Female	175254
3.	Population density (persons sq.Km)	298
4.	Decadal growth rate of population(%)	11.08
5.	Literacy rate (%)	77.60
	Male	84.20
	Female	70.70
6.	Net area irrigated (ha)	99028
	Canals	6168 (6.23)
	Tanks	12980 (13.11)
	Tube well	48799 (49.28)
	Lift irrigation	498 (0.50)
	Other	19064 (19.25)
7.	Rain fall (mms)	
	Normal	791.6
	Actual	777.4
	Number of rainy days (average)	61

Source: Haveri District at a Glance 2011-2012, District Statistical Office, Haveri Note: Figures in parentheses indicate percentages

Table 3.2: Land use pattern in the Haveri district during 2011–12

Sl. No	Classification of land	Area (ha)	Percentage
1.	Total Geographical area	485156	100
2.	Area under forest	47454	9.78
3.	Non-agricultural area	33096	6.82
4.	Barren land	5793	1.19
5.	Cultivable waste	2989	0.62
6.	Other uncultivated land	14499	2.99
7.	Fallow land	17445	3.59
8.	Net area sown	363207	74.86
9.	Area sown more than once	47922	9.88

Source: District Statistical office (2011-12)

3.1.4 Rainfall and Temperature

The influence of climate and rainfall on agriculture is important as farming predominantly depends upon these natural factors. The district enjoys sub tropical climate with temperature ranging in between 18^0 to 40^0 C. The rainfall varies in the district from over 1350.4 mm in Hirekerur to less than 798.8 mm in Savanur. October is the wettest month with normal monthly rainfall in all hydrometeriological stations is recorded in excess of 100 mm. The average daily maximum temperature is 34.1^0 C (Haveri district at a glance 2011-12).

3.1.5 Population

According to 2011 census, the population of Haveri district was 15, 98,506, of which, male and female were 8, 19,295(51.25%) and 7, 79,211(48.75%) respectively. There was change of 11.08 per cent in the population compared to population as per 2001. In the previous census of India 2001, Haveri District recorded an increase of 13.39 per cent to its population compared to 1991.

Average literacy rate of Haveri in 2011 was 77.60 per cent. It was observed that the literacy rate was 84.20 per cent among males and 70.70 per cent among females. Total literates in Haveri District were 10, 94,805 of which male and female were 60, 8,727 and 4, 86,078 respectively. With regards to Sex Ratio in Haveri, it stood at 951 per 1000 male (Directorate of Census Operations in Karnataka 2011).The district has a total of 3, 05,458 families. Of the total 2, 03,628 farmers were small and marginal farmers.

3.1.6 Major crops in study area

The area under major crops in Haveri district is presented in Table 3.3. It can be observed from the table that 52.38 per cent of the total cropped area was under cereal crops. Maize was the major cereal crop which occupied 32.64 per cent of area followed by paddy (11.67 %), jowar (7.10 %) and minor millets (0.72 %). Out of total cropped area, the share of pulses and oilseeds was 3.14 per cent and 7.08 per cent respectively. The major pulse crops grown in the district were green gram (0.93 %), horse gram (0.93 %) and tur (0.62 %). The crops like ground nut (4.72 %), sunflower (0.62 %) and safflower (0.25 %) are the major oil seed crops. The share of commercial crops, fruits and vegetables was 26.19 per cent, 1.32 per cent and 2.25 per cent respectively. The major commercial crops grown in the district are cotton (24.92%) and sugar cane (1.28 %).

3.2 Sampling procedure

Haveri has been selected for the study as it is a major Bt-cotton growing district (19.16%) in the jurisdiction of UAS Dharwad in Karnataka. In Karnataka, the area under cotton cultivation during 2011-12 was 5.54 lakh hectares and in Haveri district, the area was 106140 hectares. A multistage sampling procedure was adopted for selection of taluks, villages and sample farmers. Three taluks of Haveri district namely Hirekerur, Ranebennur and Haveri were selected based on highest area under the crop and from each taluk; two villages based on highest area under Bt-cotton were selected. From each village twenty farmers growing Bt-cotton were selected randomly and thus the total sample size was 120.

3.3 Nature and source of data

The study was based on both primary and secondary data. The secondary data on area, production and productivity of cotton in Haveri district was collected from District Statistical Office for the period from 1997-98 to 2010-11 to analyze the growth in area, production and productivity. For evaluating the other objectives of the study, required primary data were collected from sample farmers through personal interview method with the help of well structured and pre-tested schedule. The data collected pertained to the agricultural year 2012-13. The data collected was on general characteristics of farmers, land holding, assets, costs, returns, yields, Bt-cotton hybrids etc.

3.4 Analytical tools and techniques employed

To fulfill the specific objectives of the study, based on the nature and extent of availability of data, the following analytical tools and techniques have been adopted.

3.4.1 Growth rate analysis

In order to analyse the growth in area, production and productivity of cotton in the district, compound growth rates were computed using the following model.

Table 3.3: Major crops grown in Haveri district in 2011-12

Sl.No	Crop	Area (ha)	Percentage
I.	Cereals		
	Paddy	49678	12.63
	Ragi	604	0.15
	Jowar	30254	7.69
	Maize	138978	35.34
	Wheat	471	0.12
	Other minor millet	3057	0.78
Total cereals		223049	56.71
II.	Pulses		
	Green gram	3965	1.00
	Horse gram	3962	1.01
	Tur	2635	0.67
	Other pulses	2429	0.62
Total pulses		13354	3.30
III.	Oilseeds		
	Ground nut	20085	5.12
	Sunflower	2624	0.67
	Safflower	1049	0.27
	Other oil seeds	6380	1.62
Total oil seeds		30138	7.68
IV.	Commercial		
	Sugarcane	5398	1.37
	Cotton	106140	26.99
Total commercial		111538	28.36
V.	Fruits	5629	1.43
VI.	Vegetables	9596	2.44
	Total	393304	100.00

Source: District Statistical office (2011-12)

Table 3.4: Taluka wise Area under cotton in Haveri district in 2011-12

Sl.No	Taluk	Area (ha)	Percentage
1.	Ranebennur	19785	18.64
2.	Hirekerur	19054	17.95
3.	Haveri	18016	16.97
4.	Savanur	16060	15.14
5.	Byadagi	11659	10.98
6.	Hanagl	10816	10.19
7.	Shiggaon	10750	10.13
	Total	106140	100

Source: District Statistical office (2011-12)

Table 3.5: Details of the sample farmers selected for the study (Numbers)

Sl. No	Taluks	Village	Sample size
1	Hirekerur	1. Rattihalli	20
		2. Vadiampura	20
2	Haveri	1. Kittur	20
		2. Bailmadapura	20
3	Ranebennur	1. Etagi	20
		2. Mustur	20
	Total		120

$$Y_t = ab^t e^u \text{............} (1)$$

Where,

Y_t = dependent variable (area/yield/production)

a = intercept term

b = (1+r) and r is the compound growth rate

t = time trend

u = error term

The above model in Logarithmic form is expressed as, Log Y = log a + t log b + log *u.* Log a and Log b values were obtained using the ordinary least squares procedures, and the R^2 was computed for testing the goodness of fit. Antilog[(Log (b -1)]* 100 gave the per cent growth rate.

3.4.2 Tabular presentation technique

Descriptive statistics like averages, percentages etc. were used and tabulated to compile the data on general characteristics of the sample farmers, farmers wise distribution of Bt-cotton hybrids, resource use pattern, cost structure, returns and profits to obtain the meaningful information. Budgeting technique was used to estimate the costs and returns in Bt-cotton production.

3.4.3 Functional analysis

The Cobb-Douglas type of production function was used to study the effect of various inputs on Bt-cotton output. It being a homogenous function provided a scale factor enabling to measure the returns to scale. The estimated regression coefficients represented the production elasticities. The form of Cobb-Douglas production function used in the present study was as follows.

$$Y = aX_1^{b1}X_2^{b2}X_3^{b3} X_4^{b4} X_5^{b5}X_6^{b6} X_7^{b7} e^u \quad \_\_\_\_\_\_\_\_\_\_\_\_\_ (2)$$

Where,

Y = Gross returns (Rs/ha)

a = Intercept (efficiency) term

X_1 = Expenditure on seeds (Rs/ha).

X_2 = Expenditure on FYM (Rs/ha).

X_3 = Human labour expenditure (Rs/ha).

X_4 = Bullock labour expenditure (Rs/ha).

X_5 = Machine labour expenditure (Rs/ha)

X_6 = Expenditure on Fertilizer (Rs/ha).

X_7 = Expenditure on PPC (Rs/ha).

u = Error term

bi's = Output elasticities of respective inputs, i = 1, 2….7

The Cobb-Douglas production function was converted into log linear form and parameters (coefficients) were estimated by employing Ordinary Least Square Technique (OLS). The logarithmic form of equation was

$$\log Y = \log a + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + b_4 \log X_4 + b_5 \log X_5 + b_6 \log X_6 + b_7 \log X_7 + u \quad \_\_\_\_\_\_\_\_\_\_\_\_\_ (3)$$

The regression coefficients (b_i's) were tested using 't' test at chosen level of significance.

3.4.4 Measurement of efficiency

The analysis of efficiency should help to identify the possibilities for increasing income while conserving resources. The role of efficiency may be viewed as an important in policy making to stimulate income and/or promote resource conservation. The concept of efficiency was first defined by

Farrel (1957) in terms of its two dimensions technical efficiency and allocative efficiency. Technical efficiency arises when the maximum output is obtained from a given bundle of inputs and allcative efficiency arises when inputs are used in proportion, which yield maximum output. Allocative efficiency exists when resources are allocated within the farm according to market prices. It is therefore, suggested that within a static framework measures of technical efficiency retain validity as measure of goal achievement in a materialistic world (Russel and Young 1983). The idea of frontier production function is built around the concept of efficiency adduced by Farrel (1957)

3.4.4.1Technical efficiency

Timmer's output based measure of technical efficiency

Timmer (1971) imposed the Cobb-Douglas production function on the frontier and computed an output based measure of technical efficiency. The approach adopted here is to specify a fixed parameter frontier amenable to statistical analysis. This takes the following general form.

$Y = f(X) e^{u}$, $u<0$ ……………………….(4)

and the Cobb-Douglas production function in natural logarithmic form would be:

$\ln Y = \ln a + \sum b_j \ln x_j + u$, $u<0$ …………………….(5)

In estimating the above equation, the Corrected Ordinary Least Squares (COLS) regression is chosen as the most convenient means. This method is briefly outlined as under.

As a first step, the Cobb-Douglas equation was estimated by the method of OLS yielding the best linear unbiased estimates of b_i coefficients. The intercept 'a' was then corrected by shifting the function until no residual is positive and one is zero. This is done by adding the largest error term of the fitted model to the intercept. Greene (1980) has shown that a consistent, through biased of 'a' which imposes the sign uniformity on the residuals would be generated by this procedure.

Thus, Timmer measure of technical efficiency (TE_i) of a farm 'i' is the ratio of actual output to potential (Frontier) output, given the level of input use on farm 'i'. It thus indicated how much extra output could be obtained if farm 'i' were to be on the frontier with the given technology and level of input. Timmer measure of technical efficiency is given by:

$$TE_i = \frac{Y}{Y^*} \leq 1 \quad \dots\dots\dots\dots\dots\dots(6)$$

Where,

Y = Actual output

Y^* = Potential output obtainable for given level of inputs

3.4.4.2 Allocative efficiency

Given the technology, allocative efficiency exists when resources are allocated within the farm according to market prices and it implies the proper level of input use in production. To decide whether a particular input is used rationally or irrationally, its marginal value products were computed. If the marginal value product of an input just covers its acquisition cost it is said to be used most efficiently. The Marginal Value Product (MVP) was calculated at the geometric mean level of variables by using the formula.

$$\text{MVP } i^{th} \text{ resource} = b_i \frac{\bar{Y}}{\bar{X}_i} \dots\dots\dots\dots\dots (10)$$

Where,

$\bar{Y}$ = Geometric mean of the output in value

$\bar{X}_i$ = Geometric mean of i^{th} input in value

b_i = The regression coefficient of the i^{th} input

In order to determine the efficiency of allocation of the resources or price efficiency, the value of the marginal product obtained by multiplying the marginal product (b_i) by the price of the product and was compared with its marginal cost. A ratio of the value of marginal product to the factor price more than unity implied that the resources were underutilized. If the ratio was less than one, it suggested that resource was over utilized. The criterion for determining optimality of resource use was,

MVP/MFC > 1 under utilization of resource

MVP/MFC = 1 optimal use of resource

MVP/MFC < 1 excess use of resources.

3.4.5 Garrett's ranking technique

Reasons for selection of cultivars by sample respondents were prioritized by using Garrett's ranking technique. For this purpose, seven reasons were identified, first identified as important considered by the majority of respondents. Each of 120 respondents selected were asked to rank the above seven reasons from rank 1 to 7. In this analysis, rank 1 meant most important reason and rank 7 meant least important reason. In the next stage, rank assigned to each reason by each individual was converted into per cent position using the following formula.

Per cent position = 100 (R_{ij} – 0.5) / N_j

Where,

R_{ij} stands for rank given for the i^{th} factor (i= 1, 2…..7) by the jth individual

(j = 1,2…….120) N_j stands for number of factors ranked by j^{th} individual.

Once the per cent positions were found, scores were determined for each per cent position by referring Garrett's table. Then, the scores for each reason were summed over the number of respondents who ranked that factor. In this way, total scores were arrived at for each of the seven reasons and mean scores were calculated by dividing the total score by the number of respondents who gave ranks. Final overall ranking of the seven reasons was done by assigning rank 1, 2, 3… *etc* in the descending order of the mean scores.

3.5 Concepts used in the study

3.5.1 Biodiversity

Biodiversity is the variety of all living organisms at all levels. For the present study agro-diversity is defined as the diversity of existing domesticated plant (FAO, 1995). This is classified into genetic diversity, varietal diversity and species diversity. The present study deals with the varietal diversity Bt-cotton.

3.5.2 Cultivar diversity

Cultivar diversity, broadly defined as the extent of dissimilarity among set of varieties.

3.5.3 Technical efficiency

Hazarika and Subramanian (1999) defined technical efficiency as the production of maximum from a set of given resources. Technical efficiency is said to have increased when cost of performing a function for each unit of output is reduced.

3.5.4 Allocative efficiency

Farell (1957) defined allocative efficiency as the ability of the farm to maximize profit by equating the marginal revenue product of inputs to their respective marginal costs.

3.5.5 Human labour

Human labour was estimated in terms of eight hours of work per day. The prevailing wage rates were Rs.150 for male and Rs.100 for female labour.

3.5.6 Bullock labour

It was measured in pair days. Hence one pair day means eight hours of work by a pair of bullock and a man required to operate this bullock pair valued at the rate of Rs. 400 per day.

3.5.7 Machine labour

The cost of machine labour both hours and days was calculated for differential rates for different type of operation prevailed in study area.

3.5.8 Seed cost

Farm produced seed has been evaluated at the village prices prevalent at the time of sowing. Purchased seeds have been evaluated at actual rates paid by the sample farmers.

3.5.9 Farm yard manure (FYM)

Farm produced manure was evaluated at the village prices prevalent at the time of sowings. FYM purchased was evaluated at actual rates paid by the sample farmers.

3.5.10 Fertilizers

Cost of fertilizer was computed considering the actual price paid by the farmers including the transportation cost and other identical charges if any were considered.

3.5.11 Plant protection chemicals

The cost of different insecticides, weedicides and fungicides used in controlling Bt-cotton pests and diseases were calculated based on the actual price paid by the farmers towards these chemicals.

3.5.12 Variable costs

The variable costs include cost of seed, organic manure, fertilizers, wages of human and bullock labour, plant protection chemicals and interest on operational capital at the rate of 7 per cent per annum.

3.5.13 Interest on working capital

Interest has been charged at the rate of 7 per cent per annum for a crop period on the variable cost incurred during the period of cultivation.

3.5.14 Fixed costs

These include depreciation on farm implements and machinery, interest on fixed capital and land revenue.

3.5.15 Depreciation charges

Depreciation on each capital equipment and machinery owned by the farmers and used for cultivation of land was calculated for individual farmer based on the purchase value using the straight line method.

$$\text{Annual depreciation} = \frac{\text{Purchase value} - \text{Junk value}}{\text{Economic life of the asset}}$$

3.5.16 Interest on fixed capital

Interest on fixed capital was calculated at 12 per cent per annum, which is the prevailing rate of investment credit. The items considered under fixed capital are implements and machinery.

3.5.17 Land revenue

Land revenue was charged at the rates levied by the government. Allocation of the cost was done in proportion to the area under the crop.

3.5.18 Land rent

The prevailing land rent for agricultural enterprises were imputed for the sample farmers, since all land holdings were observed to be owner operated.

3.5.19 Cost of cultivation

It is the sum of variable costs and fixed costs expressed on per hectare basis.

3.5.20 Gross returns

Gross returns were obtained by multiplying the total product with its unit value.

3.5.21 Net returns

Net returns were obtained by deducting the total costs incurred from the gross returns obtained.

3.5.22 Benefit cost ratio

Benefit cost ratio was obtained by dividing the gross returns by total cost of cultivation.

RESULTS

This study was conducted in Haveri district of Karnataka. The necessary data were collected from 120 sample farmers. The data were subjected to various statistical tools and techniques to draw meaningful conclusions. The results of the study were presented in this chapter under the following heads.

4.1 Growth in area, production and productivity of cotton in Haveri district

4.2 General characteristics of the sample Bt- cotton farmers

4.3 Cropping pattern of the sample Bt- cotton farmers

4.4 Extent and magnitude of hybrid diversity in Bt- cotton

4.5 Cost and returns from Bt-cotton cultivation in different hybrids

4.6 Estimated Bt-cotton production function

4.7 Technical and Allocative efficiency in Bt-cotton cultivation

4.8 Factors influencing the preference for Bt- cotton hybrids

4.1 Growth in area, production and productivity of cotton in the study area

Growth in area, production and productivity of cotton in Haveri district was worked out for the period from 1997-98 to 2010-11 and also mean area, production, productivity of cotton and coefficient of variation for these parameters are depicted in Table 4.1. The mean cotton area was 0.83 lakh hectares with fluctuation of about 48.09 per cent. Whereas, average production and productivity of cotton was 6.05 lakh bales and 238 kg per hectares, respectively. The production and productivity of cotton were found to fluctuate about 46.04 per cent and 38.63 per cent respectively. The fluctuation in cotton production was mainly due to the fluctuation in cotton productivity.

The area, production and productivity of cotton were growing at the rate of 1.33 per cent, 6.47 per cent and 3.89 per cent per annum respectively. Annual growth rate of area was less than the annual growth rate of productivity and it is also non- significant. It is clear that positive annual growth in cotton production was due to increase in productivity rather than increase in area.

4.2 General characteristics of the sample Bt- cotton farmers

The age, family size, education level, occupational pattern and operational land holding of the sample respondents are presented in Table 4.2

4.2.1 Socio economic characteristics of Bt- cotton growing farmers

The information on socio-economic characteristics of the Bt-cotton sample respondents is presented in Table 4.2. The average age of sample cotton farmers was 48.41 years. The average size of the family was 5.37 members. The educational status of the sample farmers is also presented in table. It was noticed that on an average 84.17 per cent of the farmers were literate. Among literates, 37.50 per cent of the farmers had education up to primary level, 29.17 per cent of them studied up to high school. The farmers who had studied up to pre university level and above were 17.50 per cent and the remaining 15.83 per cent of the farmers were illiterate. As for occupation was concerned, 83.33 per cent of sample respondents undertook agriculture as a main occupation, while remaining 16.67 per cent were having subsidiary occupation.

The average size of operational land holding for the sample farmers was 3.30 ha. The proportion of land having the irrigation facility was only 38.79 per cent of the total operational land holding and remaining 61.21 per cent was under rain fed condition.

4.2.2 Operational land holding and area under Bt-cotton

Table 4.3 indicates the farm size, operational holding and area allotted for Bt-cotton by the sample farmers. The average size of land holding for the sample farmers was 3.09 hectares. Average size of leased in land was 0.21 hectares. Total operational land holding was observed 3.30 hectares. The average area occupied by the Bt-cotton was 1.46 ha.

Table 4.1: Growth in area, production and productivity of cotton in Haveri district (1997-98 to 2010-11)

Particulars	Average	CGR (%)	CV (%)
Area (lakh ha)	0.83	1.33	48.09
Production (lakh bales)	6.05	6.47**	46.04
Productivity (Kgs/ha)	238.14	3.89*	38.63

Note: ** significant @ 5%, * significant @10%

Table 4.2: General characteristics of sample farmers

n-120

Sl. No	Particulars	Unit	Average	Percentage
1	Age of the farmers	Years	48.41	-
2	Size of the family	Number	5.37	-
3	Education			
i.	Illiteracy	Number	19	15.83
ii	Primary	Number	45	37.50
iii	High school	Number	35	29.17
iv	Pre-University & above	Number	21	17.50
4	Main occupation			
	Agriculture	Number	100	83.33
	Subsidiary	Number	20	16.67
5	Operational land holding	Ha	3.30	
	Rainfed	Ha	2.02	61.21
	Irrigated	Ha	1.28	38.79

Table 4.3: Operated land holding and area under Bt. Cotton in

Sl. No	Particulars	Average area (ha)
1	Average size of land	3.09 (93.64)
2	Average size of leased in land	0.21 (6.36)
3	Total operational land holding	3.30 (100)
4	Average area under Bt-cotton	1.46 (44.24)

Table 4.4: Cropping patter of sample farmers

Season	Crops	Area (ha)	Percentage
Kharif	Cotton	1.46	44.24
	Maize	1.25	37.88
	Sugar cane	0.23	6.97
	Paddy	0.18	5.45
	Tur	0.07	2.12
	Groundnut	0.11	3.33
	Sub total	3.30	100
Rabi	Maize	0.98	36.57
	Jowar	0.84	31.34
	Vegetables	0.30	11.19
	Wheat	0.15	5.60
	Chick pea	0.23	8.58
	Seed production	0.18	6.72
	Sub total	2.68	100
Gross cropped area	-	7.90	-
Net cropped area	-	3.30	-
Cropping intensity (%)	-	239.39	-

4.3 Cropping pattern of the sample Bt-cotton farmers

Cropping pattern of sample farmers is given in Table 4.4. Major crops grown during *Kharif* by sample farmers were cotton, maize, sugarcane followed by paddy, tur and ground nut. It is evident from the table that 44.24 per cent of total kharif cropped area was occupied by cotton. Maize was the major cereal crop which occupied 37.88 per cent of area. Sugarcane, the next major commercial crop grown by sample farmers occupied 6.97 per cent of total *kharif* area and it occupies land in all the three seasons. While paddy occupied 5.45 per cent. Similarly, tur and ground nut occupied 2.12 per cent and 3.33 per cent respectively. In *rabi* season, major proportion of the gross cropped area was occupied by maize and jowar which accounts 36.57 per cent and 31.34 per cent. Followed by the other crops like vegetables, chick pea and wheat were occupied an area of 11.19 per cent, 8.58 per cent and 5.60 per cent of total *rabi* area respectively. It was noticed that grass cropped area was 7.90 ha and net sown area of the sample farmers was 3.30 ha with a cropping intensity of 239.39 per cent.

4.4 Extent and magnitude of hybrid diversity in Bt-cotton

The diversity of a crop or its cultivars or its cultivation at the regional level is due to the dynamic interplay of the factors both at micro and macro levels. In the macro level, the changing agricultural pattern (more specifically cropping pattern) and in the micro level technology-specific and farmer-specific characters will be determining the movement of cultivar diversity of cultivated crop species. In this section emphasis is given to the micro level dynamics of the cultivar diversity of Bt-cotton and the causes of it.

4.4.1 Bt-cotton seeds indented by the agriculture department during 2011-12 in Haveri district

Table 4.5 shows Bt-cotton seeds indented by the department of agriculture during 2011 in Haveri district. It was observed that more than twenty hybrids were indented in the district. Among these hybrids Mayhyo seeds was having highest share of about 33.98 per cent followed by Nuziveedu seeds (11.99%), Vikram seeds (7.47%), Vibha seeds (7.40%), Bioseeds (6.93%) etc.

4.4.2 Distribution of farmers according to cultivar grown

Distribution of farmers according to cultivars grown is presented in Table 4.6. It was observed that out of 120 respondents 81 (55.47%) were growing Kanaka hybrid. Whereas 10 (6.80%) respondents were growing Yuva Bt and about 8 (5.48%) respondents were growing Namdhari hybrid. Sample farmers were also growing hybrids like Cashplus (4.79%), Rashi (4.79%), Niraj (4.11%), Ankur (3.42%), Bt Rakshika (3.42%), Mahajhansi (3.42%), Bt Mallika (2.74%), Prasanna Bt (2.05%), Nikki (2.05%) and Vikram (1.37%)

4.4.3 Distribution of farmers according to number of hybrids grown

Distribution of farmers according to number of hybrids grown is presented in Table 4.7. It was observed from the table that out of 120 farmer respondents most of the farmers (78.33 %) preferred to cultivate only one hybrid with an average area of 1.15 ha (78.77 %) and 23 farmers (19.17%) respondents cultivated two hybrids with average area of 0.27 ha (18.47 %) and only 3 farmer respondents (2.50 %) cultivated three hybrids with area of 0.04 ha (2.74 %) Average area under Bt-cotton cultivation was 1.46 ha.

4.5 Cost and returns from Bt-cotton cultivation in different hybrids

Before actually going to analyse costs and returns in Bt-cotton production, it is better to understand physical input-output relationship and labour utilization pattern. The details are presented in following section.

4.5.1 Hybrid wise input use pattern and output obtained in Bt-cotton cultivation

Hybrid wise inputs used and output obtained per hectare of Bt-cotton cultivation by the sample farmers are presented in Table 4.8. It can be observed from the table that Yuva Bt, Namdhari hybrid and all other hybrids growing farmers were used slightly more inputs compared to that of Kanaka hybrid growing farmers.

The average per hectare seeds utilized by Kanaka hybrid growing farmers was 1.75 kg Yuva Bt growing farmers was 2.01kg, Namdhari hybrid growing farmers was 2.14 kg and other hybrids growing farmers was 2.28 kg. On an average, 3.65 tons of farmyard manure (FYM) was applied to

Table 4.5 Bt-cotton seeds indented by the department of agriculture in 2011-12 in Haveri district

Sl. No	Name of the hybrid	Quantity (in packets)	Percentage	Area (ha)
1	Mahyco Seeds	140371	33.98	28074.20
2	Nuziveedu seeds	49534	11.99	9906.80
3	Vikram seeds	30853	7.47	6170.60
4	Vibha seeds	30572	7.40	6114.40
5	Bioseed	28621	6.93	5724.20
6	Rasi seeds	25836	6.25	5167.20
7	Monsanto	18427	4.46	3685.40
8	Ankur seeds	16937	4.10	3387.40
9	Kaveri seeds	16554	4.01	3310.80
10	Pravardhan seeds	10390	3.52	2078.00
11	Krishidhan seeds	9128	2.21	1825.60
12	Ajeeth seeds	8468	2.05	1693.60
13	Prabhat seeds	6952	1.68	1390.40
14	Namdhari	6181	1.49	1236.20
15	JK Seeds	4142	1.00	828.40
16	Bayer seeds	3993	0.97	798.60
17	Seeds works India	3966	0.96	793.20
18	Solar seeds	2314	0.56	462.80
19	Xylem seeds	1146	0.28	229.20
20	Tulasi seeds	737	0.18	147.40
	Total	413051	100	82610.20

Table 4.6: Distribution of farmers according to Bt-cotton hybrids grown

Sl. No	Hybrids	Number	Percent
1	Kanaka	81	55.47
2	Yuva Bt	10	6.80
3	Namdhari	8	5.48
4	Cashplus	7	4.79
5	Rasi	7	4.79
6	Niraj	6	4.11
7	Ankur	5	3.42
8	Bt Rakshika	5	3.42
9	Mahajhansi	5	3.42
10	Bt Mallika	4	2.74
11	Prasanna Bt	3	2.05
12	Nikki	3	2.05
13	Vikram	2	1.37
	Total	146	100

Note: Some farmers grown combination of these hybrids so number has increased

Table 4.7: Distribution of farmers according to number of Bt-cotton hybrids grown

n=120

Particulars	Number	Area(ha)
One hybrid only	94 (78.33)	1.15 (78.77)
Two hybrids	23 (19.17)	0.27 (18.49)
Three hybrids	03 (2.50)	0.04 (2.74)
Total	120 (100)	1.46 (100)

Table 4.8 Hybrid wise input utilization pattern and output obtained in Bt-cotton cultivation (per ha)

Sl. No	Inputs	Units	Quantity			
			Kanaka (n=81)	Yuva Bt (n=10)	Namdhari (n=8)	Others (n=21)
1	Seed	Kg	1.75	2.01	2.14	2.28
2	FYM	Ton	3.65	3.68	3.73	3.82
3	Human labour	MD	68.76	65.24	64.85	64.68
4	Bullock pair	BPD	16.61	16.95	17.02	17.11
5	Machine labour	Hours	3.18	3.21	3.37	3.49
6	Fertilizers					
	Urea	Kg	235.54	235.85	245.23	245.00
	DAP	Kg	187.50	196.54	203.85	218.75
	MOP	Kg	125	115.74	105.95	100.45
7	Plant protection chemicals	ltr	0.97	1.10	1.24	1.24
	Yield	Qtls.	18.76	17.24	16.54	16.89

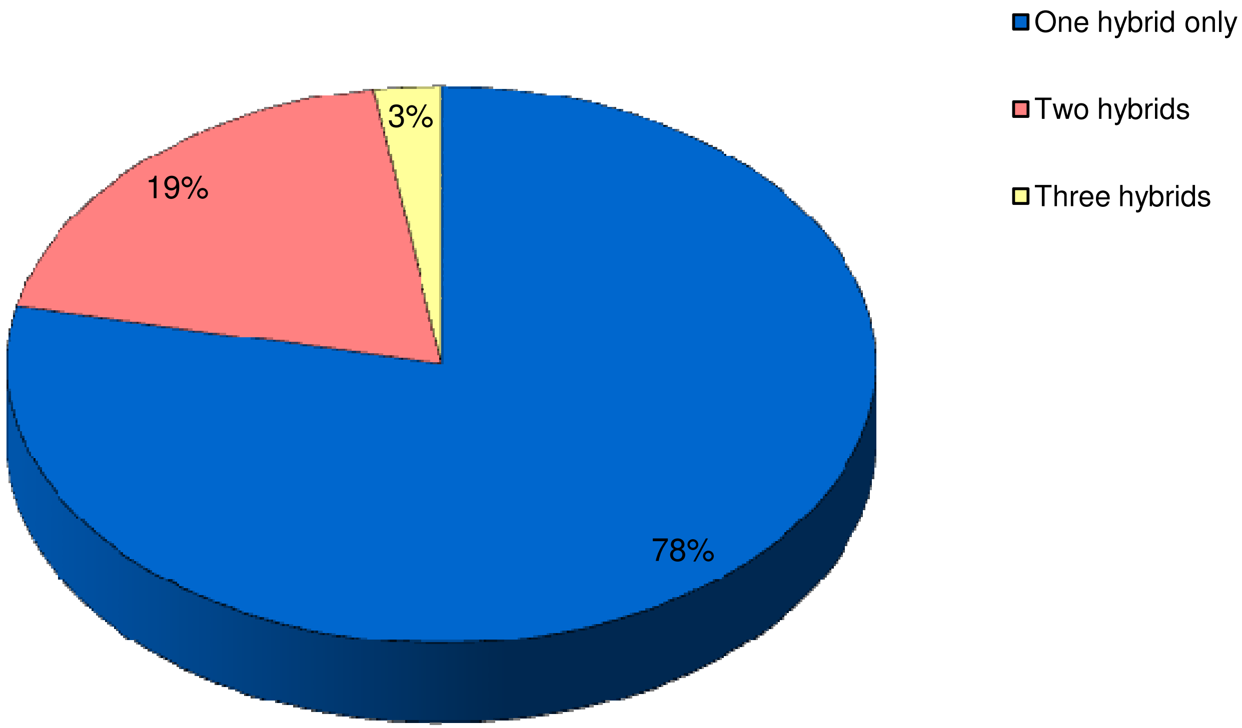


Fig. 2. Distribution of farmers according to number of hybrids grown

Kanaka, 3.68 tons to Yuva Bt, 3.73 tons to Namdhari hybrid and 3.82 tons for other hybrids. The average per hectare utilization of human labour was 68.76 man days in Kanaka, 65.24 man days in Yuva Bt, 64.85 man days in Namdhari hybrid and 64.68 man days in other hybrids. With respect to bullock labour, Yuva Bt (16.75 pair days), Namdhari hybrid (17.02 pair days) and other hybrids growing farmers used (17.11 pair days) slightly more bullock labour as compared to Kanaka hybrid (16.61 pair day). Machine labour use was more by Yuva Bt(3.21 hours), Namdhari hybrid (3.37 hours) and other hybrids growing farmers (3.49 hours) compared to Kanaka growing farmers (3.18 hours). The farmers growing Kanaka used 235.54 kg of urea, 187.50Kg of DAP and 125 Kg of MOP followed by farmers growing Yuva Bt used 235.54 kg urea, 196.54 kg DAP,115.74 kg MOP. Whereas farmers growing Namdhari hybrid used 245.23kg urea, 203.85kg DAP, 105.95kg MOP. Farmers growing other hybrids used 245.00 Kg of urea, 218.75Kg of DAP and 100.45 Kg of MOP fertilizers. On an average 0.97 l of plant protection chemical (PPC) was used by Kanaka hybrid growing farmers followed by 1.10 l, 1.24 l and 1.24 l of PPC by farmers growing Yuva Bt, Namdhari hybrid and other hybrids respectively. The average quantity of kapas obtained per hectare was 18.76 q in case of Kanaka hybrid, 17.24 q in Yuva Bt, 16.54 q in Namdhari hybrid and 16.89q in other hybrids.

4.5.2 Hybrid wise Labour utilization pattern in Bt-cotton cultivation

The operation-wise labour utilization pattern in Kanaka hybrid and other hybrids is presented in Table 4.9. It is evident from the table that the per hectare human labour used in Kanaka was 68.76 man days, bullock labour was 16.61 pair days and machine labour was 3.18 hours. Among different operations, harvesting/picking consumed the highest of 29.40 (42.76 %) man days of labour followed by marking lines and sowing 7.76 man days (11.28 %), packing 6.91 man days (10.05 %),weeding 6.12 man days (8.90 %), PPC application 3.65 man days (5.31 %), harrowing 3.42 man days (4.97%), fertilizer application 3.16 man days (4.59%), ploughing 2.89 man days (4.20 %), spreading of FYM 2.34 man days (3.40%), inter cultivation 1.84 man days (2.68 %) and loading and transportation of FYM 1.27 man days (1.84 %). In Bt-cotton cultivation, bullock labour was most commonly used than machine labour in the study area, farm operations such as marking lines and sowing consumed highest bullock labour 4.11 (24.74 %) pair days, followed by harrowing 3.95 (23.78 %) pair days, inter cultivation 3.23 (19.44%) pair days, loading and transportation of FYM 2.96 (17.82 %) pair days and ploughing 2.36 (14.21 %) pair days. Apart from bullock pair days, the operation like ploughing, harrowing and transportation of FYM consumed 1.21 (38.05 %), 0.65 (20.44 %), 1.32 (41.50 %) hours machine labour respectively.

Whereas in Yuva Bt, Namdhari hybrids and all other hybrids human labour used was 65.24 man days, 64.85 man days and 64.68 man days respectively. In Bt-cotton cultivation bullock labour, was most commonly used than machine labour in the study area. For the operations like ploughing (2.36 man days), harrowing (3.95 man days), loading and transportation of FYM (2.96 man days), Inter cultivation (3.23 man days) bullock labour used was almost same among different hybrids growing farmers in study area. Whereas in operation like marking of line and sowing bullock labour used was slightly varied among different hybrid growing farmers. Apart from bullock pair days the operations like ploughing, harrowing and loading and transportation of FYM consumed almost same machine labour hours in Yuva Bt, Namdhari and other hybrids.

4.5.3 Hybrid wise cost of cultivation of Bt-cotton cultivation

Hybrid wise cost incurred and returns realized from Bt-cotton cultivation by the sample farmers for the year 2012-13 were calculated and are presented in Table 4.10 and Table 4.11. The cost of cultivation of Yuva Bt, Namdhari hybrid and other hybrids were found to be slightly higher than that of Kanaka hybrid. The total cost of cultivation of Kanaka hybrid was ₹ 45936 per hectare of which 66.06 per cent was variable cost and 33.94 per cent was fixed cost and whereas in other hybrids total cost of cultivation was ₹ 47688 per hectare of which 67.31 per cent was variable cost and 32.69 per cent was fixed cost. Among the variable costs, the share of human labour was major component amounting to ₹8125 (17.69 %), ₹7864(17.05%), ₹7785 (16.51%) and ₹7635 (16.07%) in Kanaka, Yuva Bt, Namdhari hybrid and other hybrids respectively. The cost of bullock labour, machine labour, fertilizers, plant protection chemicals and seed was higher in case of other hybrids i.e ₹4565 (9.57 %), ₹2854 (5.99 %), ₹5056 (10.60%), ₹1768 (3.71%), ₹4104 (8.61 %) respectively as compared to Kanaka i.e, ₹4163 (9.06%), ₹2351 (5.12%), ₹4895 (10.6%) ₹1645 (3.58%), ₹3255 (7.09 %) respectively. The fixed cost includes land revenue, rental value of land, depreciation and interest on fixed capital of which rental value of land accounts highest cost ₹13205 (28.75 %) , ₹13205 (28.63%),₹13205(28.01%) and ₹13205 (27.79 %) in Kanaka, Yuva Bt, Namdhari hybrid and in other hybrids respectively.

Table 4.9: Hybrid wise labour utilization pattern in Bt-cotton production (per ha)

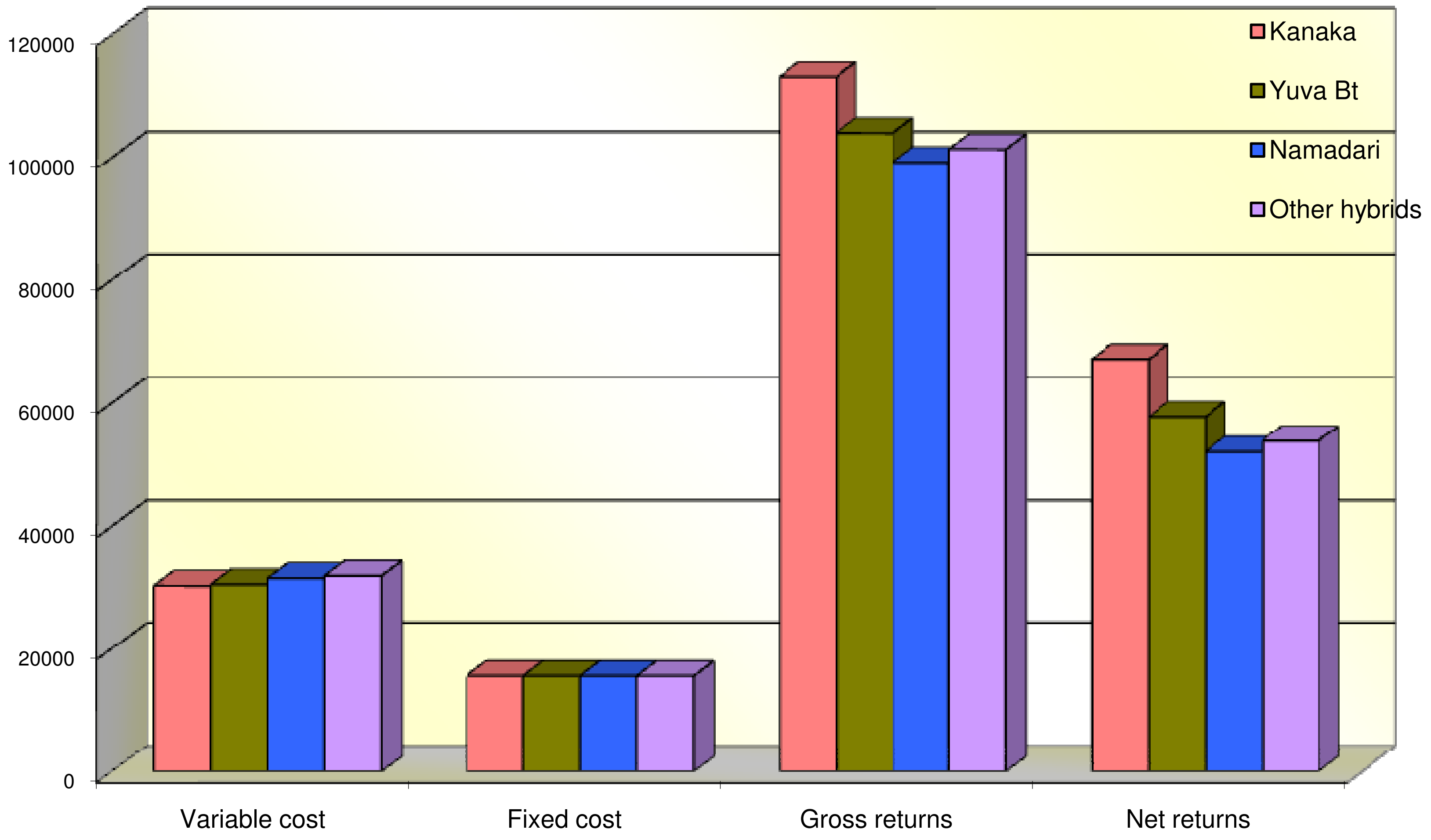
Sl. No	Operations	Kanaka(n=81)			Yuva Bt(n=10)			Namdhari(n=8)			Other hybrids(n=21)		
		Human labour (man days)	Bullock labour (pair days)	Machine labour (hrs)	Human labour (man days)	Bullock labour (pair days)	Machine labour (hrs)	Human labour (man days)	Bullock labour (pair days)	Machine labour (hrs)	Human labour (man days)	Bullock labour (pair days)	Machine labour (hrs)
1	Ploughing	2.89 (4.20)	2.36 (14.21)	1.21 (38.05)	2.89 (4.43)	2.36 (13.92)	1.21 (37.69)	2.89 (5.27)	2.36 (13.87)	1.21 (35.90)	2.89 (4.47)	2.36 (13.79)	1.21 (34.67)
2	Harrowing	3.42 (4.97)	3.95 (23.78)	0.65 (20.44)	3.42 (5.24)	3.95 (23.30)	0.65 (20.24)	3.42 (5.27)	3.95 (23.20)	0.65 (19.29)	3.42 (5.29)	3.95 (23.09)	0.65 (18.62)
3	Loading and transportation of FYM	1.27 (1.84)	2.96 (17.82)	1.32 (41.50)	1.27 (1.90)	2.96 (17.46)	1.35 (42.06)	1.27 (1.96)	2.96 (17.39)	1.51 (44.80)	1.27 (1.96)	2.96 (17.29)	1.63 (46.70)
4	Spreading of FYM	2.34 (3.40)	-	-	2.34 (3.59)	-	-	2.34 (3.60)	-	-	2.34 (3.62)	-	-
5	Marking lines and sowing	7.76 (11.28)	4.11 (24.74)	-	7.76 (11.89)	4.45 (26.25)	-	7.76 (11.97)	4.52 (26.56)	-	7.76 (11.99)	4.61 (26.94)	-
6	Fertilizer application	3.16 (4.59)	-	-	3.16 (4.84)	-	-	3.16 (4.87)	-	-	3.16 (4.89)	-	-
7	Inter cultivation	1.84 (2.68)	3.23 (19.44)	-	1.84 (2.82)	3.23 (19.06)	-	1.84 (2.84)	3.23 (18.98)	-	1.84 (2.84)	3.23 (18.88)	-
8	Weeding	6.12 (8.90)	-	-	6.12 (9.38)	-	-	6.12 (9.44)	-	-	6.12 (9.46)	-	-
9	PPC application	3.65 (5.31)	-	-	3.70 (5.67)	-	-	3.76 (5.79)	-	-	3.8 (5.88)	-	-
10	Harvesting/Picking	29.40 (42.76)	-	-	27.28 (41.81)	-	-	26.86 (41.42)	-	-	26.74 (41.34)	-	-
11	Packing	6.91 (10.05)	-	-	5.46 (8.37)	-	-	5.43 (8.37)	-	-	5.34 (8.26)	-	-
	Total	68.76 (100)	16.61 (100)	3.18 (100)	65.24 (100)	16.95 (100)	3.21 (100)	64.85 (100)	17.02 (100)	3.37 (100)	64.68 (100)	17.11 (100)	3.49 (100)

Table 4.10: Hybrid wise cost of cultivation of Bt-cotton (₹/ha)

Sl. No	Particulars	Kanaka (n=81)		Yuva Bt (n=10)		Namdhari (n=8)		Other hybrids (n=21)	
		Cost	Per cent	Cost	Per cent	Cost	Per cent	Cost	Per cent
I	Variable cost								
a)	Material cost								
	Seed	3255	7.086	3575	7.75	3864	8.13	4002	8.42
	FYM	3923	8.54	3925	8.51	3989	8.46	3997	8.41
	fertilizers	4895	10.66	4958	10.75	4974	10.55	5016	10.56
	PPC	1645	3.58	1674	3.63	1720	3.65	1768	3.72
b)	Labour cost								
	Human labour	8125	17.69	7864	17.05	7785	16.51	7635	16.07
	Bullock labour	4163	9.06	4175	9.05	4365	9.26	4565	9.60
	Machine labour	2351	5.12	2364	5.13	2785	5.91	2854	6.00
	Interest on working capital @7%	1985	4.32	1997	4.33	2064	4.38	2089	4.39
	Total variable cost	30345	66.06	30532	66.19	31546	66.92	31926	67.19
II	Fixed cost								
	Land revenue	57	0.12	57	0.12	57	0.12	57	0.12
	Depreciation	658	1.43	658	1.43	658	1.39	658	1.38
	Rental value on land	13205	28.75	13205	28.63	13205	28.01	13205	27.79
	Interest on fixed capital @12%	1670	3.64	1670	3.62	1670	3.54	1670	3.51
	Total fixed cost	15590	33.94	15590	33.80	15590	33.07	15590	32.81
III	Total cost of cultivation	45936	100	46122	100	47136	100	47516	100.00

Table 4.11: Cost and returns profile of Bt-cotton production

Sl. No.	Particulars	Kanaka (n=81)	Yuva Bt (n=10)	Namdhari (n=8)	Other hybrids (n=21)
		Value (₹)	Value (₹)	Value (₹)	Value (₹)
1	Total cost of cultivation	45936	46122	47136	47516
2	Gross returns (₹/ha)	113026	103892	99240	101340
3	Net returns	67090	57770	52104	53824
4	Cost of production (₹/q)	2448	2675	2849	2813
5	Profit (₹/q)	3576	3351	3150	3187
6	B:C ratio	2.46	2.25	2.10	2.13
7	Yield(q/ha)	18.76	17.24	16.54	16.89



120000
100000
80000
60000
40000
20000
0
Kanaka
Yuva Bt
Namadari
Other hybrids
Variable cost
Fixed cost
Gross returns
Net returns

The details of per hectare cost, yields and returns are presented in Table 4.11. The per hectare average yield of Kanaka (18.76 q/ha) was higher than that of Yuva Bt (17.24q/ha), Namdhari hybrid (16.54q/ha) and other hybrids (16.89 q/ha). The returns structure of Kanaka and other hybrids revealed that gross returns were higher (₹113026) in Kanaka as compared to that of Yuva Bt (₹103892), Namdhari hybrid (₹99240) and other hybrids (₹101340). The net returns from Yuva Bt (₹57770), Namdhari hybrid (₹52104) and other hybrids (₹53824) were quit low as compared to Kanaka (₹ 67090).

The per quintal cost of production was ₹2448, ₹2675, ₹2849 and ₹2813 in Kanaka, Yuva Bt, Namdhari hybrid and other hybrids respectively. The per quintal profits were ₹3576, ₹3351, ₹3150 and ₹3187, in Kanaka, Yuva Bt, Namdhari hybrid and other hybrids. It was due to very high price received by respondents. Thus, cultivation of Kanaka was more profitable than other hybrids in the study area and also supported by a high B: C ratio of 2.46 over other hybrids 2.13.

4.6 Production function

The Cobb-Douglass production function was estimated to analyse the relationship between resources and productivity of Bt-cotton using the data from sample farmers. The gross income in rupees realized from Bt-cotton output was taken as dependent variable while expenditure made on seed (₹), fertilizers and FYM (₹), human labours (₹) bullock labours (₹) machine labour (₹) and PPC (₹) were taken as independent variables.

The estimates of the production functions for Kanaka hybrid and other hybrids were obtained separately and are presented in Table 4.12. The inputs included in model explained 92 per cent of variation in Bt-cotton output in Kanaka hybrid and 88 per cent in other hybrids as revealed by the coefficient of multiple determinations (R^2). The summation of regression coefficients indicated increasing returns to scale in both Kanaka (1.85) and other hybrids (1.73) *i.e.* for each incremental use of all inputs by one per cent simultaneously farmers would get more than one per cent of output. The high and significant F values indicated that the Cobb-Douglas production function was adequate in explaining the variation in output.

The estimated parameters of human labour (1.205), machine labour (0.112) were significant at one per cent, while bullock labour (0.137) was significant at five per cent. Whereas the coefficient of seed (0.0004), FYM (0.032), fertilizer (0.229) and PPC (0.137) were positive and non significant in Kanaka hybrid. In other hybrids human labour (0.502,) bullock labour (0.102), fertilizer (0.368) and PPC (0.664) elasticities were significant at one per cent and coefficient of seeds (0.00022), FYM (0.059) and machine labour (0.039) were positive but statistically non significant.

4.7 Technical and Allocative efficiency in Bt-cotton cultivation

4.7.1 Technical efficiency in Bt-cotton production

The technical efficiency in Bt-cotton production was worked out by using Timmer method. The distribution of farmers according to different technical efficiency ratings along with average technical efficiency is presented in Table 4.13 for Kanaka hybrid and other hybrids. The average technical efficiency for Kanaka hybrid was 85 per cent. About 7.41 per cent of farmers were found to operate at technical efficiency rating of below 70 per cent, whereas 25.93 per cent of farmers were found to operate at technical efficiency rating of 70 to 80 per cent. About 46.91 per cent of farmers were found to operate at technical efficiency rating of 80 to 90 per cent.and 19.75 per cent of farmers were found to operate at technical efficiency rating of more than 90 per cent.

The average technical efficiency for other hybrids was 81 per cent. About 7.69 per cent of farmers were found to operate at technical efficiency rating of below 70 per cent, 30.77 per cent of farmers were found to operate at technical efficiency rating of 70 to 80 per cent, whereas 46.15 per cent of farmers were found to operate at technical efficiency rating of 80 to 90 per cent. And 15.38 per cent of farmers were found to operate at technical efficiency rating of more than 90 per cent.

4.7.2 Allocative efficiency in Bt-cotton production

The knowledge of the marginal value products of resources facilitates comparison of marginal value product with marginal factor cost of the resources to arrive at optimal use of resources. The MVP to MFC ratios for different resources is furnished in Table 4.14. for Kanaka hybrid and other hybrids. The MVP to MFC ratios for Kanaka hybrid was greater than unity for human labour (4.282) and PPC (3.384) indicating the greater scope for using additional units of these resources to increase

Table 4.12: Estimated production function of Kanaka and other hybrids

Particulars	Parameters	Coefficients	
		Kanaka hybrid	Other hybrids
Number of observation	n	81	39
Intercept	A	-5.093*	-4.28**
Seeds	X_1	0.0004 (0.041)	0.00022 (0.035)
FYM	X_2	0.032 (0.042)	0.059 (0.043)
Human labour	X_3	1.205** (0.199)	0.502** (0.103)
Bullock labour	X_4	0.137* (0.066)	0.102** (0.039)
Machine labour	X_5	0.112** (0.069)	0.039 (0.03)
Fertilizer	X_6	0.229 (0.144)	0.368** (0.162)
PPC	X_7	0.137 (0.113)	0.664** (0.090)
Returns to scale	∑bi	1.85	1.73
Coefficient of determination	R^2	0.92	0.88
F value	F	54.365	75.069

Note: Figures in parentheses are standard errors
** Significance at 1% level
* Significance at 5 % level

Here other hybrids includes Yuva Bt, Namdhari and others

Table 4.13: Distribution of farmers according to technical efficiency ratings for Kanaka and for other hybrids

Technical efficiency ratings	Number of farmers	
	Kanaka hybrid (n=81)	Other hybrids (n=39)
<70	6 (7.41)	3 (7.69)
70-80	21 (25.93)	12 (30.77)
80-90	38 (46.91)	18 (46.15)
90 and above	16 (19.75)	8 (15.38)
Average technical efficiency	85	81

gross income from Kanaka hybrid cultivation. The MVP to MFC ratio was found positive but less than unity for seeds (0.00015), FYM (0.028) bullock labour (0.321), machine labour (0.066) and fertilizer (0.164) indicating excessive use of these inputs.

The MVP-MFC ratios for other hybrids were greater than unity for human labour (9.630) indicating the greater scope for using additional units of this resource to increase gross income from other hybrids cultivation. The MVP to MFC ratio was positive but less than unity for seeds (0.0005), FYM (0.018) bullock labour (0.516), machine labour (0.155), fertilizer (0.049) and PPC (0.878) indicating excessive use of these inputs.

4.8 Factors influencing the preference for Bt- cotton hybrids

Opinion survey was conducted to know some of the main reasons for selection of Kanaka hybrid over other hybrids by sample respondents and were ranked using Garrette ranking technique and the results were presented in Table 4.15. The respondents were asked to rank the reason in a scale of one to seven, the least score being 7^{th} rank and highest score for rank one. The ranks indicate farmers' preference for different hybrid characteristics. In ranking process big size of bole/more number of boles was given first rank by farmers (77.05). The second main reason ranked by farmers was resistance to pest/diseases (62.10) followed by more number of pickings (60.30), high yield (51.50), high market price (44.05) and easy availability of seeds (30.40) were ranked third, fourth, fifth and sixth respectively. Less cost of cultivation (25.60) was received last rank by the sample farmers.

Table 4.14: Allocative efficiency of resources in Kanaka and in other hybrids

Inputs	MVP/MFC	
	Kanaka hybrid	Other hybrids
Seeds	0.00015	0.0005
FYM	0.028	0.018
Human labour	4.282	9.630
Bullock labour	0.321	0.516
Machine labour	0.066	0.155
Fertilizer	0.164	0.049
PPC	3.384	0.878

Table 4.15: Reasons for selection of Kanaka hybrid over other hybrids by sample respondents

Sl. No.	Reasons	Score	Rank
1	Big size of bole and more number of boles	77.05	I
2	Resistance to insect and disease	62.10	II
3	More no. of Pickings	60.30	III
4	High yield	51.50	IV
5	High market price	44.05	V
6	Easy availability of seeds	30.40	VI
7	Less cost of cultivation	25.60	VII

DISCUSSION

The results of the study presented in the previous chapter have been discussed in this chapter under the following heads. The main thrust given was to throw light on some of the important causes responsible for major trends and facts observed in the results chapter.

5.1 Growth in area, production and productivity of cotton in the Haveri district

5.2 General characteristics of the sample Bt- cotton farmers

5.3 Cropping pattern of the sample Bt- cotton farmers

5.5 Extent and magnitude of hybrid diversity in Bt- cotton

5.5 Cost and returns from Bt-cotton cultivation in different hybrids

5.6 Estimated Bt-cotton production function

5.7 Technical and allocative efficiency in Bt-cotton cultivation

5.8 Factors influencing the preference for Bt- cotton hybrids

5.1 Growth in area, production and productivity of cotton in the study area

The compound growth rates of area, production and productivity of cotton in the study area was worked out during the period from 1997-98 to 2010-11 along with the factors responsible for the same are discussed here. Table 4.1. revealed that mean area, production and productivity of cotton was about 0.83 lakh hectares, 6.05 lakh bales and 238 kg per hectares respectively. The fluctuations in area, production and productivity were respectively 48.09 per cent, 46.04 per cent and 38.63 per cent. The annual growth rates of cotton area, production and productivity were 1.33 per cent, 6.47 per cent and 3.89 respectively. The growth of cotton area was found to be positive (1.33%) but not significant. This clearly indicated that the positive annual growth in cotton production in study district was mainly due to increase in the productivity rather than increase in area. This increase in productivity was due to introduction of Bt-cotton.

5.2 General characteristics of the sample Bt- cotton farmers

Table 4.2 revealed the general information about the Bt-cotton growers in the study area. The average age of the respondents was 48.41 years indicating that most of the farmers were of middle age group. Middle age group farmers are more aggressive in adopting new technology in the form of Bt-cotton for more profit. The average size of the family of Bt- cotton growers is 5.37 members in the study region when compared to state average of 5.10 members was approximately same reflecting the availability of family labour to manage the farms efficiently. As for as education is concerned, 84.17 per cent of respondents were observed to be literate which indicated that majority of the farmers were educated in the study area. Literacy level of sample respondents ranged from primary school to pre-university & above. It may be noted that higher the education level more will be the knowledge and better will be the understanding capacity of new technologies. Operated land holding and area under Bt-cotton were presented in Table 4.3. The average size of the land holding was 3.30 ha and in that majority of area is (2.02 ha) rain fed and remaining (1.28 ha) area is having irrigation facility. Bt-cotton was the most popular commercial crop in the study area as average area allocated for the Bt-cotton was 1.46 ha.

5.3 Cropping pattern of the sample Bt- cotton farmers

Copping pattern followed by farmers in a particular area depends upon rain fall condition, irrigation facilities, commercial importance of crops, food habit and climatic conditions of the area. All most all types of crop group like cereals, pulses, oil seeds, commercial crops and vegetables were grown by the sample respondents (Table 4.4). Thus, as measure to face various types of risks and uncertainties farms cropping pattern was diversified.

5.4 Extent and magnitude of hybrid diversity in Bt-cotton

It was observed from Table 4.6 that about thirteen different hybrids were cultivated by sample farmers whereas majority of the farmers cultivated Kanaka hybrid (55.47%), only about 44.53 percent farmers' gown for cultivation of other hybrids. This is mainly because of important characteristics of

Kanaka hybrid such as big size of boles and more number of boles per plant as compared to other hybrids. Table 4.7 reveled that in the study area only about 21.67 percent of sample farmers were diversified their cultivation. Most of the sample farmers were cultivated only one hybrid this was mainly due to high cost of Bt-cotton seeds.

5.5 Cost and returns from Bt-cotton cultivation in different hybrids

Hybrid wise inputs used and output obtained per hectare of Bt-cotton cultivation were presented in Table-4.8. The inputs used were found to be more in Yuva Bt, Namdhari hybrid and other hybrids compared to that in Kanaka hybrid. There was high amount of application of chemical fertilizers in anticipation of good yield in both Kanaka hybrid and other hybrids. Pesticides and other PPC chemicals were used to minimize / control the pests. But as the type of cotton seeds used by the farmers was Bt-cotton the incidence of boll worm was very less. Hence the use of plant protection chemicals for protecting the crop from pests and diseases was less. The study conducted by Puran *et.al.* (2010) indicated that the Bt-cotton farmers used less of PPC by nearly 26 per cent when compared to non Bt-cotton farmers. Hence, results of the present study are in conformity with the above mentioned study.

The hybrid-wise labour utilization pattern is presented in Table-4.9. The total human labour utilization is more in Kanaka as compared to Yuva Bt, Namdhari hybrid and other hybrids. This is mainly because more number of pickings in Kanaka compared to other hybrids. Among the various operations, harvesting/picking operations consumed higher proportion of human labour as this operation was carried out for 2-3 times. The entire crop cannot be harvested at one stretch and the picking of the opened bolls has to be carried out at suitable intervals. Spreading of picking operation over several weeks and higher output of Bt-cotton requires more number of human labour. Most of the farmers used bullock labour as against use of tractor labour because use of bullock labour worked out to be cheaper than tractor labour use. But some large farmers used tractor for ploughing and other operations in both Kanaka and other hybrids.

Hybrid wise cost incurred and returns realized from Bt-cotton cultivation are presented in Table-4.10. and Table-4.11. The total cost of cultivation of Yuva Bt hybrid (₹46122), Namdhari hybrid (₹47136) and other hybrids (₹47516) were more when compared to that in Kanaka (₹45936). This is because farmers growing other hybrids have used more of inputs like seeds, fertilizer and plant protection chemicals.

The cost of human labour, fertilizer, seeds and bullock labour were the items of cost with major share in the variable costs in all the four hybrids (Kanaka, Yuva Bt, Namdhari hybrid and other hybrids) because most of the operations like harvesting/picking, spraying and weeding are human labour intensive and the other operations like harrowing and inter-cultivation were bullock labour intensive. The distribution pattern of operational cost under various inputs revealed that cost of human labour was the highest in Kanaka (₹8125/ha) as compared to Yuva Bt (₹46122), Namdhari hybrid (₹47136) and other hybrids (₹7635/ha). Whereas average bullock labour cost was more in the case of farmers growing other hybrids (₹4565/ha) than in farmers growing Kanaka (₹4163/ha). It was also noticed that the more expenditure on pesticide was seen in Yuva Bt (₹1674/ha), Namdhari hybrid (₹1720/ha) other hybrids (₹1768/ha) as compared to Kanaka (₹1645/ha).

With respect to returns, the gross return obtained per hectare in Kanaka was high (₹113026) as against the Yuva Bt (₹103892), Namdhari hybrid (₹99240) and other hybrids (₹101340). Net returns per hectare obtained was high in the case of Kanaka growing farmers (₹67090) as compared to Yuva Bt (₹57770), Namdhari hybrid (₹52104) other hybrid (₹53824). This was mainly due to yield obtained by the Kanaka was more (i.e. 18.76 q /ha) as against Yuva Bt (17.24q/ha), Namdhari hybrid (16.54q/ha) other hybrids (16.89 q/ha). The per quintal cost of production for Kanaka was (₹2448) low as compared to Yuva Bt (₹2675), Namdhari hybrid (₹ 2849) and other hybrids (₹2813). The per quintal profits realized by Kanaka was (₹3576) high as compared to Yuva Bt (₹3351), Namdhari hybrid (₹3150) and other hybrids (₹3187). This is due to high price received for Kanaka as compared to Yuva Bt, Namdhari hybrid and other hybrids. Thus, cultivation of hybrid Kanaka was found to be more profitable as compared to Yuva Bt, Namdhari hybrid and other hybrids in study area by sample farmers. And it also supported by a very high magnitude of B: C ratio of 2.46 in Kanaka as against 2.25, 2.10 and 2.13 in Yuva Bt, Namdhari hybrid and other hybrids respectively. The study conducted by Menasinahal, (2011) indicated that B:C ratio of cotton was found to be 2.43. Hence, results of the present study are in conformity with the above mentioned study.

5.6 Production function

The production function estimates for Kanaka and other hybrids were presented in Table 4.12. The value of co-efficient of determination (R^2) was found to be 0.92 and 0.88 in case of Kanaka and other hybrids respectively. This revealed that the independent variables included in the model have explained 92 and 88per cent of variation in the output in Kanaka and other hybrids, respectively. The high and significant F value indicated that the Cobb-Douglas function was adequate in explaining the variation in Bt-cotton output due to variation in the variables included in the model.

In the case of Kanaka the sum of regression co-efficients was more than one, indicating increasing returns to scale. This means that if all the inputs were increased by one per cent, the yield of Kanaka would increase by 1.85 per cent. This was mainly due to significant influence of human labour and bullock labour in case the of Kanaka. The increasing returns to scale clearly revealed that there is a scope for further increase in cotton production by increasing the above inputs. On the contrary, the sum of regression co-efficients in the case of other hybrids (1.73) was found to be more than one but less than that of Kanaka. In other hybrids, the increasing returns is mainly due to significant influence of human labour, bullock labour, fertilizer and PPC.

5.7 Technical and allocative efficiency in Bt-cotton cultivation

The technical efficiency in Bt-cotton production was measured as a ratio of actual output to maximum attainable physical output by each farmer based on Timmer measure of technical efficiency the results are presented in Table 4.13 for Kanaka hybrid and other hybrids. Average technical efficiency was slightly more in Kanaka (85%) as compared to other hybrids (81%). In Kanaka out of 81 farmers, about 6 (7.41%) farmers were found to operate at technical efficiency rating of below 70 per cent and about 16 (19.75%) farmers were found to operate at technical efficiency rating of more than 90 per cent. Majority of the farmers were found to achieve only 85 per cent of technical efficiency and hence there is still scope for improving Kanaka output by reducing technical inefficiency without using additional resources. In other hybrids out of 39 farmers, about 3 (7.69%) farmers were found to operate at technical efficiency rating of below 70 per cent and about 6 (15.38%) farmers were found to operate at technical efficiency rating of more than 90 per cent. Majority of the farmers have achieved only 81 per cent of technical efficiency and hence there is scope for improving other hybrids productivity by reducing technical inefficiency without using additional resources.

The allocative efficiency of different resources is furnished in Table 4.14 for Kanaka and other hybrids. The allocative efficiency in Kanaka hybrid for human labour (4.28) and PPC (1.64) were more than one indicating that still there is scope for higher utilization of these inputs and which in turn would increase the gross income. This would help to maximize profit in cotton production. While the ratios for seed, FYM, chemical fertilizer, bullock labour and machine labour were lesser than unity revealing that these resources are over utilized. Use of these resources need to be reduced if not they will reduce the level of output. Whereas allocative efficiency in other hybrids for human labour (9.63) was more than one indicating the scope for higher utilization of this input and which in turn would increase the gross income. This would help to maximize profit in cotton production. While the ratios for seed, FYM, chemical fertilizer, PPC, bullock labour and machine labour were lesser than unity revealing that these resources are over utilized. Use of these resources need to be reduced if not they will reduce the level of output. The results obtained in respect of human labour are in conformity with the results of Gamanagatti (2011).

5.8 Factors influencing the preference for Bt- cotton hybrids

Some of the major reasons for selection of Kanaka hybrid over other hybrids have been identified and listed in Table 4.15. As per the sample respondents, majority have agreed that big size of bole and more number of boles per plant was the major character considered while selecting any hybrid. Next most important character considered was resistance of crop to pests and diseases. Because incidence of boll worm was major problem in cotton. Apart from these characters some other characters also considered while selecting hybrids such as more number of pickings, high yield, high market rate, easy availability of seeds and less cost of cultivation.

SUMMARY AND POLICY IMPLICATIONS

Cotton (*Gossypium* spp.) "the Queen of fibers" is multipurpose crop grown under various agro-climatic conditions. Cotton is an important fibre crop of global significance, and cultivated in tropical and sub-tropical regions of more than seventy countries, the world over. The major producers of cotton are China, India, USA, Pakistan, Uzbekistan, Argentina, Australia, Greece, Brazil, Mexico and Turkey. These countries contribute about 85 per cent to the global cotton production. India has the largest area (11.98 m. ha) under cotton at global level and has the productivity of 518 kg lint /ha and ranks second in production with 365 lakh bales after China during 2012-13. The cultivation of crop generates direct and indirect employment in the economy. Cotton industries provide means of livelihood for about 250 million people through its cultivation, trade and Industries in India. It occupies a place of pride being the prime supplier of raw material (85%) for textile industry, which is one of the leading industries in the country. Commercially cotton is one of the best export earning commodities in the country. Textiles and related exports of which cotton constitutes nearly 65 per cent, accounts for nearly 33 per cent of the total foreign exchange earnings of the country (Bhagirath and Kadambini, 2010).

Biodiversity and agriculture are strongly interrelated because while biodiversity is critical for agriculture, agriculture can also contribute to conservation and sustainable use of biodiversity. Indeed sustainable agriculture both promotes and is enhanced by biodiversity. Maintenance of this biodiversity is essential for the sustainable production of food and other agricultural products and the benefits these provide to humanity, including food security, nutrition and livelihoods.

Agro biodiversity or crop varietal diversity is the part of biodiversity that is directly relevant for agricultural production. It includes the genetic diversity within and between crops and animals used for agricultural production. Biodiversity that closely interacts with crops is usually considered part of agro biodiversity. It includes pests, diseases, soil organisms, pollinating insects, etc. (Almekinders, 2001). The function of agro biodiversity in agricultural systems is still poorly understood. The objective to increase agro biodiversity for more sustainable agriculture is still largely based on assumptions and anecdotal information, rather than on solid ecological and socio-economic evidence. Varietal diversity, broadly defined as the extent of dissimilarity among a set of varieties, is increasingly recognized as important to crop production and has commanded growing attention from research in recent years.

Farmers and agricultural policy makers may have an interest in varietal diversity because no single variety can completely resist or tolerate all potential stresses, and yield reduction from a particular stress may be lower, on average, when there are more sources of stress tolerance. By providing a broader base of stress tolerance, varietal diversity may also reduce yield variability when pest infestations strike or bad weather occurs.

An important gap in the diversity literature is the lack of research addressing the impact of varietal diversity on yield and income of farmers. In industrialized countries, most studies on crop diversity are limited to genetic analysis of varieties and breeding stock and they rarely addressed the impact of diversity in developing countries, little is even known about crop diversity, and virtually nothing is known about the varietal diversity and how it affects production and income at the household. Regional or national level. Such a lack of attention is surprising given the large proportion of people that rely on farming and the great importance that developing country governments attached to the food security. Therefore this study is planned to assess the impact of varietal diversity in cotton on yield, income and employment levels in Haveri district with the following specific objectives.

Objectives

1. To analyze the nature and magnitude of growth in area, production and productivity of cotton in Haveri district.
2. To study the extent and magnitude of diversity in cultivars and cultivation of Bt-cotton.
3. To estimate the cost and returns of major Bt- cotton hybrids.
4. To examine the technical and allocative efficiency in Bt- cotton hybrids cultivation.
5. To study the factors influencing the preference of Bt-cotton hybrid

Methodology

The present study was taken up in the Haveri district of Karnataka state. Haveri district was purposively selected for the study, as this district has highest area under Bt-cotton cultivation in Karnataka.

The study was based on both primary and secondary data. The secondary data on area, production and productivity of cotton was collected from District Statistical Office for a period of fourteen years from 1997-98 to 2009-10 to analyze the growth in area, production and productivity. The primary data was collected from the randomly selected farmers. Keeping in view the objective of the study, multistage sampling procedure was adopted for selection of respondent farmers. Primary data collected pertained to the year 2012-13. In the first stage, three taluks with highest area under Bt-cotton crop were selected. At the second stage, two villages from among the predominantly Bt-cotton-growing villages in each of taluks were selected. In the final stage, 20 farmers growing Bt-cotton from each village were randomly selected. Thus the total sample study was size was 120. The data collected was on general characteristics of farmers, land holding, assets, costs, returns, yields, Bt-cotton hybrids etc.

Analytical techniques

For the purpose of achieving the objectives of the study, the data collected were subjected to the statistical analysis. To compute the growth rate in area, production and productivity, compound growth model was estimated. To work out the extent and magnitude of varietal diversity and cost and returns structure tabular analysis and budgeting technique were employed. Cobb-Douglas production function was fitted to estimate the technical and allocative efficiency in Bt- cotton hybrids cultivation. Garrett's ranking technique was used to know factors influencing the preference of Bt-cotton hybrid.

Major findings of the study

1. Growth rate analysis

It was observed that growth rates in area, production and productivity of cotton in Haveri district during entire period of study (1997-98 to 2010-11) was 1.33 per cent, 6.47 per cent and 3.89 respectively with fluctuation of 48.09 per cent, 46.04 per cent and 38.63 per cent respectively. Annual growth rate of productivity was more than the area and CGR of area was not statistically significant. From this it was clear that positive annual growth in cotton production was due to increase in productivity rather than increase in area.

2. Extent and magnitude of cultivar diversity

More than twenty Bt-cotton hybrids were cultivated in the district. Among these Mayhyo hybrids seeds was having highest share of about 33.98 per cent followed by Nuziveedu seeds (11.99%), Vikram seeds (7.47%), Vibha seeds (7.40%), Bioseeds (6.93%) etc. It was found from the study that majority of sample farmers (67.50%) were growing Kanaka a Mayhyo hybrid remaining (32.5%) respondents were cultivated other hybrids. Most of the farmers (78.33 %) preferred to cultivate only one hybrid with an average area of 1.15ha (78.77 %) and 23 farmers (19.17%) respondents cultivated two hybrids with average area of 0.27ha (18.47 %) and only 3 farmer respondents (2.50 %) cultivated three hybrids with average area of 0.04 ha (2.74 %) Average area under Bt-cotton cultivation was 1.46 ha.

3. Cost and returns structure in Bt-cotton hybrids

The per hectare average yield of Kanaka (18.76 q) was higher than that of Yuva Bt (17.24q/ha), Namdhari hybrid (16.54q/ha) other hybrids (16.89 q). The returns structure of Kanaka Yuva Bt, Namdhari hybrid and other hybrids revealed that gross returns were higher (₹113026) in Kanaka as compared to that of Yuva Bt (₹103892), Namdhari hybrid (₹99240) and other hybrids (₹101340). The net returns of Kanaka (₹ 67090) was higher than Yuva Bt (₹57770), Namdhari hybrid (₹52104) other hybrid (₹53824).

The per quintal cost of production was ₹2448, ₹2675, ₹ 2849 and ₹ 2849 in Kanaka, Yuva Bt, Namdhari hybrid and other hybrids respectively.The per quintal profits realized by Kanaka was (₹3576) high as compared to Yuva Bt (₹3351), Namdhari hybrid (₹3150) and other hybrids (₹3187). This is due to high price (₹6000/q) received for Kanaka as compared to Yuva Bt, Namdhari hybrid and other hybrids. Thus, cultivation of Kanaka was more profitable than other hybrids in the study area and was also supported by a high magnitude of B: C Ratio of 2.46 over 2.25, 2.10 and 2.13 in Yuva Bt, Namdhari hybrid and other hybrids respectively.

4. Technical and allocative efficiency in Bt-cotton production

The results of production function analysis indicated that the inputs included in model explained 92 per cent of variation in Bt-cotton output in Kanaka and 88 per cent in other hybrids. The high and significant F value indicated that the Cobb-Douglas function was adequate in explaining the variation in Bt-cotton output due to variation in the variables included in the model.

The sum of regression co-efficient was more than one, indicated increasing return to scale in both Kanaka and other hybrids. The elasticity of production for human labour and machine labour were significant at one per cent, while for Bullock labour was significant at five per cent. The elasticity coefficients for seed, FYM, fertilizer and PPC were positive and non significant in Kanaka hybrid. Whereas in other hybrids production elasticities human labour, bullock labour, fertilizer and PPC were significant at one per cent.

Average technical efficiency was slightly more in Kanaka (85%) as compared to other hybrids (81%). In Kanaka out of 81 farmers, about 6(7.41%) farmers were found to operate at technical efficiency rating of below 70 per cent and about 16 (19.75%) farmers were found to operate at technical efficiency rating of more than 90 per cent. Majority of the farmers were found to be have achieved only 80 to 90 per cent of technical efficiency and hence there is scope for improving Kanaka productivity by reducing technical inefficiency without using additional resources. In other hybrids out of 39 farmers, about 3(7.69%) farmers were found to operate at technical efficiency rating of below 70 per cent and about 8 (15.38%) farmers were found to operate at technical efficiency rating of more than 90

The MVP to MFC ratios in Kanaka showed that there was scope for increased use of human labour and PPC keeping the use of all other resources at a constant level. The MVP to MFC ratios for other hybrids showed that there was scope for increased use of human labour keeping the use of all other resources at a constant level.

6. Factors influencing the preference for Bt-cotton hybrids.

Big size of boles and more number of boles and resistance to pest and diseases were the major factors which influence the farmers in selection of Bt-cotton hybrids. The factors like easy availability of seeds and less cost of cultivation were ranked last by the respondents.

POLICY IMPLICATIONS

1. Cotton production in the study area is monopolized by Mahyco and Nuziveedu cotton hybrids. Which may lead to panic situation in minds of the farmers particularly when seed supply is inadequate. Therefore public cotton hybrids may be evolved which are competent enough to Mahyco and Nuziveedu cotton hybrids.

2. The cost of Bt. Cotton seeds is high. Bt. Cotton seeds of high quality should be made available to the farmers at affordable price to increase the use by farmers and to increase their profitability.

3. The analysis of resource use efficiency revealed that the resources are not optimally used in cultivation of Bt-cotton as indicated by MVP to MFC ratios (Fertilizer, PPC, FYM). The farm management specialists should demonstrate and educate the farming community regarding judicious and optimal use of inputs.

4. Very few Bt-cotton growers were found to operate at high technical efficiency rating of above 90 per cent with average technical efficiency of 85 per cent in Kanaka and 81 per cent in other hybrids. So there exists a vast scope for improving Bt-cotton productivity in the study area by increasing the technical efficiency without the use of additional quantity of resources like Mechanization of harvesting can be followed as it is already practiced in some developed counties.

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DIVERSITY IN CULTIVATION OF Bt-COTTON HYBRIDS IN HAVERI DISTRICT-AN ECONOMIC ANALYSIS

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ABSTRACT

The focus of the present study was to study the economies of diversity in cultivation of Bt-cotton hybrids in Haveri district. A sample of 120 farmers was selected using multi stage random sampling method. Field level data pertained to the agriculture year 2012-13. For analyzing the data, Growth rate analysis, Cobb-Douglas production function, Timmer's measure of technical efficiency, budgeting technique and tabular analysis were employed. The annual growth rates in area, production and productivity of cotton in Haveri district were positive and significant. More than twenty Bt-cotton hybrids were cultivated in the district. Among these Mayhyo hybrids seeds had highest share of 33.98 per cent followed by Nuziveedu seeds (11.99%), Vikram seeds (7.47%), Vibha seeds (7.40%), Bioseeds (6.93%) etc. Majority of sample farmers (67.50%) were growing Kanaka a Mayhyo. Most of the farmers (78.33 %) preferred to cultivate only one hybrid, while 19.17 per cent cultivated two hybrids. Average area under Bt-cotton was 1.46 ha. The total cost of cultivation of Yuva Bt hybrid (₹46122), Namdhari hybrid (₹47136) and other hybrids (₹47516) were more when compared to that in Kanaka (₹45936). Thus, Kanaka was more profitable than Yuva Bt, Namdhari and other hybrids and also recorded high B: C ratio of 2.46 over 2.25, 2.10, and 2.13 respectively. The average technical efficiency was higher in Kanaka (85%) as compared to that in other hybrids (81%). The ratio of MVP to MFC for human labour and PPC was more than one in Kanaka hybrid. The ratio in other hybrids was greater than one for human labour indicating under utilization of these resources.